MONDAY POSTER

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A DYSPROSIUM-BASED RING DISPLAYING LARGE MAGNETOCALORIC EFFECT AND SLOW MAGNETIC RELAXATION

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Single-molecule magnets (SMMs) [1] are increasingly being considered as the next step towards the miniaturization of devices for information storage, but their operating range is limited by the spin-blocking temperature T_B which, despite recent advances [2], remains very low. On the other hand, some magnetic molecules have been found to possess a significant magnetocaloric effect (MCE) [3]. Unfortunately, obtaining good SMM properties together with a large MCE for the same complex is difficult due to their different requirements on the cluster anisotropy [4]. Here we show that a recently synthesized $Fe_{10}Dy_{10}$ ring combines a large MCE below 12 K and magnetic hysteresis below 1 K. A comparison with the isotropic Gd- and Y-based analogs – the former displaying a record-breaking S = 60 total-spin ground state – with the same structure shows that the entropy variation of the Dy-based complex remains favorable because of the weak nearest-neighbors ferromagnetic coupling and of the frustration induced by the next-nearest-neighbors antiferromagnetic exchange. Suitably tailored SMMs can therefore also become effective self-coolers in a relatively broad temperature range down to just above T_B.

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MAGNETIC, TRANSPORT, OPTICAL AND MAGNETO-OPTICAL PROPERTIES OF In_2O_3 CONTAINING Fe_3O_4 NANOPARTICLES

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This study investigates magnetic, transport, optical and magneto-optical properties of In_2O_3 containing Fe_3O_4 nanoparticles, and shows that the formation of nanoparticles is increased by annealing in vacuum and inhibited by the inclusion of tin. Thin films of Fe doped In_2O_3 containing Fe_3O_4 were deposited on sapphire substrates by pulsed laser deposition at low oxygen pressure. The concentration of Fe was varied between 1% and 5% and the effect of including 5% of Sn and also annealing in vacuum were investigated. Structural analysis indicated a high concentration of Fe_3O_4 nanoparticles which was also confirmed by magnetic and magneto-optics studies. Transport measurements indicated that the films were in a metallic regime and an anomalous Hall effect was observed for the sample with 5% of Fe. Magnetic circular dichroism spectra taken in field and at remanence were analyzed to show that the sample had a magnetically polarized defect band located below the conduction band as well as magnetic Fe_3O_4 nanoparticles. The results were analyzed to indicate that there are two different magnetic components, Fe_3O_4 nanoparticles and the magnetization from the defect states. The signal from the defect states near the band edge was enhanced by increasing the number of carriers by either including Sn or by annealing in vacuum. However the concentration of nanoparticles was reduced dramatically by the inclusion of 5% of Sn. The substantial values of the coercive field were due to the presence of the Fe_3O_4 nanoparticles.

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EXTREMELY LARGE PHOTOINDUCED MAGNETORESISTANCE IN THE Fe/SiO_2/p-Si HYBRID STRUCTURE

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The use of hybrid structures under nonequilibrium conditions can lay the foundation of the new concept of spin-based electronics.

Study of the magnetotransport properties of the Fe/SiO_2/p-Si structure with a Schottky barrier under nonequilibrium conditions yielded the unexpected results: the extremely large magnetoresistance (MR) effect induced by optical radiation (0.98 nm) and the dependence of the resistance on the magnetic field sign. The sample under study was a circuit with the MIS back-to-back diodes. The bias current controls the sign and magnitude of the MR effect, which attains 10^5 % in a field of 2 kOe. Under the equilibrium conditions, the device exhibits the dc MR effect, but its magnitude does not exceed 20% at 90 kOe [1]. On the ac current, the magnetic field effect is stronger: the magnetoimpedance is over 80% at 5 kOe [2]. The field effect is caused by the surface states localized at the SiO_2/p-Si interface. The photoinduced giant MR is also related to the presence of the surface states, which simultaneously participate in the optical transitions and the spin-dependent tunneling. The observed asymmetry relative to the magnetic field sign originates from the Lorentz forces affecting nonequilibrium carriers and the specific topology of the device.

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RELATIVISTIC THEORY OF TRANSPORT PROPERTIES OF RANDOM NICKEL-BASED FERROMAGNETIC ALLOYS

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The formulation of a materials-specific parameter-free theory of transport properties of itinerant magnets represents a long-standing problem. This concerns especially phenomena related to the spin-orbit interaction, such as the anisotropic magnetoresistance (AMR) and the anomalous Hall effect (AHE). In this study, we focus on the concentration trends of the residual resistivity, AMR and AHE in selected random Ni-based alloys (Ni-Fe, Ni-Co, Ni-Mn, Ni-Pt). Their electronic structure is calculated by means of a fully-relativistic TB-LMTO method and the coherent potential approximation. The zero-temperature conductivity tensor is evaluated using a recent implementation [1] of the Kubo-Středa formula [2]. The obtained results indicate that the high AMR values in these alloys can be ascribed to a very weak disorder in the majority spin channel while the observed change of sign of the AHE can be interpreted as a band-filling effect. The importance of the so-called Fermi-sea contribution to the AHE, formulated along the Bastin approach to the conductivity tensor [3], will be discussed as well.

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SPIN HALL EFFECT ASSISTED MAGNETIC DOMAIN WALL MOTION IN PERPENDICULARLY MAGNETIZED CO/NI NANOWIRE

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INTRODUCTION

Current-induced domain wall motion (CIDWM) has been widely studied due to its potential applications. Recently, new aspect of spin torque such as spin Hall effect (SHE) has been emerged and found to affect the magnetization dynamics. By investigating CIDWM under in-plane bias field, here we show the evidence of SHE assisted DW motion in perpendicularly magnetized Co/Ni nanowires sandwiched by Pt layers.

RESULTS AND DISCUSSION

Figure 1 shows the in-plane field dependence of DW velocity *v*. Asymmetric dependence of *v* is observed, implying the existence of the effective in-plane offset fields. This offset field can be explained by additional torque originated from the SHE of Pt layer. The experimental results have been confirmed by micromagnetic simulation.

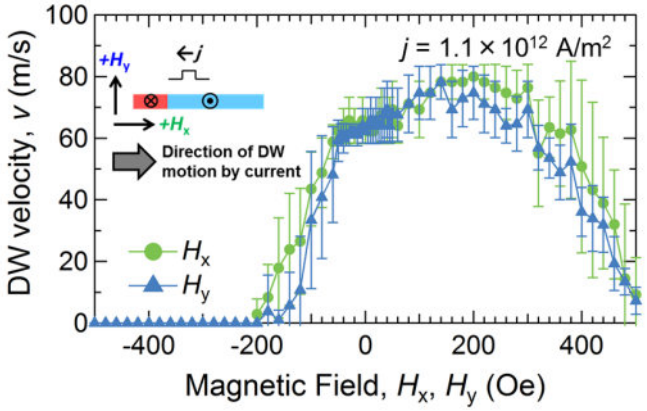

Figure 1 DW velocity *v* with respect to the in-plane bias fields.

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TOWARD SWITCHABLE NANOELECTRONICS DEVICES

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INTRODUCTION

Switching the electronic or magnetic states of molecule(s) is one of the foremost paradigms in molecular electronics. An interesting set of molecules that undergo a transition up to room temperature, are the so-called Spin-crossover complexes. Indeed, a bistable behavior can be triggered by various external stimuli and in particular by an electric field [1]. Unfortunately there's nowadays a poor understanding of the transport mechanisms leading to a rather high uncertainty whether the observed switching occur due to a spin state conversion or other phenomena [2][3].

Here, we report transport measurements of nanoparticles of ca. 4 nm diameter based on the Fe(II) coordination polymer placed in between nanometer-spaced planar electrodes of different widths [2]. First, we determined the resistance of empty electrodes, before a monolayer of such nanoparticles was transferred by contact-printing. A clear increase in conductance has been evidenced while conductive-AFM measurements confirmed the presence of a homogeneous monolayer with an insulating character.

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STRAIN MEDIATED ELECTRIC FIELD MANIPULATION OF SPIN STRUCTURES IN NICKEL NANOSTRUCTURES ON PMN-PT

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We present results of strain induced magnetization control of Ni structures imaged by Photoemission Electron Microscopy with X-ray Magnetic Circular Dichroism magnetic contrast (XMCD-PEEM). Using $Pb(Mg_{0.33}Nb_{0.66})O_3]_{(0.68)}$-$[PbTiO_3]_{0.32}$ (PMN-PT) substrates in (110) direction, effective uniaxial in-plane strains can be generated by the application of in-situ, out-of-plane electric fields. The magnetization configurations of the polycrystalline Ni structures reflect the strain induced uniaxial easy magnetic axis from inverse magnetostriction (Figure 1). Direct comparison with the influence of applied magnetic field and micromagnetic simulations allow us to quantify the corresponding energy terms.

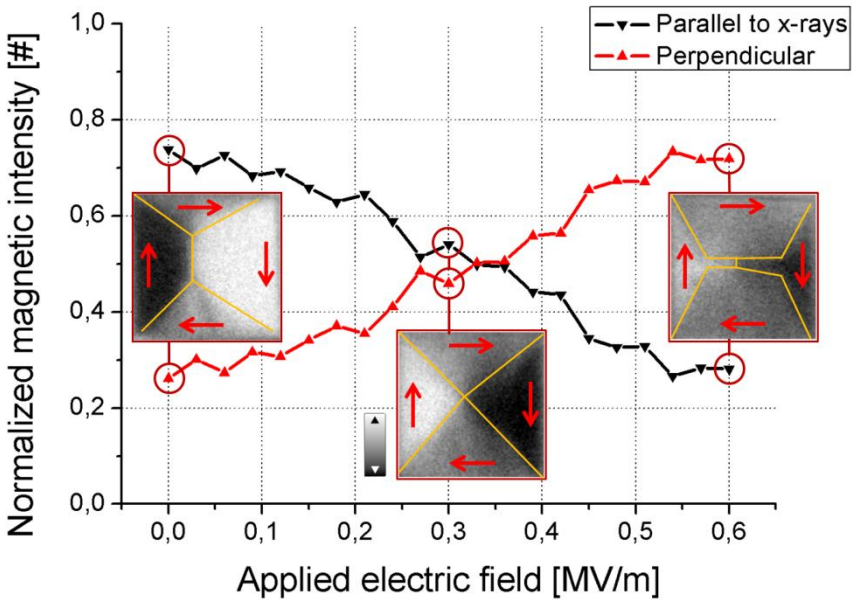

Figure 1: Strain induced easy magnetic axis in a Ni square (2 µm) on PMN-PT substrate by inverse magnetostriction. The plot shows the combined areas (as fraction of the total square area) of domains with vertical magnetization (black curve) and horizontal magnetization respectively (red curve) changing as function of the in-plane strain state indicated by the out-of-plane voltage applied to the PMN-PT substrate (x-axis). Three examples of magnetic images of the Ni square (lines are guides to the eye) at 0.0, 0.3 and 0.6 MV/m electric field are shown; the as-deposited (neutral) state corresponds to 0.3MV/m after poling.

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ATOMIC AND ELECTRONIC INTERFACE STRUCTURE OF HALFMETAL HEUSLER BASED SPIN VALVES

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Halfmetal Heuslers alloys have recently attracted a lot of attentions due to their high spin polarisation. Co based Heuslers in particular were rather successfully applied as electrodes in current-perpendicular-to-plane spin valves (CPP-SV) devices. Magnetoresistance (MR) of the SVs strongly depends of the ordering of the Heuslers electrode(s) and atomic structure of the interfaces between the electrodes and metallic spacers [1,2]. Hence understanding the atomic structure of these devices is crucial in order to correlate their structure to functionality, i.e the MR. In this work we carried out Scanning Transmission Electron Microscopy and Density Functional study (DFT) of Co_2(Mn,Fe)Si/Ag/Co_2(Mn,Fe)Si CPP-SVs interface structures.

The STEM/HAADF shows that even the best prepared CPP-SVs (the ones with highest MR) show interface mixing between Co and Ag atomic columns. The DFT calculations show that first couple interface layers of the electrodes are spin-depolarized even at ideal sharp interfaces. Additional mixing at the interface increases the magnetically dead layer at the Co_2FeMnSi/Ag interface. Finally we studied the effect of various δ-doping interface metallic layers with the aim to recover the bulk spin-electronic structure in vicinity of the Co_2FeMnSi/Ag interfaces.

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ELECTRONIC AND TRANSPORT PROPERTIES OF CaC/LiCl(MgS)/CaC (001) HETEROSTRUCTURES

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Electronic structure calculations performed for presumed CaC compound by using tight-binding linear muffin-tin orbital (TB-LMTO) method show, in agreement with previous data [1], that metastable B1 phase with the equilibrium lattice parameter a_{CaC}=5.23 Å and a total spin magnetic moment of 1.9 μ_B/f.u. has nearly half metallic ferromagnetic characteristics.

Electronic properties of CaC/LiCl(MgS)/CaC (001) heterostructures are studied by means of a layered Green's function technique implemented within TB-LMTO formalism [2] and the transport properties by using Kubo approach implemented within TB-LMTO formalism [3].

Away from interfaces, CaC layers have bulk-like characteristics. At CaC/LiCl(MgS) (001) interfaces C and Ca magnetic moments are little reduced and small polarizations are induced on Li(Mg) and Cl(S) interfacial sites. Small ferromagnetic couplings with amplitudes decaying exponentially are evidenced. All conductances depend on barrier characteristics and decrease exponentially with barrier thicknesses. In the ferromagnetic state of the junctions the highest contributions to the conductances are given by the minority spin electrons (Fig. 1a). High tunneling magnetoresistance values are predicted (Fig. 1b).

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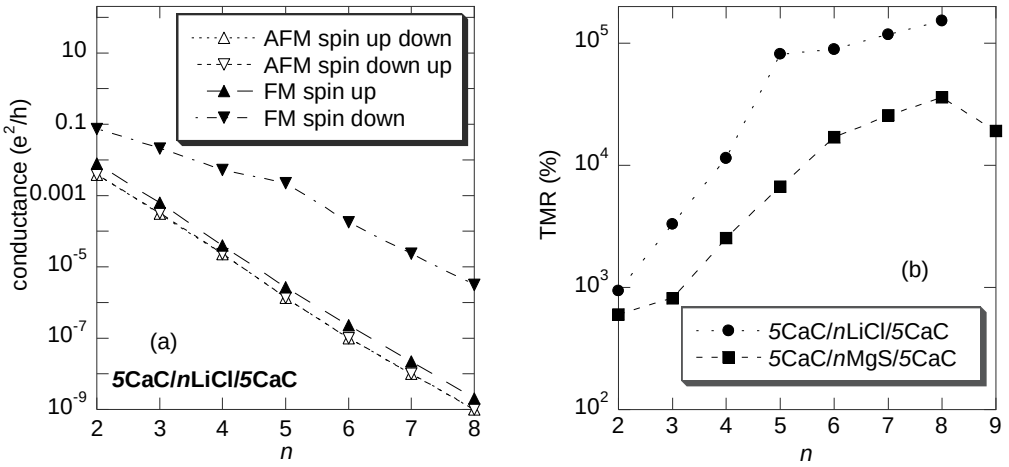

Figure 1 Conductances versus barrier thickness (a) and TMR ratios (b) for *5*CaC/*n*LiCl(MgS)/*5*CaC junctions

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SPIN TORQUE INDUCED MAGNETIC VORTEX DYNAMICS IN TRI-LAYER NANOPILLARS

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Spin polarized current passing through a nanomagnet transfers angular momentum creating a spin transfer torque to the magnetization. The spin transfer torque can induce the magnetization switching or to steady oscillations. Non-uniform (vortex) magnetization oscillations were observed in such magnetic nanostructures as nanopillars, nanocontacts and tunnel junctions. To explain these experiments and predict new phenomena related to the spin torque induced spin dynamics, an adequate theoretical approach is needed.

We calculated stability of the different magnetization ground states in tri-layer F/N/F nanopillars of ferromagnet(F)/nonmagnetic spacer(N)/ferromagnet(F) [1]. Then, we calculated the main physical parameters of the spin polarized current induced vortex oscillations in magnetostatically coupled F/N/F nanopillars, such as the vortex oscillation frequencies [2], the signal linewidths and the vortex core trajectories. The calculation approach is based on the Thiele formulation of the non-uniform magnetization dynamics using vortex center coordinates. All the results are represented via the ferromagnetic layer and spacer sizes, Gilbert damping and the degree of the spin polarization of the ferromagnetic layers. The obtained equations can serve as a theoretical basis for interpretation of the experiments on the spin torque induced magnetization dynamics in nanopillars.

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EFFECTS OF HEAT ON MAGNETIZATION DYNAMICS

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The work presented here is aimed at investigating the interplay between spin dynamics and heat currents in magnetic systems.
By means of two local probes, we conducted time-resolved transmission measurements microwave pulses 10 ns long at a frequency of 7.1 GHz. We were able to observe spin waves propagation in a single-crystal Yttrium Iron Garnet (YIG) slab subjected to a temperature gradient of the order of 30K/cm. The relative orientation of the sample, the applied field and the temperature gradient was as in the famous Spin Seebeck geometry [1].
We also studied electrically detected FMR of electrodeposited Co/Cu/Co asymmetric spin valves positioned at the middle of Cu nanowires, when subjected to a strong heat current by means of a laser diode, in order to extend the quasi-static study of switching field versus heat current [2].

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ANISOTROPIC MAGNETORESISTANCE IN NiFe/IrMn EXCHANGE BIAS SYSTEMS

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ABSTRACT

Anisotropic magnetoresistance (AMR) is the dependence of the resistivity of a ferromagnetic metal on the angle between current and magnetization. As it is an interesting tool to investigate magnetic anisotropy it can be widely used in the study of systems presenting exchange-bias. In this work we have used AMR to investigate the magnetic anisotropy of the NiFe/IrMn interface in both a sample with just one bilayer and another one consisting of 20 interfaces stacked. In the multilayer we deposited Ta between consecutive F/AF bilayers in order to avoid IrMn/NiFe coupling. The samples were grown onto Si (100) substrates covered with a Ta buffer layer by magnetron sputtering. The structural characterization was performed by X-ray diffraction and the chemical modulation was checked by X-ray reflectometry. Magnetic hysteresis curves were obtained by a VSM magnetometer. Then the AMR measurements were carried out using the usual four-probe technique under a magnetic field applied by a rotating coil. Finally we have carried out simulations of the experimental data. The results show a significant difference in the AMR behavior between the two samples. AMR intensities from bilayer and multilayer are quite different at the exchange-bias field value and 180°. The multilayer required an extra term to match the experimental data which accounts for the AF-surface unstable spins.

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THE MAGNETIC PROPERTIES OF IRON DOPED ZIRCONIA: THEORY AND EXPERIMENTS

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Diluted magnetic oxides are driving increasing interest in solid state physics and materials science communities for their potential applications in spintronic devices where the information is encoded in the electron spin. This will reduce electrical consumption or will allow the storage and manipulation of non-volatile data beyond room temperature, an essential requirement for the nano-electronic industry. Among oxides, ZrO_2 is a promising candidate with a high dielectric constant and ionic conductivity which has recently been integrated in ultra-scaled devices.

We systematically investigated, both theoretically and experimentally, $Zr_{1-x}Fe_xO_{2-y}$ ranging from diluted (x=0.05) up to large (x=0.25) Fe concentration. By ALD we grew thin films of high-k Zirconia in cubic phase (figure, right panel) with Fe uniformly distributed in the film, as proven by ToF-SIMS and TEM measurements. Iron is in Fe^{3+} oxidation state [1] suggesting the formation of oxygen vacancies with y concentration close to x/2. By *ab initio* simulations we investigated the microscopic mechanisms responsible of the magnetic behaviours at different Fe concentration (figure, left panel), enlightening the role of oxygen vacancies and y/x ratio in determining the formation of a magnetic semiconductor or the production of spin polarized carriers. Preliminary results by AGFM show hysteresis loops suggesting that the material is para/ferromagnetic at room temperature. Further measurements are in progress to verify the latter result.

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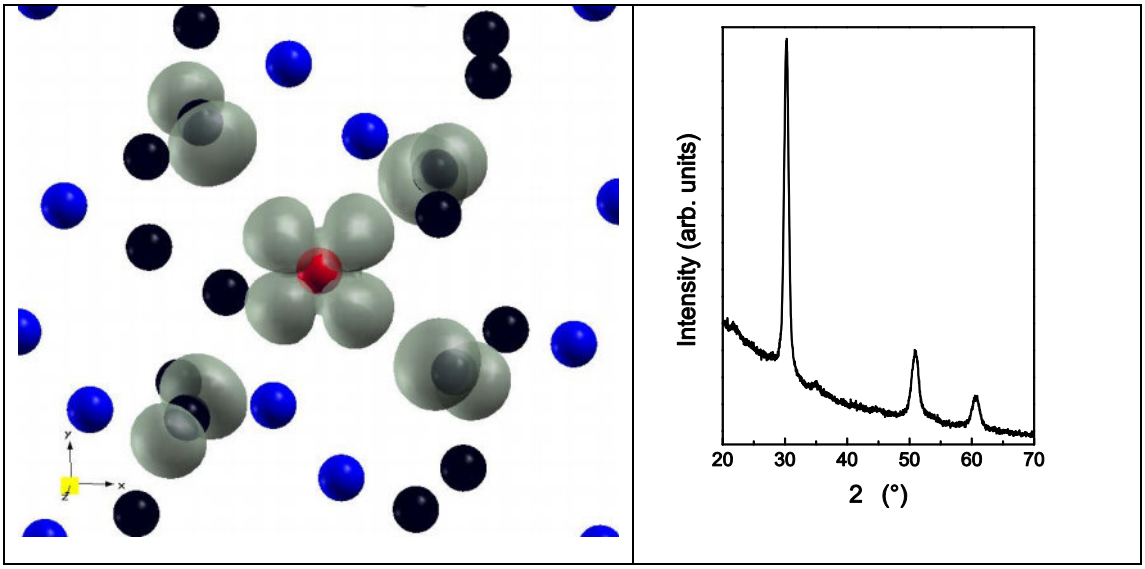

***Fe doped ZrO_2**: simulation of hole wave-function (left panel) and XRD pattern corresponding to the cubic phase (right panel). Fe concentration is about 12-13% in both cases.*

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ULTRAFAST DEMAGNETIZATION DYNAMICS IN FEPT FERROMAGNETIC THIN FILMS WITH PERPENDICULAR ANISOTROPY

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The final use of FePt in storage devices requires detailed knowledge about its ultrafast demagnetization behavior. In this work, ultrafast magnetisation dynamics of continuous film sample of FePt with perpendicular anisotorpy is investigated by means of the time-resolved Kerr magnetometry. The measurements reveal a transition between type I (sub-ps magnetization recovery) and type II (the second demagnetization with a different timescale and no magnetization recovery within 30 ps range) behavior with the increase of the laser fluency. To explain the behavior, the magnetization dynamics have been simulated using a thermal micromagnetic model based on the Landau-Lifshitz-Bloch equation coupled to the two-temperature model, reproducing well the experimental results. Within this model, the slowing down of the demagnetization time and the transition to the type II behavior can be explained as a consequence of high electron temperature in FePt. At high pump fluence, the resulting electron temperature after the equilibration with the phonon temperature remains close to the Curie temperature leading to critical slowing down effect. Our results open possibilities for ultra-fast control of demagnetisation in FePt, the most promising candidate for future magnetic recording applications. Importantly, we have shown that one is able to controllably manipulate the degree of demagnetisation and its ultra-fast rates by varying the amount of the deposited energy.

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TWO-STAGE REMAGNETIZATION OF FERROMAGNETIC FILMS

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Remagnetization of thin films is a phenomenon being, in many respects, similar to the crystallization which could be described by the analytical Kolmogorov approach [1] being based on the idea of crystallization centers, arising in the bulk, around which the growth of another phase grains occurs. To describe the magnetic relaxation we use the analog of that approach – in the initial state, the system is magnetized up to the saturation by applying a strong field whose direction then reverses sharply and the magnetization relaxation occurs. That process proceeds through the originating centers magnetized opposite to the initial magnetization, while growing grains are domains of a new magnetic phase.

In the original variant, Kolmogorov model deals with two phases only (”liquid“ and ”solid“). Absolutely new situation arises when *three* magnetic phases could coexist – two phases of opposite magnetizations (original and final), and the third (intermediate) phase with magnetization perpendicular to the initial one. Such a situation is possible for films with the easy plane anisotropy (for example, Fe/GaAs(001) or CoPt(110)/MgO) if the magnetic field is perpendicular to the film plane.

For that case, Kolmogorov model needs to be generalized properly. The result of such a generalization is the prediction of the two-stage remagnetization consisting of two successive processes differing sharply by characteristic relaxation times. Available data are qualitatively agrees with the model suggested.

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MICROMAGNETIC SIMULATIONS OF COERCIVITY IN COBALT ANTIDOTS ARRAYS

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The coercivity mechanisms in antidot arrays have been a subject of extensive studies. Several experimental groups [1] report on the coercivity decay as a function of the periodicity ($Hc \sim 1/\lambda$), while recent experimental results on more closely packed structures [2] reveal a maximum of the coercive field. To elucidate the question, we performed micromagnetic simulations of the hysteresis process of Cobalt thin films with antidots arranged into a squared lattice. In agreement with experimental indications we have assumed that the nominal antidot size may be larger than the lithographed region since the antidot can be surrounded by the damaged nonmagnetic area. In the extreme case of closely packed antidots this corresponds to the "dot" regime, since there is no continuous magnetic material.

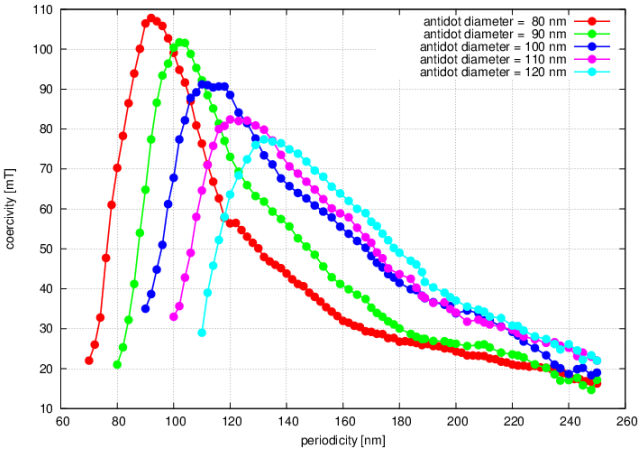

Fig. 1 The dependence of the calculated coercivity on the periodicity for various antidot diameters.

The resulting simulated coercivity (Fig. 1) has a maximum when the lattice period is slightly larger than the diameter of the antidots. The increase of the coercivity happens due to the stronger pinning for larger values of the periodcity in the "dot" and the antidot regimes. Further increase of the periodicity results in a decrease of the coercivity due to a facilitated nucleation. This regime is characterized by existence of domain walls pinned by the antidots.

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Magnetic and Structural Properties of Equiatomic FeRh thin films

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Equiatomic FeRh thin films with varying thickness have been prepared on MgO (100) substrates via molecular beam epitaxy (MBE). The optimization of the stoichiometry was monitored using XRD, RBS and AES while the magnetic properties were probed using SQUID magnetometry. In Fig.1 XRD results evidence a well ordered CsCl-type crystal structure. By increasing the annealing temperature of the films, the structural quality of the films also increases. Moreover, the known first order phase transition at ~350 K from an antiferromagnetic (AF) to a ferromagnetic (FM) state [1] slightly shifts towards higher temperatures [Fig. 2]. M-H loops of films annealed at 800 C and 850 C recorded at 300 K show an opening, which is likely related to the magnetic field-induced AFM-FM phase transition. Residual low-temperature ferromagnetic moments are of unknown origin, but likely related to strain or diffusion effects at the surface or interface [2].

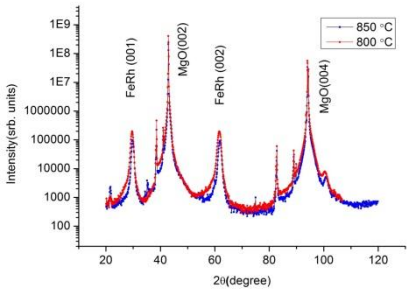

Figure. 1 X-ray diffraction spectra for $Fe_{50}Rh_{50}$ film annealed at 800 and 850 °C

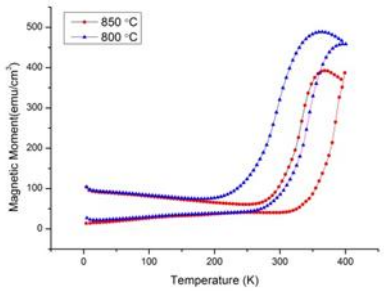

Figure. 2 Temperature dependence of the magnetization for $Fe_{50}Rh_{50}$ film annealed at 800 and 850 °C.

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EFFECT OF UNIAXIAL MAGNETOCRYSTALLINE ANISOTROPY ON SPECTRUM OF HYBRID WAVES IN HEXAFERRITE FILMS

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INTRODUCTION

In the last years different planar structures consist of the dielectric and the ferrite layers with high magnetocrystalline anisotropy (e.g. hexaferrites) have been studied extensively [1-2]. This study is associated with a demand of micro- and nanoelectronics for signal processing devices, operating in subterahertz frequency range. Due to the high magnetocrystalline anisotropy the frequency range for spin waves in hexaferrite films is shifted to subterahertz frequencies at reasonable bias magnetic fields. This makes them very good candidates as information carriers for subteraherts applications.

The presented work is devoted to the theoretical analysis of the influence of strength and mutual orientation of the external bias magnetic field and the field of uniaxial magnetocrystalline anisotropy on the spectrum of normal hybrid wave modes propagating in the hexaferrite film. The two types of hehaferrite films are examined and compared: the M-type hexaferrite and Y-type.

RESULTS AND DISCUSSION

The investigation of the relation between the form of the hybrid electromagnetic-spin-wave spectrum of the hexaferrite film and the mutual orientation of the anisotropy axis and the external bias magnetic field is presented. The investigation covers the solution of both static and dynamic problem. The solution of static problem is obtained from a minimization procedure for the magnetic energy density for the hexaferrite film with arbitrary orientation of the axis of uniaxial anisotropy. The solution of the dynamic problem is derived accoding to the spin-wave mode expanson technique [3]. The obtained spectrum of hybrid electromagnetic-spin waves shows a strong dependence on mutual orientation of the anisotropy axis and the external bias magnetic field. The influence is quite different for hehaferrites with anisotropy type “easy axis” and with “easy plane” anisotropy. For M-type hexaferrites (“easy axis” anisotropy) the hybrid waves propagating in hexaferrite film show simultaneously dispersion properties of different types for different spin-wave modes, i.e one and the same spin-wave spectrum contains the dispersion branches having different signs of group velocity. Moreover, the type of the propagating hybrid electromagnetic-spin waves can be controlled by only the value of the bias magnetic field for given orientation of the anisotropy axis and given orientation of the external bias magnetic field.

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MICROMAGNETIC SIMULATION OF A FERROMAGNETIC PARTICLE

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In this work the magnetic behavior of a ferromagnetic particle has been investigated by means of micromagnetic modeling through the Finite Element Method. The simulations were performed on a particle with uniaxial magnetocrystalline anisotropy and ellipsoidal shape, including spherical, oblate and prolate cases, and dimensions up to 100 times the exchange length.

A damped PDE is used to describe the motion of a magnetic moment in an effective magnetic field, resulting from the variational derivative of Gibbs energy with respect to the magnetic polarization. A Rayleigh dissipation function is used to take into account the relaxation of the moment towards equilibrium. The time-dependent PDE is used as an iterative procedure rather than a real time model. Contributions to the effective field arise from exchange, magnetic anisotropy, Zeeman and magnetostatic energy. The magnetostatic field is calculated simultaneously by solving the Laplace equation for the magnetic scalar potential. The average mesh size in the magnetic domain is kept smaller than the width of a Bloch wall. In order to treat the open boundary problem an infinite element scheme is used.

The results indicate the critical size for coherent rotation, curling and multidomain reversal modes. Above a critical size the formation and motion of domain walls is clearly observed. The estimated domain wall width is lower than the one referenced in international literature. From the demagnetization curves the associated nucleation and coercive field are estimated (fig. 1).

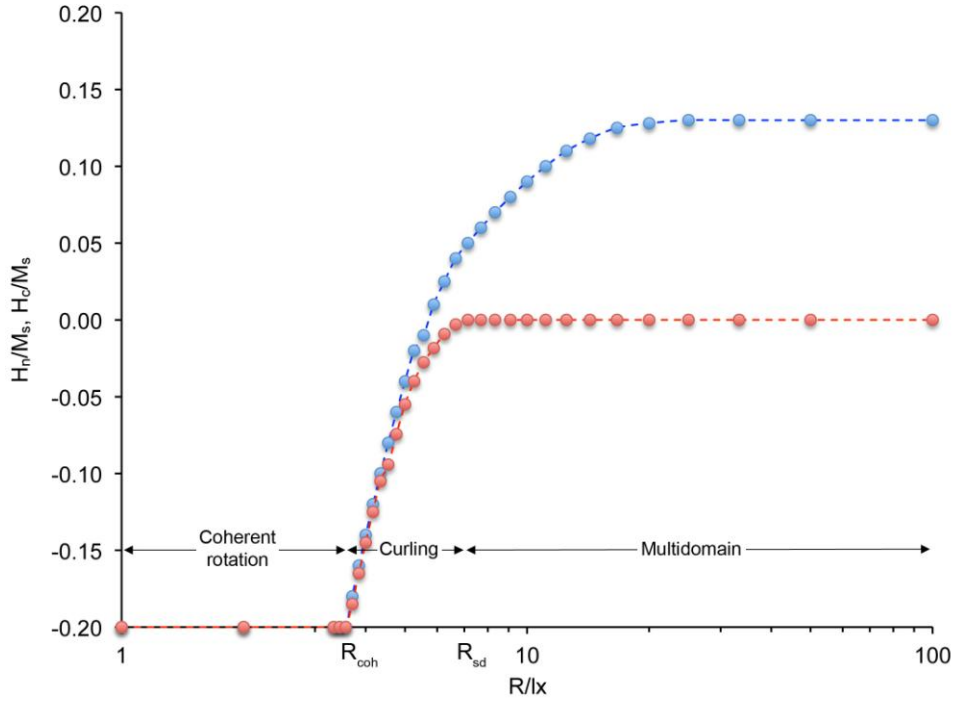

Fig. 1 Nucleation (H_n, blue) and coercive (H_c, red) field vs the radius of a spherical particle with hardness parameter κ=0.32 and easy axis parallel to external field.

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MAGNETIC AND MAGNETOCALORIC PROPERTIES OF $Pr_{1-x}Sr_xCoO_3$ COBALTITES

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INTRODUCTION

The physical properties of $Ln_{1-x}A_xCoO_3$ (Ln= La, rare earth and A = Ca, Sr, Ba) perovskites, can be controlled by changing the ionic radius of Ln, by doping A-type ions at Ln ion site. $Pr_{1-x}Sr_xCoO_3$ ($0.30 \leq x \leq 0.65$) stands out for interesting magnetic properties. These compounds have sharp paramagnetic to ferromagnetic-like transitions and very low electrical resistivity which recommend them as magnetocaloric effect materials.

EXPERIMENTAL

The samples $Pr_{1-x}Sr_xCoO_3$ ($0.30 \leq x \leq 0.6$) were synthesized using the ceramic method. The X-ray analyses show only one phase having monoclinic or orthorhombic symmetry. The magnetic measurements were done in the temperature range 5-300 K and up to 12 T. The resistivities were measured up to 7 T. The magnetocaloric effect was estimated from the isothermal *M–H* curves under different temperatures for ΔB = 1-4 T.

RESULTS AND DISCUSSION

The magnetic measurements indicate that the samples exhibit two phase transitions: a paramagnetic-ferromagnetic phase transition at about 220 K and a second one below 120 K. The compounds were found to have metallic behaviour, with negligible magnetoresistance. The maximum magnetic entropy change, for the sample with x = 0.5, was 1.9 J/kg·K, while the relative cooling power is around 107 J/kg, for ΔB = 4 T. This means we can obtain rather high cooling powers in various temperature ranges, with reasonably good magnetocaloric values.

OBSERVATION OF DOMAIN WALL MOTION IN A Co/Pt WIRE UNDER GATE ELECTRIC FIELD

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The velocity of a magnetic domain wall (DW) v_{DW} is one of factors to determine the performance of magnetic devices. Recently, we have reported that v_{DW} can be changed by applying an electric field [1]. Here we report the direct observation of the DW motion under the transparent ITO gate electrode by using a magneto-optical Kerr effect (MOKE) microscope.

The DW motion was captured under the gate voltage V_G and perpendicular magnetic fields. Figure. 1 shows the snapshots of the MOKE microscope. The left regions of the Co/Pt wires from the arrows are covered by the ITO. Each snapshot was captured 34 seconds after the DW started to move left from the arrows. It is obvious that travel distance of DW is changed by V_G. Furthermore, v_{DW} is modulated by one order magnitude by changing V_G (Figure. 2). This result is consistent to the one we reported before [1].

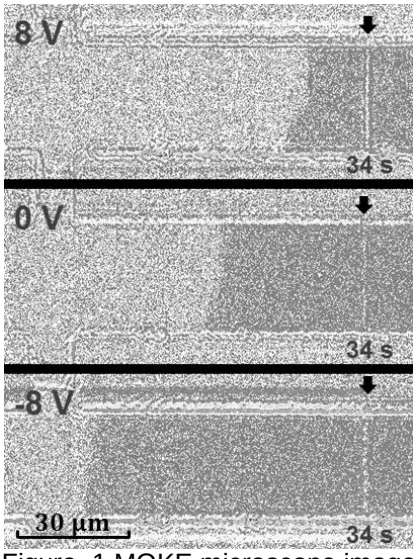

Figure. 1 MOKE microscope images

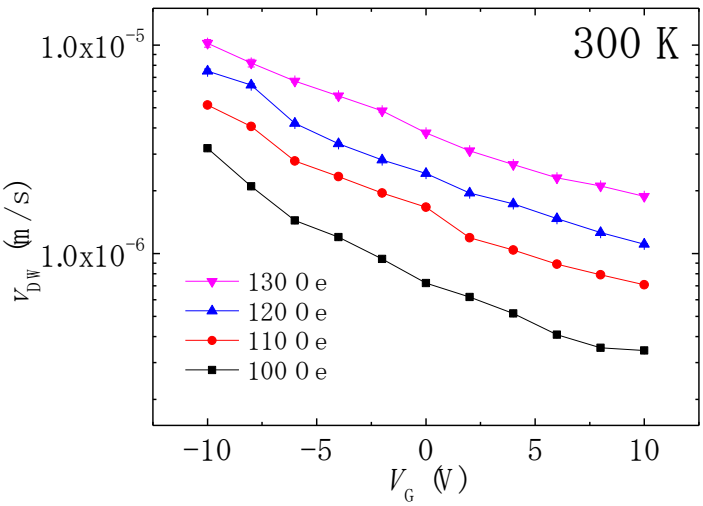

Figure. 2 DW velocity as a function of

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PHYSICAL MICROMODEL FOR PREISACH HYSTERON IN GRAINED MEDIA

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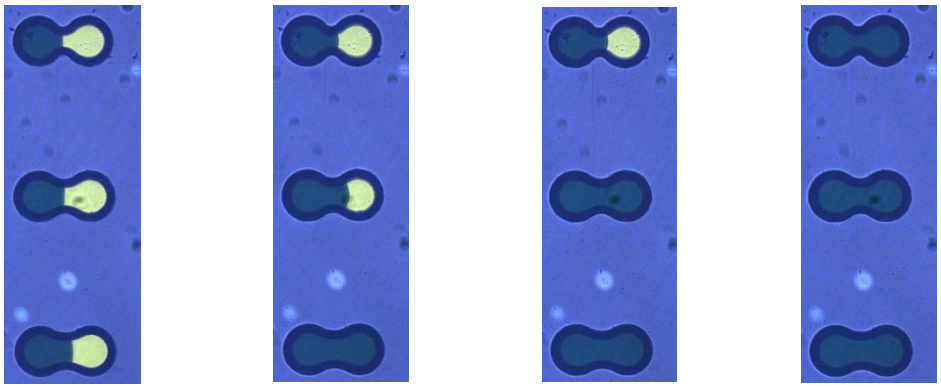
Two basic physical models (Wohlfarth-Stoner and Globus) used for Preisach hysteron description should be modified for adequate hysteresis description. Pure Wohlfarth-Stoner model with homogeneous rotation of magnetization takes place rarely due to domains formation. Globus model considers domain wall (DW) displacements from equilibrium position in diameter plane inside uniaxial sphere-like grain. But diameter DW position is unstable due to DW surface energy.

Film elements with various shapes and sizes were used for experimental and numerical investigation of single DW stable positions and magnetization processes by DW bulging and displacement. Monodomain elements were etched in crystalline garnet film with uniaxial anisotropy and single DW was formed in each element. Magnetization processes were investigated by magnetooptical method.

On the contrary of Globus model DW stable positions are found naturally in local narrowing parts of elements shape as it is shown in Figure 1 for dumbbell-like elements. Therefore hysteron basic loop possesses three-level shape including part with zero magnetic moment in the vicinity of zero external field. Switching field value depends upon width and width gradient in the vicinity of element narrowing part. Asymmetry between switching field from zero moment to saturation state and return switching was revealed and explained in terms of magnetostatic field asymmetry in the presence of element width gradient.



H=0 H=1.0 Oe H=2.5 Oe H=5.0 Oe

Figure 1. Microphotographs of magnetization by domain wall displacement in garnet dumbbell-like elements with different width and curvature radius values of dumbbell bridges in normal external field H. Dumbbell length L= 200 μm, garnet film magnetization $4\pi M$ = 25 G, film thickness h = 3 μm.

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The yield stress of fluidized beds of soft magnetic particles stabilized by a magnetic field

We present experimental measurements of the yield stress of gas-fluidized beds of soft magnetic particles stabilized by an externally imposed magnetic field [1]. The magnetic field is applied in the bubbling regime and the velocity in the vertical direction is decreased. At a critical gas velocity particle chains formed due to attractive magnetostatic forces become jammed and the bed transits to a solidlike expanded state with a nonnegligible yield stress. Our experimental setup allows us for taking measurements of the yield stress of the bed stabilized by a magnetic field oriented either in the vertical or horizontal direction (co-flow and cross-flow field configurations, respectively). In the cross-flow field configuration, the magnetic yield stress is increased with particle size. On the other hand, the magnetic yield stress is decreased in the co-flow field configuration as particle size is increased. This is interpreted as due to the dependence of the interparticle magnetostatic force on the interparticle contact angle with the field, which is on average affected by particle size in the jammed bed.

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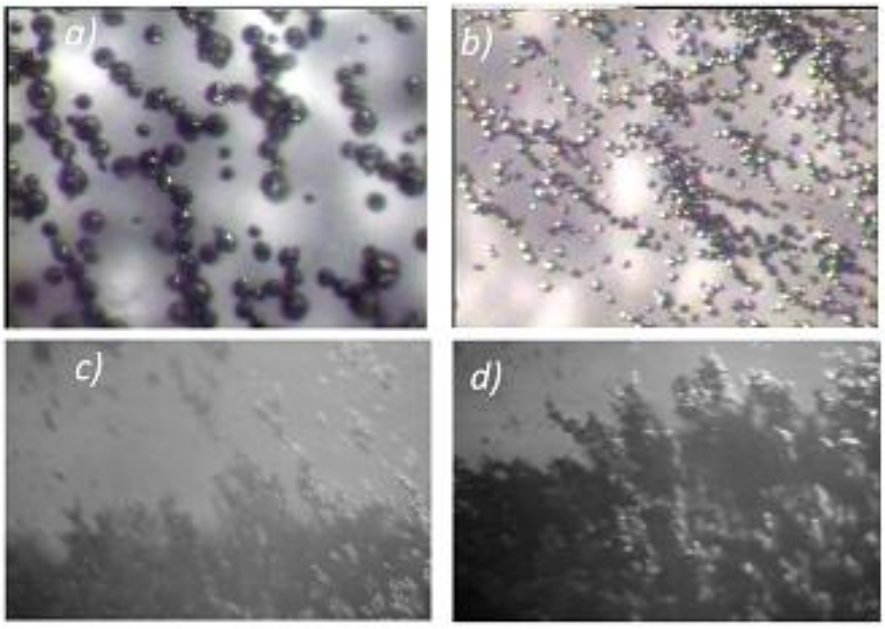

Images of magnetofluidized beds of magnetite beads showing chainlike aggregates elutriated from the free surface. The gas flows in the vertical direction and the applied magnetic field is horizontal.

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SPIN DYNAMICS AND ENERGY DISSIPATION DURING FAST MAGNETIZATION REVERSAL: FROM MICRO- TO NANO-MAGNETIC SWITCHES

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The dissipated energy and the spin eigenmodes excited during magnetization reversal in bistable magnetic switches, consisting of either micro- or nano-metric elliptical nanodots, are analysed by micromagnetic simulations. Both the irreversible magnetization reversal, obtained by the application of an external field along the easy axis, and the precessional switching, obtained applying a short pulse of field oriented perpendicular to the initial magnetization direction, are considered.

In the second part of this presentation, we analyse the energy cost of a quasi-reversible (adiabatic) switching, resulting from driving the magnetization to reverse across the hard axis by a proper quasistatic sequence of external fields. It is shown that the minimum expected value of $\Delta E=k_B T \ln(2)$, known as “Landauer limit”, is recovered by micromagnetic simulations, provided that the adopted erasure protocol includes a proper time interval where the probability distribution of the nanodot magnetization has the same amplitude in the two possible states.

This work was supported by the European Community’s Seventh Framework Programme (FP7/2007-2013) under Grant No. 318287 “Landauer" and by the Ministero Italiano dell’Università e della Ricerca (MIUR) under PRIN Project No. 2010ECA8P3 "DyNanoMag".

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GLOBAL, LOCAL, AND MICROMAGNETIC ANALYSIS OF EPITAXIAL $NDCO_5$ THIN FILMS

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INTRODUCTION

The rare earth-cobalt magnet $NdCo_5$ undergoes a spin-reorientation-transition from a magnetic easy *c*-axis above 310 K via a magnetic easy cone to a magnetic easy plane below 255 K. This spin-reorientation is investigated in epitaxial $NdCo_5$ thin films grown by pulsed laser deposition on single-crystalline MgO(110) substrates [1].

The temperature-dependent magnetization processes are analyzed globally by Vibrating Sample Magnetometry [1] and locally by Scanning Electron Microscopy with Polarization Analysis [2]. For a further understanding of the observed magnetization processes micromagnetic simulations are performed for selected temperatures.

The results of the global and local measurements confirm the spin-reorientation-transition. The domain observation shows a transition from a 2-domain state with the magnetization oriented parallel to the *c*-axis above 310 K via a 4-domain state to again a 2-domain state below 255 K, which is 90° rotated [2]. The micromagnetic simulations reveal the dependence of the domain walls on temperature and on their orientation with respect to the crystallographic *c*-axis.

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COERCIVITY AND RANDOM INTERFACIAL EXCHANGE COUPLING

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Exchange biasing (EB) phenomena in antiferromagnetic - ferromagnetic systems are usually accompanied by an increase of coercivity [1]. Several aspects of these phenomena are explained within the random interfacial field model [2] but the diversity of EB systems and lack of interfacial spin structure information, are limiting factors. Hard/Soft bilayers systems on the other hand, are analogous to EB systems as the minor loop of the soft layer is biased by the hard and furthermore offer bias layer tunability [3]. In sputtered CoPt/Co hard-soft bilayers EB shows a linear dependence on the hard layer magnetization, while coercivity a quadratic dependence (Figure 1) for samples prepared under different conditions. Analysis of minor hysteresis loop features supported by Monte-Carlo simulations shows that the coercivity of soft layer is mainly determined by the tunable randomness of the domain state of the hard layer.

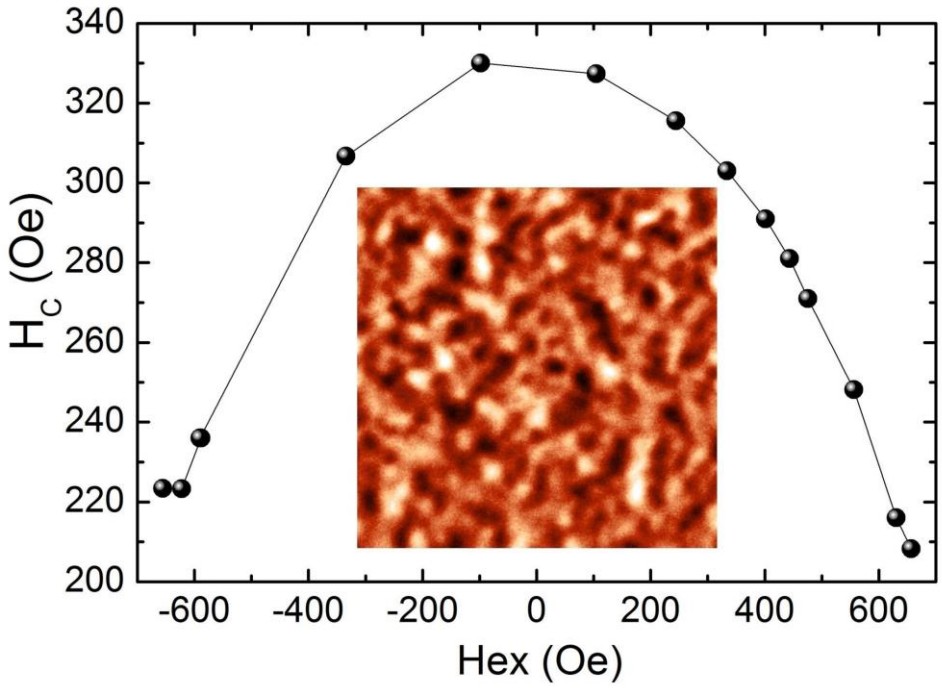

Figure 1: Minor loop coercivity versus exchange bias. Inset: MFM image of the hard layer demagnetized state.

ACKNOWLEDGEMENT
Research co-financed by the European Social Fund and Greek national funds through the Research Funding Program " ARCHIMEDES III".

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TRANSIENT MAGNETIC TUNNELING MEDIATED BY A MOLECULAR BRIDGE IN THE JUNCTION REGION

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INTRODUCTION

This paper extends our recent theoretical study of transient currents in molecular bridge junctions [1] to magnetic tunneling. Presently, we calculate the excess magnetic tunneling through the molecular bridge shunting the junction.

MODEL

The system is represented by two ferromagnetic electrodes bridged by a molecular size island with a few discrete electronic levels and a local Hubbard type correlation. The island is linked with the electrodes by tunneling junctions whose coupling strength is assumed to undergo rapid changes affecting the connectivity of the system.

METHOD

We employ the non-equilibrium Green's functions. The finite-time correlated initial conditions are taken into account using the partitioning-in-time method we developed previously [1]. The numerical solution is obtained solving the real-time Dyson equation in the integro-differential form self-consistently.

RESULTS

The switching events controlling the junctions give rise to transient changes of magnetisation of the island. They strongly depend on the static galvanic bias between the electrodes, mutual alignment of their magnetisation and on the time scale of the switching series.

ACKNOWLEDGMENT

This research was supported by the Czech Science Foundation within the grant project P204/12/0897

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ULTRAFAST MAGNETIZATION DYNAMICS IN Gd-Yb-BIG FILM INDUCED VIA INVERSE FARADAY EFFECT

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In the last decade, light-induced phenomena in ferrimagnetic garnets have attracted a lot of experimental and theoretical attention. Non-thermal optical coherent control and magnetization switching has been observed in ferrimagnetic garnet systems via the Inverse Faraday effect. Ultrafast magnetization dynamics of garnet single crystal with composition Gd-Yb-BIG(111) were studied by time-resolved measurements using an optical pump-probe technique. The amplitude and precession frequency were measured as functions of external magnetic field and polarization of the pump at different wavelength. We observe two distinct frequencies of precession with differing by two orders of magnitude. The excitation efficiency of slow mode precessions strongly depends on the amplitude of external magnetic field. However, high-frequency precession is independent on the magnetic field at wide spectral range. Strong dependence of amplitude and phase of both frequency modes on the light pump polarization was observed. One can expect that this high-frequency dynamics (up to 50 ps) is the result of the exchange resonance between magnetic ions in garnet lattice at the octahedral and tetrahedral sites. Our results contribute to understanding ultrafast magnetization processes and non-thermal optical control of magnetization in picoseconds time scale.

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ONE-DIMENSIONAL DYNAMICS OF THE DOMAIN WALLS IN MULTILAYER FERROMAGNETIC STRUCTURE

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In recent years, lots of studies focus on the multilayer magnetic structures. The presence of layers, different one from the other in one or more magnetic parameters value, can be taken into account, for example, by the spatial modulation of the material magnetic parameters [1]. It is known that the presence of a thin layer, with the parameters of magnetic anisotropy lower than in the adjacent layers, in a three-layer structure may cause, for instance, the appearance of a new magnetic phase nucleus or new dynamic effects such as reflection of the moving DW from an "attractive potential". This paper focuses on the influence of the magnetic anisotropy parameters spatial modulation on the nonlinear dynamics of the DW in a five-layer ferromagnetic consisting of three broad layers separated by two thin layers. We also demonstrated the presence of a certain critical value of the distance between thin layers that leads to two qualitatively different scenarios of the domain wall dynamic behavior. The structure and properties of the magnetic inhomogeneities of three- and four-kink type, excited in thin layers, has been investigated. We found two possible oscillation modes for the localized magnetic inhomogeneities in the form of two coupled breathers.

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REORIENTATION OF POLARIZATION DOMAINS IN CR THIN FILMS

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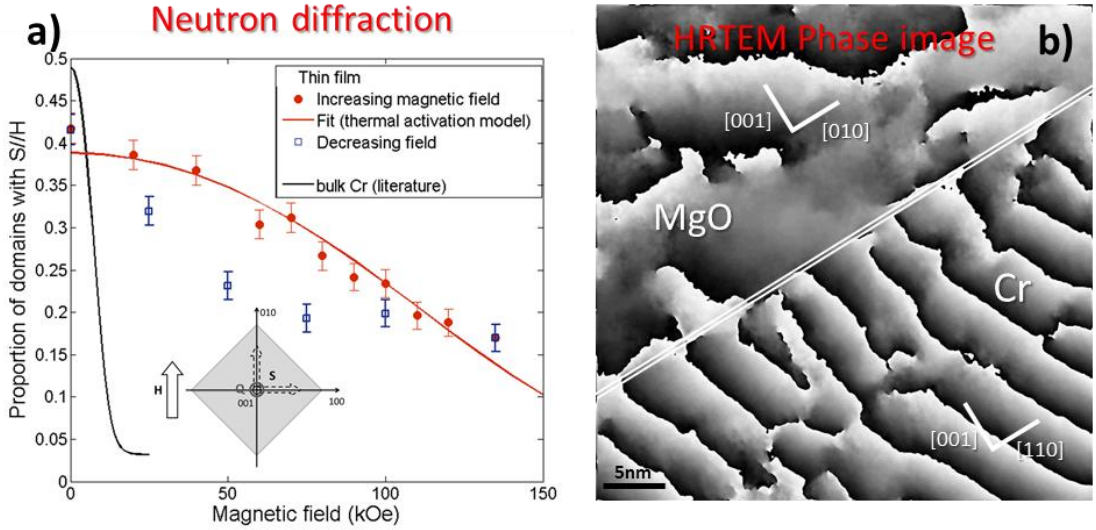
Cr is an itinerant antiferromagnet whose spin density wave propagates along the <100> crystalline axes. In the transverse phase, the spins lie perpendicular to the propagation vector Q, along <100>, so for a single-Q sample, 2 polarization domains exist. In bulk Cr, applying a magnetic field along a crystalline axis favors the growth of domains with polarization perpendicular to it, this reversible reorientation being complete near 20kOe [1]. While the polarization domains have been widely studied for bulk Cr [1,2], studies on thin films domains are scarce.

We have hence studied by neutron diffraction the magnetic field-induced reorientation of the polarization in a single-Q Cr thin film, where, additionally to strain effects, interface and finite size shall influence the magnetism. Like for bulk Cr, the domains with polarization along the magnetic field disappear progressively, however the reorientation is irreversible and incomplete even at 135kOe (Figure a). Assuming that the reorientation of domains is thermally activated [1], we show that the number of spins rotating coherently is far smaller than in bulk Cr and determined by the local anisotropy induced by interface dislocations (Figure b).



a) Population of disadvantaged domains with magnetic field. b) Periodic lattice of dislocations at the Cr/MgO interface

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CRYSTAL STRUCTURE AND NEGATIVE MAGNETIZATION IN Sm_2Al AND $Sm_{1.988}Gd_{0.012}Al$ COMPOUNDS

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Ever since the discovery[1-2] of spin and orbital moment compensation in $SmAl_2$, there has been a lot of interest in identifying other Sm-based materials showing similar phenomenon. A ferromagnet with no net magnetization is of significant interest, both from applications and fundamental interest. Though, anomalous magnetic properties are seen to be quite common in many Sm-containing materials, the exact compensation of spin and orbital moments is not very prevalent. Here we report Sm_2Al and $Sm_{1.988}Gd_{0.012}Al$ compounds, with orthorhombic crystal structure (space group Pnma), showing negative magnetization in temperature dependence magnetization data. Both compounds magnetically order at ~ 150 and 200 K respectively and below this temperature, magnetization data shows a compensation temperature (T_{comp}) which shifts with field. Hysteresis loops obtained below T_{comp} signify that both Sm_2Al and $Sm_{1.988}Gd_{0.012}Al$ possess exchange anisotropy. Both, exchange anisotropy field and coercive field are found to be quite large and comparable to those of the classical spin-orbit compensated ferromagnet $(Sm,Gd)Al_2$.

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MAGNETISM, CRYSTAL AND ELECTRONIC STRUCTURE OF SELECTED $Gd(In_{1-x}Sn_x)_3$ COMPOUNDS

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ABSTRACT

In the paper magnetic properties of polycrystalline $Gd(In_{1-x}Sn_x)_3$ intermetallic compounds are presented. The cubic $AuCu_3$ type of crystal structure for the whole series was confirmed with the use of X-ray powder diffraction. A partial replacement of In by Sn atoms is reflected in the oscillating behaviour of the temperature of the magnetic phase transition (T_{N1}) from ~45K (x=0.0) to ~26K (x=0.9). Additionally, below T_{N1} an extra phase transition at T_{N2} is observed. Moreover, the In/Sn substitution is also reflected in the oscillation dependence of the effective moment (μ_{eff}), the paramagnetic Curie temperature (θ_p) as well as the temperature independent susceptibility χ_0. Simultaneously, the value of magnetization at 7T also exhibits oscillating behaviour. The observed changes may be related to some surface effects and the presence of additional canted AFM structure below T_{N2} [1-5].

Electronic structure studied by XPS method indicates that In/Sn substitution results in an energy shift in the valence band (VB) related to electron transfer from Gd to In/Sn. It may cause the increase values of effective magnetic moment. Such an energy shift is also observed in the case of Gd*4d* lines. In addition a gradual substitution indium by tin shows the change in the maximum intensity of states near by the Fermi level I_{max}(VB) and its shape. The variation of I_{max}(VB) versus Sn content also reveals an oscillating dependence.

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TEMPERATURE DEPENDENCE OF THE LOCAL MAGNETIC MOMENT AT A Cd IMPURITY DILUTED IN *R*Ni_2 COMPOUNDS

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The systematic of the local magnetic moment formation and the related magnetic hyperfine fields at a Cd impurity diluted in *R*Ni_2 compounds at 0K have been studied both experimentally and theoretically [1]. In the present work we focus our discussion on the temperature dependence of the *R*Ni_2 (*R* = Nd, Sm, Gd, Tb, Dy) compounds within an integral functional approach in the static approximation [2], the temperatures ranging from 0K up to the critical temperatures T_c of these compounds, when they become paramagnetic. We calculate the perturbed densities of states and the local magnetic moments at the Cd impurity site, in each temperature. The calculated magnetic hyperfine fields as a function of temperature are in good agreement with the available experimental data [3].

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TEMPERATURE DEPENDENCE OF THE MAGNETIC HYPERFINE FIELD AT A Cd IMPURITY IN GdM_2 (M = Fe, Co, Ni) COMPOUNDS

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In this work we discuss the temperature dependence of the local magnetization and the related magnetic hyperfine field at a Cd impurity embedded in GdM_2 (M = Fe, Co, Ni) compounds. We adopt here a functional integral approach in the static approximation, which is an extension of conventional mean field calculation [1]. The temperature range goes from 0K up to the critical temperature T_c. After determining the local charge potential via an extended Friedel sum rule, we obtain the local perturbed densities of states, the local magnetic moments and the local magnetic hyperfine field at the Cd impurity site. The self-consistent calculations show a good agreement with the available experimental data [2, 3].

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AB-INITIO INVESTIGATION OF ELECTRONIC AND MAGNETIC STRUCTURE OF Cr_3Si WITH FERROMAGNETIC DOPANTS

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INTRODUCTION

Cr_3Si crystallizes in A15 structure [1] and is Pauli paramagnet. Although there is no sign of superconductivity in case of this material, other A15 alloys e.g. V_3Si [2] or Nb_3Sn [3] reveal superconducting behavior. Experimental investigations of Cr_3Si doped with transition metals show that doping with iron leads to consecutive increase of magnetic susceptibility with Fe content, while doping with Co results in anomalous magnetic properties [4].

In this contribution we present theoretical investigation of Co impurities' distribution in $Co_xCr_{3-x}Si$ for x = 0.125 and 0.0625. An influence of Co doping on electronic and magnetic properties of the alloys is emphasized. It is shown that total energy is decreasing with the decrease of Co-Co distance which may be understand as a tendency to clustering of cobalt atoms.

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MAGNETOTRANSPORT IN HEUSLER ALLOYS WITH NATIVE DISORDER

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Heusler alloys represent an important class of materials [1]. Their properties depend on the preparation even for samples with the same stoichiometry. One of the reasons is the presence of native disorder which can strongly influence magnetic moments and transport properties. We study the electronic and magnetic structure of selected Heusler alloys from first principles using the TB-LMTO method. The disorder is included within the coherent potential approximation (CPA). The transport properties are calculated using a fully-relativistic Kubo-Středa approach adapted to disordered multisublattice systems [2]. We calculate the full tensor of conductivity including usual conductivity (σ_{xx}) and the anomalous Hall effect given by off-diagonal elements (σ_{xy}). We also study the spin-disorder resistivity caused by scattering on disordered magnetic moments. As case studies we choose half-metallic Heusler alloys Co_2CrAl and Co_2MnAl, as well as the spin gapless semiconductor alloy Mn_2CoAl for which experimental and theoretical studies appeared recently [3]. Our main conclusion is that a proper inclusion of disorder significantly improves agreement between the experiment and theory.

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STRESS INDUCED PERPENDICULAR MAGNETIC ANISOTROPY IN FEPT THIN FILMS

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FePt thin films have been broadly studied in the last years due to possible technological applications of its crystalline ordered phase. However, films grow in disordered crystalline phase (called $A1_0$) at room temperature, which presents a rich variety of magnetic phenomena. In particular, as-made films show a critical thickness above which the magnetic domains change from a planar to a stripe-like configuration. The latter is induced by a perpendicular component of the magnetic anisotropy originated by the combined effects of magnetocrystalline anisotropy (texture) and magnetoelastic energy (induced stress) [1].

We grew a series of six samples of FePt thin films with a thickness of 100 nm, varying the Ar pressure in the sputtering chamber from 3 to 13 mTorr. By this procedure it is possible to maintain an almost constant texture, but relaxing the in-plane stress. The samples were characterized by X-ray diffraction. With an AFM-MFM microscope, we have observed the transition from a striped pattern to in-plane magnetic domains for a sputtering pressure between 9 and 11 mTorr. We have also compared these images with dc magnetization and Ferromagnetic Resonance measurements. From these data we concluded that the magnetoelastic effects are the major contribution to the perpendicular anisotropy.

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STUDY OF CRYSTAL STRUCTURE AND ELECTRONIC PROPERTIES ON CECUAL3 SINGLE CRYSTAL

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Cerium compounds crystallizing in tetragonal BaNiSn3-type structure reveal such interesting properties as heavy-fermion behavior, unconventional superconductivity, valence fluctuations or/and complex magnetic order at low temperatures. The nature of Ce atom with only one weekly shielded 4f-electron combined with competition between RKKY and Kondo interaction, and with the crystal field effect are crucial for electronic properties of these compounds.

CeCuAl3 compound is of particular interest as it was recently found to be one of few compounds in which the strong electron-phonon coupling is present and results in the formation of so called: vibron quasi-bound state [1]. CeCuAl3 was investigated by means of several experimental techniques but often with contradictory statements about magnetization easy-axis, details of magnetic order at low temperatures and even the crystal structure type in which this compound crystallizes. We present the thorough study of crystal structure as well as the consistent information about magnetic and transport properties of CeCuAl3 single crystal.

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MAGNETIZATION STUDY OF $TbFe_5Al_7$ SINGLE CRYSTAL

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The ferrimagnetic $TbFe_5Al_7$ compound (T_C = 242 K, T_{comp} = 84 K) with the tetragonal crystal structure of the $ThMn_{12}$-type has been studied on a single crystal in magnetic fields up to 14 T. The compound displays strong easy-plane magnetic anisotropy (Fig. 1). Substantial anisotropy is also present within the basal plane leading to strong magnetic hysteresis. The easy magnetization direction is the [100] axis at T = 2 K with the spontaneous magnetic moment M_s = 1.24 μ_B/f.u. A spin-reorientation transition occurs from the [100] axis to the [110] axis around the compensation temperature. At $T < T_{comp}$ $TbFe_5Al_7$ displays field-induced magnetic transitions along the [100] axis, whereas at $T > T_{comp}$ there are transitions observed along the [110] axis (Fig. 2). The critical fields H_{cr} of the transitions along both axes tend to zero upon approaching $T = T_{comp}$. A more detailed study of $TbFe_5Al_7$ requires higher magnetic fields and is in progress.

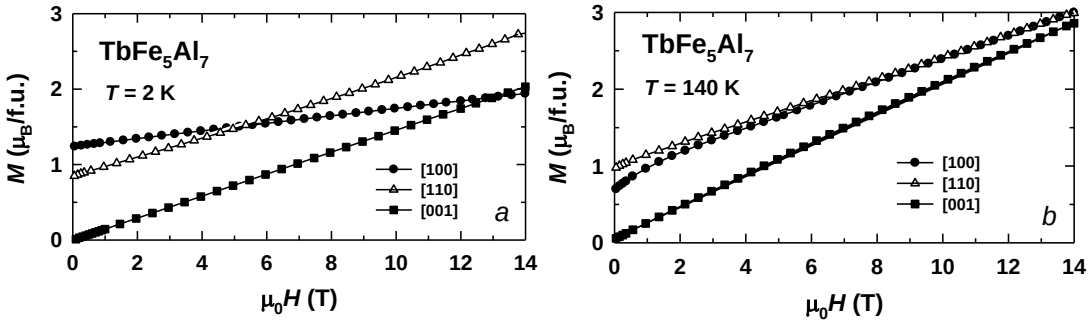

Fig. 1. Magnetization curves of $TbFe_5Al_7$ at T = 2 K (*a*) and T = 140 K (*b*).

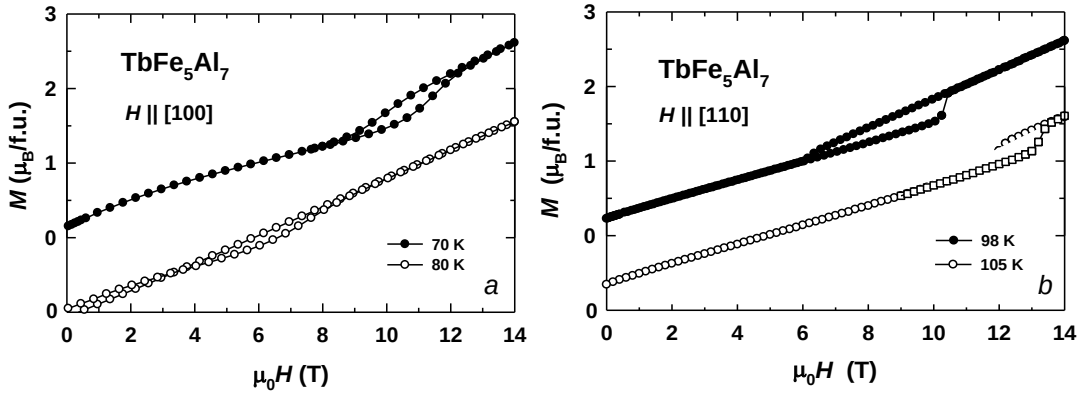

Fig. 2. Magnetization curves along the [100] (*a*) and [110] (*b*) axes of $TbFe_5Al_7$ in the vicinity of $T = T_{comp}$.

ANGLE DEPENDENCE OF FERROMAGNETIC RESONANCE PEAK WIDTHS IN Fe-*X*(*X*= Cr AND Cu) SINGLE CRYSTAL THIN FILMS

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INTRODUCTION

Gilbert's damping constant α of ferromagnetic 3-d transition metal thin films is an important factor to develop high frequency magnetic recording system and spintronics devices. In this work, angular dependence of α for Fe alloy thin films with addtion of non-magnetic bcc-Cr and fcc-Cu elements were investigated by FMR spectroscopy in terms of crystal structure.

EXPERIMENTAL PROCEDURE

Q-band FMR spectra of $Fe_{100-x}Cr_x(001)$ and $Fe_{100-y}Cu_y(001)$ single crystal thin films (x, y < 15 at%) were investigated with changing static magnetic field direction in the film plane. The α was estimated by FMR peak widths of the spectra.

RESULTS AND DISCUSSION

In-plane angle dependence of the resonance field H_r for the $Fe_{88}Cr_{12}(001)$ specimen showed four-fold magnetic anisotropy(Fig. 1). Magnetization easy directions were parallel to the $<100>_{bcc}$ directions. The crystalline anisotropy constant K_1 was estimated to be 1.1×10^5 erg/cm^3. The α was also four-fold symmetrically varied. The α had the maximum and minimum values at the $<100>_{bcc}$ and the $<110>_{bcc}$ directions, respectively. The difference between the maximum and the minimum values of the α increases with increasing the Cr concentration, although the K_1 decreases(Fig. 2). The α of the Fe-Cu specimens did not depend on the crystal direction. The α is independent of K_1.

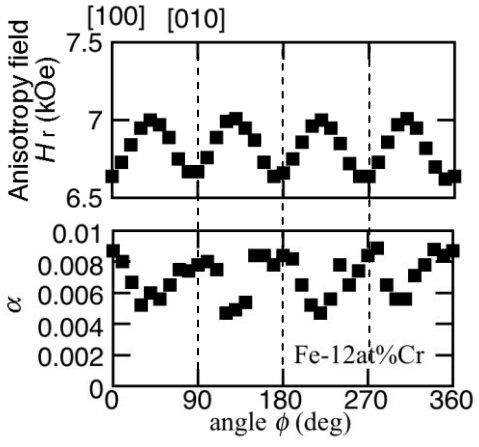

Fig.1 Angular dependence of H_r and α

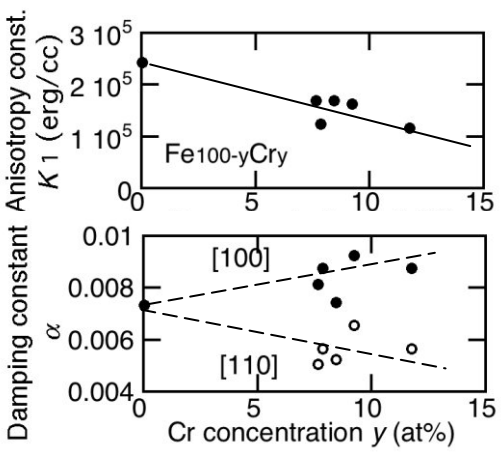

Fig. 2 Cr concentration dependence of K_1 and α

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GROWTH OF COBALT MANGANESE ALUMINIUM THIN FILMS BY PULSED LASER DEPOSITION

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The effects of the deposition temperature, laser energy and deposition time on the characteristics of Co_2MnAl films deposited on GaAs substrates were investigated. The grown films were characterized by AFM for film roughness and surface topography. Film thickness and elemental composition were measured using Rutherford Back Scattering (RBS) technique, while crystalline structure and phase composition were investigated by XRD. The RBS measurements showed that the stochiometry of the films was satisfactory and very close to that of the target Co: 0.5, Mn: 0.25, Al: 0.25. The thickness of the films was found to increase as the laser energy was increased from 200 to 400 mJ, in particular for the films deposited at 400 °C. We also found an increase in the films thicknesses as the deposition temperature was increased for the samples grown at 200 and 300 mJ. However, for the films deposited at 400 mJ, we noticed a decrease in the film thicknesses' as the deposition temperature was increased. The best film quality as deduced from XRD, RBS and AFM results for producing these single layers were those deposited at 600 °C with the laser energy at 300 mJ.

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STRIPES ROTATION AND MAGNETIC ANISOTROPY OF TbFeGa ALLOYS

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Magnetic films with perpendicular magnetic anisotropy (PMA) are attractive materials for applications in the fields of high density magnetic recording and spintronics. The magnetic domains orientation is known to affect the signal propagation through these materials when used in spintronic devices.

Recently, the PMA of TbFeGa alloys has been demonstrated [1]. In this work TbFeGa films were deposited by cosputtering, using two targets of $TbFe_2$ and Fe_3Ga. The effect of the type of power source (DC or pulsed) used in each target on the magnetic domain configuration has been investigated. It was found that the evaporation conditions strongly influence the out of plane (OOP) anisotropy of the films. Magnetic force microscopy (MFM), which shows the presence of stripe domains (fig. 1), has been used to investigate the rotatable anisotropy of these alloys. A magnetic field of variable intensity placed at 90 degrees with respect to the stripes direction has been applied, while in-field MFM images were recorded. The results clearly show the correlation between OOP and rotatable anisotropies, which allows to control the stripe domains rotation process and therefore the stripes orientation, by changing the films preparation conditions.

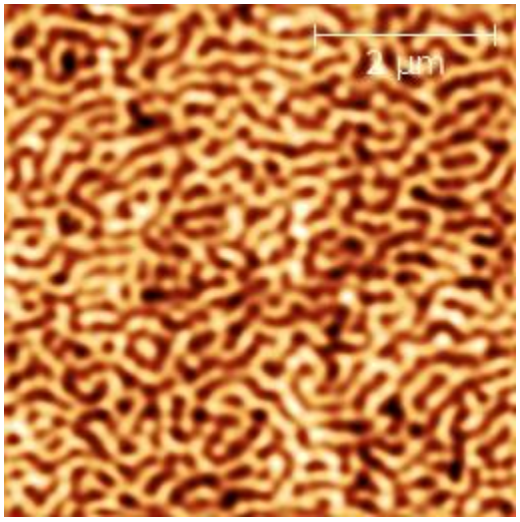

Figure 1. MFM signal recorded at remanence from the sample $Tb_{10}Fe_{76}Ga_{14}$.

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Deposition and Characterization of Novel $Fe_{2-x}NiSn$ (x=0-1) Heusler Alloy Films

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1. INTRODUCTION

Recent combinatorial studies of Heusler alloys by first-principles computational methods [1], predict the existence of tetragonal structure in Fe_2YZ alloys with high magnetic moments (up to 4.5 μ_B per f.u.), making them candidate materials for rare earth free permanent magnets. In the following we present the deposition, structural and magnetic characterization of Fe-Ni-Sn Heusler alloy films with compositions between 1:1:1 and 2:1:1 grown on SiO_2 and epitaxial substrates.

2. RESULTS AND DISCUSSION

The XRD pattern of 44nm film grown on STO is shown in figure 1(a). Two main peaks are observed (at 30.6 and 63.5 deg) that can be identified as the (110) and (220) of a cubic structure with lattice constant 4.13Å. In contrast, the thinner ones (10nm) are crystallized in a mixture of hexagonal (P63/mmc(194)) and cubic structure (Fm-3m(225)).

Typical in-plane and out-of-plane normalized hysteresis loops for film grown on MgO are shown in figure 1(b). The films show in-plane anisotropy with coercivity of 580 Oe, whereas films grown on SiO_2 show a mixed anisotropy.

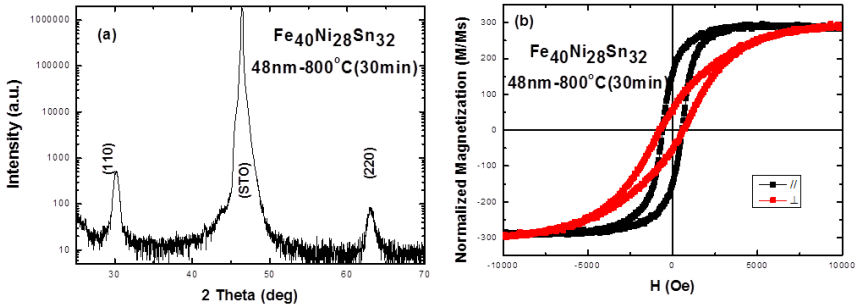

Figure 1: (a) XRD pattern and (b) hysteresis loops of films grown on STO and MgO, respectively

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ACKNOWLEDGEMENT

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FERROMAGNETIC-NONMAGNETIC TRANSITION ON FePt-*M* FILMS WITH *M*=3*d*-5*d* TRANSITION METALS

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The $L1_0$ FePt ordered alloy has a high K_u (7.0×10^7 erg/cm^3) due to alternating Fe and Pt layers along the [001] direction. For example, by substituting Rh for Pt in the equiatomic $L1_0$ structure, the antiferromagnetic phase is stabilized [1]. In this study, the ferromagnetic (FM)-nonmagnetic (NM) transition on FePt-*M* (*M*=3d-5d) films are investigated.

$(Fe_{1-x}M_x)_{50}Pt_{50}$ (*M*=Cr, Mn) and $Fe_{50}(Pt_{1-x}M_x)_{50}$ (*M*=Ru, Rh, Ir) films were prepared by sputtering method. All the films were annealed at 700 °C for 10 min.

Figure1(a) shows the composition dependence of the saturation magnetization of $Fe_{50}(Pt_{1-x}M_x)_{50}$ films at room temperature. The critical compositions of FM-NM transition of the films with *M*=Ru, Rh, Ir are x=0.25, 0.34, 0.20, respectively. Figure1(b) shows the average number of *d*-electron dependence of the critical compositions. For example, in the substitution of Ir($5d^7$) for Pt($5d^9$), the average number is calculated by 9(1-x)+7x = (9×0.80)+(8×0.20) = 8.52. It seems that the FM-NM transition have a close relation to the average number of *d*-electron, and all the critical compositions of *M*=Ru, Rh, Ir are on about 8.56.

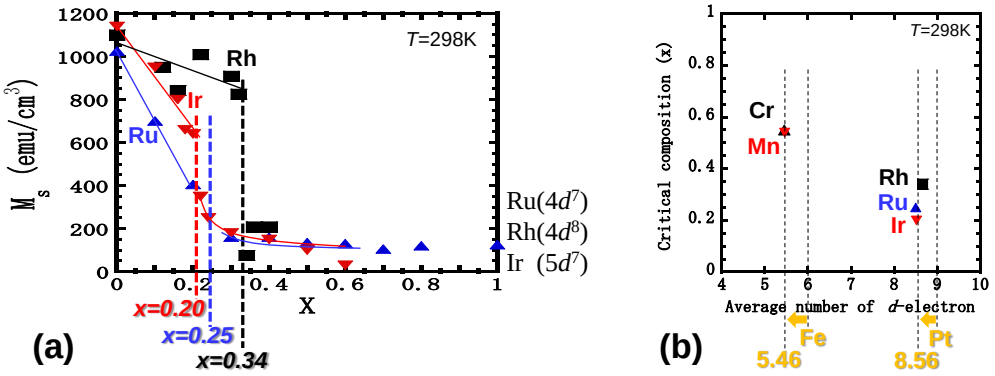

Figure1 (a) Composition dependence of saturation magnetization of $Fe_{50}(Pt_{1-x}M_x)_{50}$ (M=Ru, Ir, Rh) films at room temperature. (b) Critical composition as a function of average number of *d*-electron.

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This work was supported by NEDO(11B07008d).

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MAGNETIC AND STRUCTURAL PROPERTIES OF THE FILLED SKUTTERUDITE $BaFe_{4-x}Pt_xSb_{12}$ (x=0, 0.05, 0.2) COMPOUNDS

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We have synthesized the filled skutterudite $BaFe_{4-x}Pt_xSb_{12}$ (x=0 , 0.05 , 0.2), with $LaFe_4P_{12}$ structure, space group at room temperature using solid-state sintering. Magnetization measurements have been carried out on these samples in the temperature range 5-300K up to the field of 9 Tesla. The low-field dc magnetic susceptibility (χ = M/H) splits into two branches at lower temperatures in magnetic field of 20 Oe for zero-field-cooled (ZFC) and field-cooled (FC) cases. The bifurcation temperature is called T_{irr}. Magnetization at H=7T for each sample, shows a distinct feature (kinks like) at lower temperatures. The high-T data exhibit Curie-Weiss like behaviour. Using the Brillouin function we show that the samples are not simple paramagnetic, but superparamagnetic. Based on the analysis of $1/\chi$ versus T in the intermediate temperature range below T_{irr}, the irreversibility effects arise from the long range magnetic ordering between superparamagnetic clusters.

This work was supported in part by TUBITAK Project (111T779) and Marmara University.

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MAGNETİC AND STRUCTURAL PROPERTİES OF THE NEW $YFe_{2-x}Pt_xSb_2$ (x=0, 0.01, 0.05) COMPOUNDS

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We report the magnetic study on the YFe2-xPtxSb2 (x=0, 0.01,and 0.05) compounds, synthized by using solid state sintering. All samples are crystalized with $ThCr_2Si_2$ structure, space group I4/mmm at room temperature . We observe a Hopkinson effect at the blocking temperature T_B for each sample, but this peak is broaden much more for x=0.05. The Blocking temperature, T_B decreases with non-magnetic Pt impurities (T= 100K, 87K, and 47K respectivily for x=0, 0.01, and 0.05), wheares the saturation magnetization values (obtained from M versus H hystersis cycles at 5K) increases with Pt contents. Low-field DC magnetic susceptibility for the sample of x=0, 0.01 above T_B obeys perfectly to modified Curie-Weiss behavior, while the fitting for x=0.05 is rather poor. The Brillouin function analysis shows that all the samples are not simple paramagnetic, but superparamagnetic. To further understand the magnetic behavior of samples at lower temperatures, we also perform magnetization measurements at low-H and low-T. The data analysis lead us to suggest that magnetic ordering inside the superparamagnetic clusters still continues with decreasing temperature even below T_B.

This work was supported in part by TUBITAK Project (111T779) and Marmara University.

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SYNTHESIS AND ANALYSIS OF $(Fe,Co)_{2-3}B$ MICROCRYSTALLINE ALLOYS

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INTRODUCTION

$(Fe,Co)_{2-3}B$ based alloys show a potential as basis for novel hard magnetic applications. A high magnetocrystalline anisotropy of about K_1 = 400 kJ/m³ has been reported for Co_2B [1]. We have studied various compositions with different Co and Fe content. Conventional structural, microstructural and magnetic properties of $(Fe,Co)_{2-3}B$ alloys have been analyzed.

METHODS AND RESULTS

Cast ingots of different compositions have been synthesized by induction melting in inert atmosphere using master alloys of $Co_{85}B_{15}$ and $Fe_{80}B_{20}$. In addition, melt-spun ribbons were prepared from the cast ingots by a pressure difference of He between air chamber and vacuum chamber of 200 mbar and a wheel speed of 26.7 m/s. The exact compositions, which were chosen for the investigations, are: $(Fe_xCo_{1-x})_{71}B_{29}$, x= 0.7-1.0. The hysteresis curve of the samples was measured by PPMS at room temperature. Figure 1a and b show as an example the increased coercive field of the melt-spun flake compared to the cast alloy. The microstructure exhibits an average grain size in the order of 100-200 nm. The influence of the Fe to Co ratio on the coercive field and microstructure will be discussed.

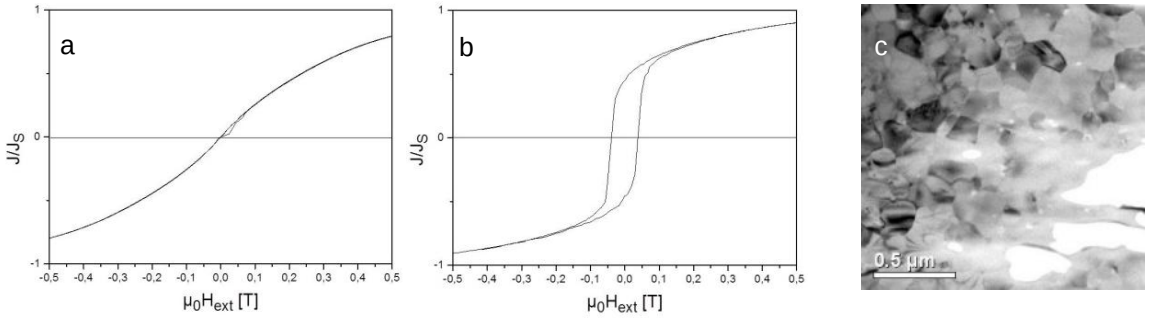

Figure 1: Comparison of measured hysteresis curves of cast (a) and melt spun (b) $(Fe_{0.7}Co_{0.3})_{71}B_{29}$ samples. (c) TEM bright field image of the microcrystalline microstructure of the melt spun ribbon.

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ACKNOWLEDGEMENTS

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MAGNETIC, ELECTRICAL AND STRUCTUAL PROPERTIES OF ANNEALED FERROMAGNETIC $ZnSnAs_2$:Mn THIN FILMS ON InP SUBSTRATES: COMPARISON WITH UNDOPED $ZnSnAs_2$

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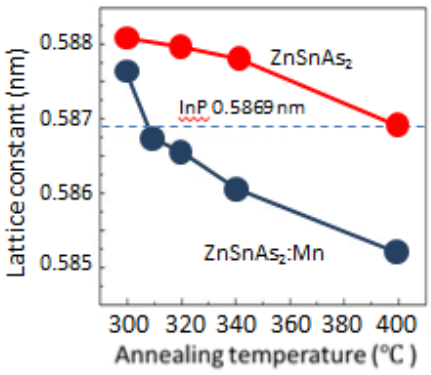
Ferromagnetic semiconductors showing ferromagnetism at room temperature have been of considerable interest since they offer prospects for realizing semiconductor-based spintronics. Recently, magnetically Mn-doped $ZnSnAs_2$ thin films were shown as one of the few ferromagnetic semiconductors compatible with III-V semiconductors. [1].This paper presents the annealing studies of magnetic, electrical and structural properties in Mn-doped and undoped $ZnSnAs_2$ epilayers, which were annealed at slightly higher temperatures than the growth temperature. $ZnSnAs_2$:Mn layers were epitaxially grown on InP (001) substrates at 300°C, and showed the Curie temperatures more than 334 K. The lattice constants of $ZnSnAs_2$:Mn and undoped $ZnSnAs_2$ films are plotted as a function of annealing temperature in Fig.1. The magnetic properties were measured (Fig.2). The Curie temperature had a tendency to slightly increase up to an annealing temperature of 340°C, and completely disappeared at 400°C. The ferromagnetism could be attributed to hole-mediated ferromagnetism resulting from the Mn ion substitutions on both the II-group Zn and IV-group Sn sites, especially from the large solubility of Mn^{2+} substitution on Zn sites. The disappearance of ferromagnetism may be explained by several types of mechanisms; migration of mobile interstitial Mn atoms, diffusion of substitutional Mn ions to the surface, substitution of interstitial Mn atoms on Zn vacancies, and formation of MnAs clusters. It is expected that this material plays a significant role in demonstrating a spin-polarized FET on InP substrates.



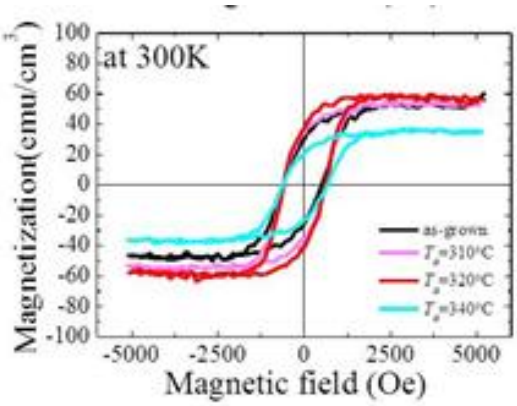


Figure1 (left figure): Lattice constants of $ZnSnAs_2$:Mn and undoped $ZnSnAs_2$ films

Figure2 (right figure): Magnetic properties of Mn-doped $ZnSnAs_2$ films

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ORDERED PHASE FORMATION IN Sm-Ni THIN FILM DEPOSITED ON Cr(100) UNDERLAYER

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$SmCo_5$ alloy with $D2_d$ ordered structure is a high K_u material and the film has been investigated for applications like recording media, MEMS, etc. The Co site in $SmCo_5$ structure can be replaced with other transition metal elements. In the last JEMS [1], we reported that $SmFe_5$ film can be formed through hetero-epitaxial growth on single-crystal substrate. In the present study, $Sm_{17}Ni_{83}$ (at.%) films are deposited on Cr(100) underlayers by UHV-MBE system. The effect of substrate temperature on the ordered phase formation is investigated. The crystallographic property during film formation is investigated by RHEED [Figs.1(a)–(c)]. The films deposited below 200°C consist of amorphous phase. With increasing the temperature to 400°C, formation of $SmNi_5$ ordered phase is promoted. An epitaxial $SmNi_5$ ordered film with high crystallographic quality is formed at 500°C. Fig.1(e) shows the out-of-plane and in-plane XRD spectra of film deposited at 500°C. In-plane $SmNi_5(0001)$ superlattice reflection is recognized in addition to out-of-plane $SmNi_5(11\bar{2}0)$ reflection. The magnetic properties of $SmNi_5$ film will be presented at the conference.

[1] T. Yanagawa *et al*.: EPJ Web Conf. 40, 06007 (2013).

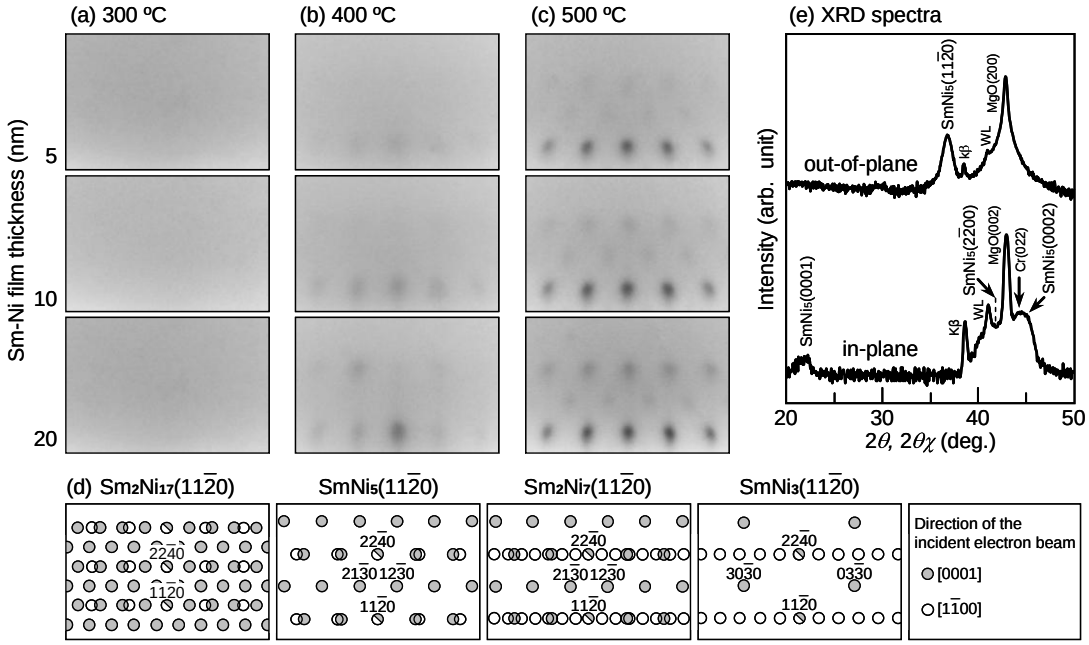

Fig.1 (a)–(c) RHEED patterns. (d) Schematic diagrams of RHEED patterns. (e) XRD spectra.

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MAGNETOSTRICTION OF FCC(110) SINGLE-CRYSTAL FILMS OF Ni-Fe, Ni, AND Co UNDER ROTATING MAGNETIC FIELDS

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Soft magnetic materials are often exposed to alternating magnetic fields. It is thus important to investigate the magnetostriction under rotating magnetic fields. In the study of fcc(100) films, it has been shown that magnetostriction behavior is strongly related with the in-plane film magnetic anisotropy [1]. In the present study, magnetostriction is investigated for fcc(110) films of $Ni_{80}Fe_{20}$, Ni, and Co. Magnetization tends to saturate at a higher magnetic field when applied along [1-10] (Fig.1(a)). A magnetostriction waveform consisting of sinusoidal and triangular shapes is observed under a rotating field of 40 Oe (Fig.1(b)). The waveform is similar to that observed for an oriented silicon steel plate [2]. The Ni-Fe(110) film is not magnetically saturated when the field is applied along [1-10], where domain walls are observed in the Bitter images. Such magnetostriction behavior seems to be explained by a domain wall motion model under a rotating magnetic field. With increasing the field, the waveform becomes sinusoidal due to saturation of magnetostriction as shown in Fig.1(b). The results for Ni and Co films will be presented at the conference.

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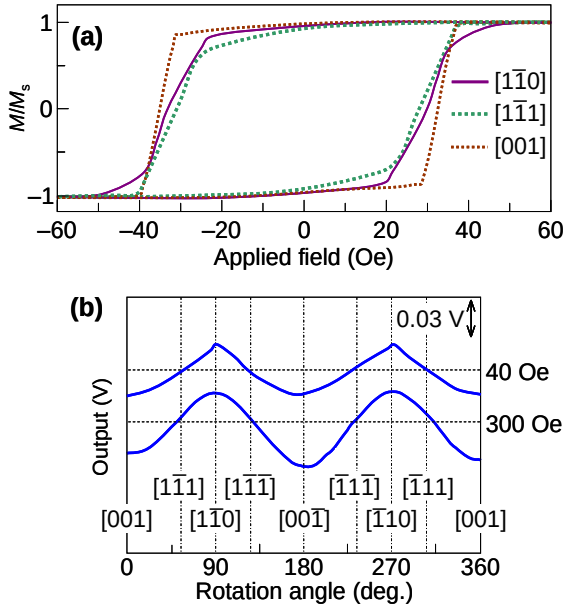

Fig.1 (a) Magnetization curves and (b) output waveforms of magnetostriction measured for Ni-Fe(110) film.

FORMATION of $Sm(Co_{1-x}Ni_x)_5$ EPITAXIAL THIN FILMS ON Cu(111) UNDERLAYERS

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RT_5 (*R*: rare earth metal, *T*: transition metal) alloys with K_u greater than 10^7 erg/cm^3 have attracted much attention to applications like ultra-high density recording media, MEMS, etc. In the last JEMS, we reported the structure and magnetic properties of $SmFe_5$-alloy films epitaxially grown on Cu(111) underlayers. In the present study, $Sm_{17}(Co_{1-x}Ni_x)_{83}$ (at. %) (x = 0, 0.2, 0.4, 1) were deposited on Cu(111) underlayers by UHV-MBE. The effect of substrate temperature on the ordered phase formation is investigated. Fig.1 shows the RHEED patterns observed during Sm-Co and Sm-Ni film formation at different temperatures and the XRD spectra measured after film deposition. $SmCo_5$ and $SmNi_5$ ordered alloy epitaxial films are formed at 500°C. When the temperature decreases down to 400°C, Sm-Co film includes amorphous phase in addition to ordered crystal, whereas Sm-Ni film consists of ordered crystal with high crystallographic quality. Ordered phase formation is apparently influenced by the *T* element. The effect of Co/Ni composition on the structure and magnetic properties will be presented at the conference.

[1] T. Yanagawa *et al*.: *EPJ Web Conf.* 40, 06007 (2013).

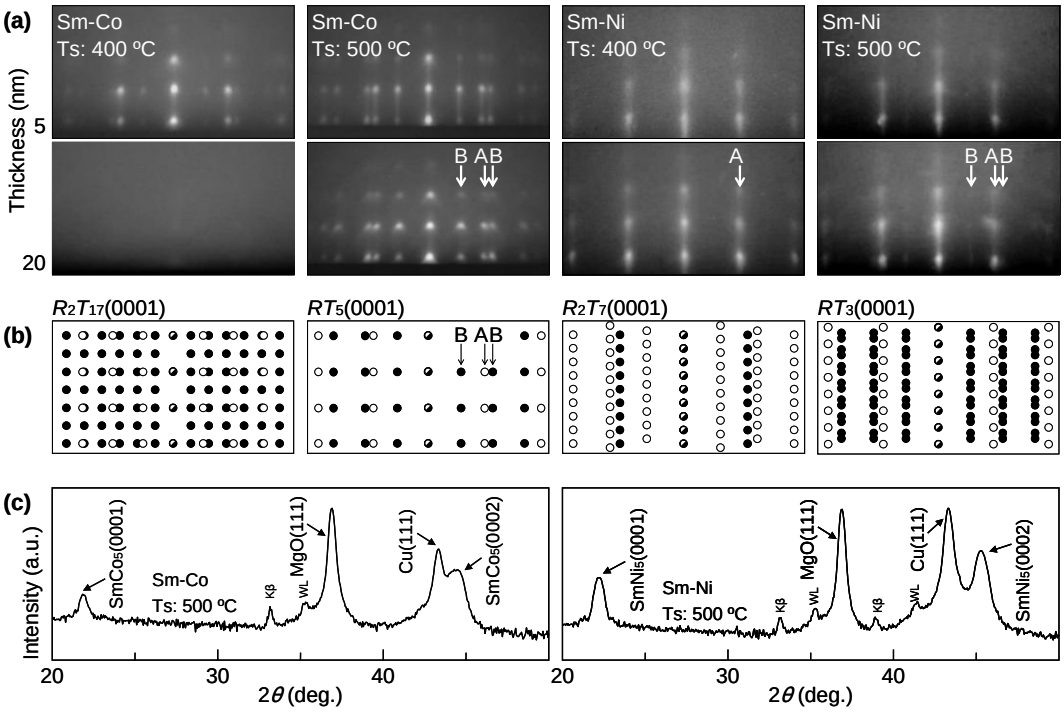

Fig.1 (a) RHEED patterns. (b) Schematic diagrams of RHEED patterns. (c) XRD spectra.

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EXPLORING MAGNETIC ANISOTROPY AND PERMANENT MAGNET POTENTIAL IN $(Fe,Mn)_{1.95}(P,Ge)$

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Although Fe_2P has been widely studied for its strong magnetic anisotropy, this property has always been underappreciated due to its low Curie Temperature (T_C), which keeps it from serious consideration for permanent magnet applications.

We thus report novel high temperature magnetic anisotropy properties observed in Mn and Ge poor samples belonging to the $(Mn,Fe)_{1.95}(P,Ge)$ system, detected in both magnetic and x-ray diffraction measurements. Such an observation, among many possibilities, may point towards new and concrete fields of permanent magnet research in Fe_2P-type systems [1].

Still, further research is demanded, as our results reveal a T_C of about 430 K, a substantial increase relatively to Fe_2P but not yet an ideal value. Besides this, and a lack of coercivity, we are also limited by the use of Ge, an element whose scarcity makes it unfit for wide scale applications [2].

On all accounts this seems to be the first time such a behavior was observed in an Fe_2P-type system at high temperature, and it may now open new avenues for novel magnetic research and applications.

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CHARACTERISATION OF MAGNETOSTRICTIVE AMORPHOUS RIBBON USING MAGNETO-ELASTIC RESONANCE

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Magnetoelastic sensors based on amorphous ferromagnetic ribbons, wires or thin films have been receiving an increasing interest within the sensor's community due to the wide range of parameters they can measure. Ribbon shape resonators have been early developed in 60's and then characterized for 20 years, with special attention to the magneto-mechanical coupling coefficient k_{33}. However, the estimation of k_{33} is difficult and remains a lock for technological applications of magnetostrictive materials. Since different methods were developed to measure the magnetostriction, none are well adapted to amorphous ribbons due to their mechanical behavior.

In order to make a sensor, we have studied magneto-elastic resonator and then developed an analytical model [1]. It establishes the complete transfer function between the input and output voltages and finally allows to estimate k_{33} from the experimental frequency response. Derived from the model we developed a new technique [2] to establish and estimate the characteristics of a magnetostrictive resonator from the experimental frequency response free from any kind of mechanical measurement. This technique is suitable to estimate the magneto-mechanical coupling coefficient k_{33} and the Young's modulus and also to establish the magnetostriction curves λ(H) of amorphous ribbons.

Results obtained from resonators made of 2605SC and 2826 from Metglas™ ribbon confirmed the validity of the present technique. The present technique has serious advantages upon others as it is non-destructive, low cost and easy to develop compared to common ones. In addition, it has been shown that the estimation of k_{33} cannot directly results from the ratio of resonance and anti-resonance frequencies, contrarily to usual formula: indeed, this ratio does not depend only on k_{33} but also on the damping parameter η included in our model.

Oral
Conference topics: Soft Magnetic materials and applications

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COMPUTERIZED B-H LOOP TRACER FOR SOFT MAGNETIC THICK FILMS IN THE AUDIO-FREQUENCY RANGE

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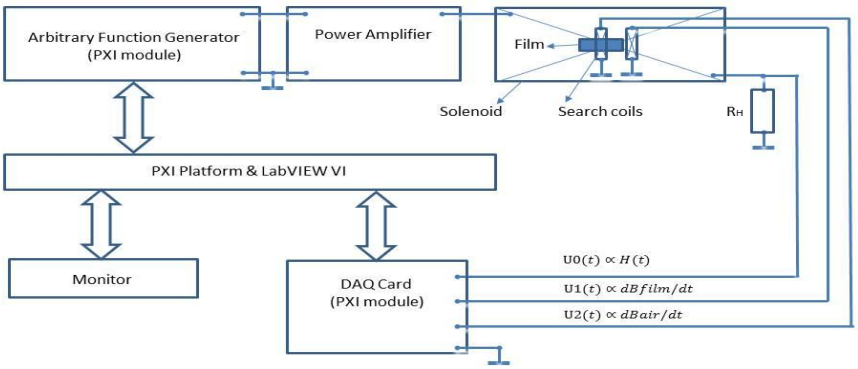
There is an interest for the development of high performance nanostructured resistive laminated soft metallic magnetic materials as core inductors for high efficiency DC-DC converters [1], [2]. The very small volume of the samples requires special techniques for their characterization. Systems such as Vibrating Sample Magnetometers (VSM), SQUID magnetometers or magneto-optic Kerr effect (MOKE) are inappropriate or insufficient for the low field measurements of soft magnetic materials and more sensitive methods have to be used [3], [4].

This paper describes a computerized B-H loop tracer for the measurements of thick films with thickness down to a few micrometers in the audio frequency range. The computerized system consists of a PXI platform where an arbitrary function generator card and a DAQ card are housed. The generated signal is amplified in a power amplifier and fed to the magnetizing solenoid. The film is placed inside the solenoid and a pair of pick-up coils is used for flux density, B sensing and air flux compensation. The magnetic field strength, H, proportional to the primary current, I, is measured using a shunt resistor. The necessary signal processing is implemented in LabVIEW software.

The main challenges which appeared in the building of the system were: (a) air flux compensation, (b) noise reduction and (c) low cost maximization of the magnetizing field. The solutions chosen to bypass these problems are described analytically in the main text of the paper.



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METAL INJECTION MOULDING (MIM) OF NDFEB MAGNETS

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3. private, contact via T. Hartwig

Due to the increased and unstable prices for Rare Earth elements there are activities to develop alternative hard magnetic materials. Reducing the amount of material necessary to produce complex sintered NdFeB magnets can also help to reduce some of the supply problem. Metal Injection Molding (MIM) is able to produce near net shape parts and can reduce the amount of finishing to achieve final geometry.

Although MIM of NdFeB has been patented and published fairly soon after the development of the NdFeB magnets there has never been an industrial production. This could be due to the fact that MIM was very young at that time and hardly developed. Thus, the feasibility of the process needs to be revaluated. This paper presents results of our work on determining the process parameters influencing the magnetic properties of the sintered magnets as well as the shrinkage during processing. The role of binder and powder loading on the alignment of the particles as well as on the carbon and oxygen contamination was examined.

PREPARATION AND PROPERTIES OF ULTRAFINE SINGLE CRYSTALLINE AND TEXTURED POLYCRYSTALLINE ND2FE14B PARTICLES

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Single crystalline or textured polycrystalline magnetically hard particles combined with nano sized magnetically soft particles are critical for the bottom-up fabrication of future exchange coupled magnets with high energy density [1],[2]. In the present study, we discuss the preparation and properties of single crystalline particles and textured polycrystalline flakes obtained after surfactant assisted ball milling of HDDR processed Nd-Fe-B powder. Isolated single grain particles (200-500 nm) were obtained after 4 hours of milling at 400 rpm in oleic acid and heptane. Further milling of the single crystalline particles at 800 rpm in the same media produced polycrystalline flakes of size 0.2 to 1.0 µm. Electron diffraction patterns obtained from TEM confirm the single crystalline nature particle and in-plane texture of flakes obtained after 4 and 14 hours of milling respectively. Magnetically oriented single grain particles show a degree-of-texture of 88% and remanence of 148.1 emu/g (in // direction) which is much higher than the degree-of-texture (56%) and remanence (119.5 emu/g) obtained for un-milled HDDR Nd-Fe-B powder.

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STUDY OF THE MAGNETIC PROPERTIES OF THE TERNARY COMPOUNDS $MN_{3-X}FE_XSN$ AND $MN_{2-X}FE_XSN$, $0 \leq X \leq 1.25$.

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Nowadays there is a need to develop more efficient appliances as refrigerators, due to the importance of energy economy to our society. Magnetic refrigerators can achieve higher efficiencies than conventional ones. Also important is the development of efficient devices to use renewable energies as solar and geothermal, which are, generally, low quality thermal sources, although abundant and cheap. In this context, thermomagnetic motors are important because calculations show they can achieve higher efficiencies than conventional devices.

Magnetic refrigerators and thermomagnetic motors require materials presenting high saturation magnetization, Curie temperatures tunable by composition and formed of inexpensive materials. This motivated us to study the magnetic properties of the compounds $Mn_{3-x}Fe_xSn$ and $Mn_{2-x}Fe_xSn$, $0 \leq x \leq 1.25$. It is expected that the solubility of Fe in these compounds is limited, once the accepted Fe-Sn diagram does not show compounds of these stoichiometries. We prepared samples by arc melting and heat treament at 800C or 900C during 10 days. The samples where analysed using metallography (optical and electronic), X-rays diffraction and magnetic measurements. The results confirm that up to $x = 1.25$ both phases form Fe solid solutions. For the 3:1 phase it is observed a marked increase of the saturation magnetization and of the Curie temperature for $x > 0.5$. The same is observed for the 2:1 compound for $x > 0.75$. Curie temperatures increase above room temperature for both compounds as x increases, and this compositional tunning make both materials promising for applications in magnetic refrigerators and thermomagnetic motors.

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TEMPERATURE DEPENDENCE OF FERROMAGNETIC RESONANCE IN SINGLE AND BIPHASE MAGNETIC MICROWIRES

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Single and biphase magnetic microwires attract increasing interest for their applications in sensors and microwave absorbers. Previous works were reported on their magnetic characteristics[1], particularly on room-temperature ferromagnetic resonance[2].

Single-phase amorphous microwires, 1-10μm diameter, were fabricated by quenching-drawing technique, exhibiting high-positive (FeSiB-alloys) and vanishing-negative (CoFeSiB-alloys) magnetostriction. A second FeNi-polycrystalline layer, 2-10μm thick, was electroplated onto their surface. Static (VSM) and Dynamic (FMR) studies were performed in the temperature range 5-300K. FMR studies were taken by cavity-perturbation technique (DC-field dependence of microwave-absorption) at 9.5GHz-frequency, complemented by network analyzer at 1-20GHz frequency up to 2kOe DC-field.

Totally different temperature dependence of resonance field, Hr, and resonance line-width was observed for single-phase FeSiB and CoFeSiB wires which is connected with the corresponding magnetoelastic anisotropy evolution. In FeSiB, two Hr observed peaks decrease with increasing temperature in the range 5-150K, remaining nearly constant at higher temperatures. For CoFeSiB wires, single Hr peak increases with temperature for all temperatures. CoFeSiB/FeNi-biphase microwires show complex structure, and particularly significant low-temperature zero-field absorption, quite promising for the creation of low-temperature microwave-absorbing composites with enhanced efficiency.

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BENEFICIAL OF HIGH TEMPERATURE TREATMENT ON $La_{0.7}Pr_{0.3}Fe_{11.4}Si_{1.6}$ COMPOUND

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INTRODUCTION

The structure and magnetic properties of the $La_{0.7}Pr_{0.3}Fe_{11.4}Si_{1.6}$ compounds have been investigated using different heat treatment. It was found that a short, high temperature annealing (HTA) process~1523 K / 4 hours has benefits for the formation of $NaZn_{13}$ phase compared with a long, low temperature (LTA) annealing process~1323 K / 14 days. Effect of different treatment was been determined by x-ray diffraction, dc magnetization and scanning electron microscopy. The Rietveld refinement results can be clearly seen that the weight fraction of the $NaZn_{13}$ phase increases from 69 % for LTA to 96 %, while the weight fractions of LaFeSi and α-Fe phase for HTA are reduced as shown in Figure 1. Indicated to obtain single $NaZn_{13}$–type phase by a peritectic reaction is quite difficult using conventional melting (LTA) [1].

Curie temperature (T_C) of $La_{0.7}Pr_{0.3}Fe_{11.4}Si_{1.6}$ produced by the LTA method is 10 K higher than by HTA and has different magnetic phase transition characteristics because of the different Si concentration in the $NaZn_{13}$ phase, which is LTA method form higher Si composition and contribute to increase T_C and change the nature of transition from first to second order characteristic [2]. The magnetic entropy change $-\Delta S_M$ and relative cooling power (RCP) show enhancement from 7 J kg^{-1} K^{-1} and 105 J kg^{-1} for LTA to 16.5 J kg^{-1} K^{-1} and 390 J kg^{-1} for HTA respectively. HTA method for $La_{0.7}Pr_{0.3}Fe_{11.4}Si_{1.6}$ with small hysteresis loss shows the advantage in promising material candidate to magnet refrigerator application and comparable with other system [3].

FIGURES

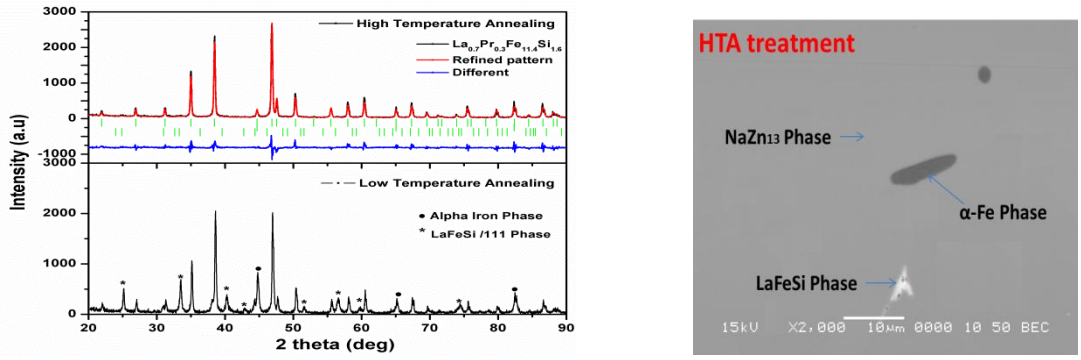

Figure 1. (Left) Comparison of room temperature XRD patterns and (Right) SEM image for $La_{0.7}Pr_{0.3}Fe_{11.4}Si_{1.6}$ using HTA treatment method

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$Gd_5(Si_xGe_{1-x})_4$ SYSTEM – AN UPDATED PHASE DIAGRAM

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Magnetocaloric $Gd_5(Si_xGe_{1-x})_4$ has a complex magnetic-structural phase diagram which can be divided into three distinct regions. In the silicon rich region ($0.575 \le x \le 1.0$) there is a second order magnetic phase transition with no associated structural transition. In the germanium rich region ($0 \le x \le 0.3$) there is a first order magnetic-structural transition from Gd_5Si_4-type orthorhombic ferromagnetic phase to Sm_5Ge_4-type orthorhombic antiferromagnetic phase [1]. In the most interesting middle region ($0.4 \le x \le 0.503$), there is a first order magnetic-structural phase transition exhibiting the highest magnetocaloric effect [1]. Recently, in this middle region, the "non-existent" second order magnetic phase transition temperature of orthorhombic phase was estimated using the Arrott Plot technique [2].

This work investigates the magnetic-structural phase diagram in the middle region. The paramagnetic response of magnetic moment vs. magnetic field isotherms was used to estimate the "non-existent" second order magnetic phase transition temperature of monoclinic phase using the Curie-Weiss law.

The obtained temperature data points (SOPTT of Monoclinic in Fig. 1) form a line that is parallel to the first order magnetic-structural phase transition line indicating relationship between the two effects.

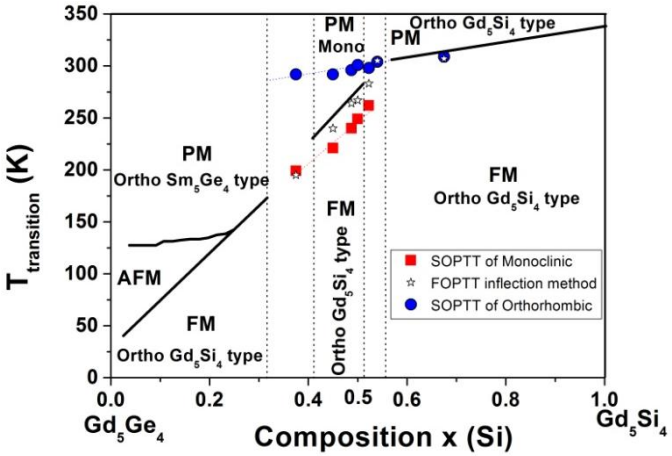

Figure 1. Magnetic-structural phase diagram of the $Gd_5(Si_xGe_{1-x})_4$ system.

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INTEGRATION OF Ni-Cu-Zn AND HEXAGONAL FERRITES INTO LTCC MODULES; COFIRING AND MAGNETIC PROPERTIES

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Soft ferrites with adequate permeability profiles are required for the fabrication of multilayer ferrite inductors (MLFI) either as monolithic passive components or integrated inductors in complex LTCC (Low Temperature Ceramic Cofiring) modules. Cofiring of the ferrites, low-k dielectric and silver coil windings is performed at about T = 900°C. Chemical compatibility and matching of the shrinkage and thermal expansion behaviors are important requirements for co-firing of integrated inductors.

We have studied the cofiring behavior and the magnetic properties of Ni-Cu-Zn spinel ferrites as well as hexagonal Co/Ti-substituted M-type $BaFe_{12-2y}Co_yTi_yO_{19}$ ferrites. Application of sintering additives is required for sufficient shrinkage and densification at 900°C. Ni-Cu-Zn ferrites are used for multilayer inductors for operating at kHz frequencies. Optimized compositions allow higher operating temperatures and applications in power modules. Cofiring of the ferrite- and LTCC tapes and silver was tested at reduced oxygen partial pressure in order to reduce silver migration, but the limited stability of the ferrites limits the p_{O2} of cofiring to 10^{-3} atm.

Substituted hexagonal M-type ferrites might operate under high-frequency conditions up to 2 GHz. For M-type $BaFe_{12-2y}Co_yTi_yO_{19}$ ferrites with y=1.2 planar magneto-crystalline anisotropy and soft magnetic behavior is observed. They exhibit a permeability of μ = 20 and a resonance frequency of 1 GHz. Moreover, substituted M-type ferrites are stable under cofiring conditions at 900°C. The fabrication of multilayer inductors and the integration into LTCC modules using free and constrained sintering strategies is demonstrated.

ENERGY TRANSFER LAWS OF CURRENT TRANSFORMING HARVESTER

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INTRODUCTION

Power source for devices on high voltage electrical power line is always the hot R & D topic. Among various exist approaches, the current transforming harvester (CTH), which captures energy via magnetic flux from the conductor, is the mostly widely used, reliable, and cost-effective one. This paper focuses on the analysis of CTH's energy transfer laws in order to optimize its structure and parameters. Firstly, based on the basic electromagnetic relation of iron core coil circuit, ignore its iron loss, leakage flux and winding resistance, establish the simplified equivalent circuit model for CTH (as show in Fig.2) , where the secondary side load is assumed to be one fixed impedance. Let the load impedance angle be φ , get the equivalent phasor diagram for all currents (as show in Fig.3). Then, through approximating iron core's magnetic hysteresis loop as piecewise straight line, calculate out the CTH's maximum power transferred ability under iron core saturated or unsaturated cases (as show in Equ.1). Finally, detailed discuss the practical optimization method for electromagnetic parameters, core structure, coil turns and the auxilary energy converting circuit according to Equ.1. The simulation and experiment results verify the above analysis.

FIGURES AND TABLES

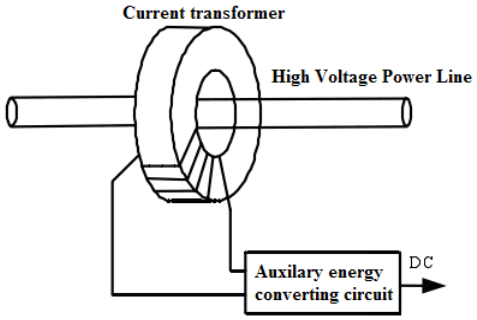

Fig. 1 Power line energy harvester

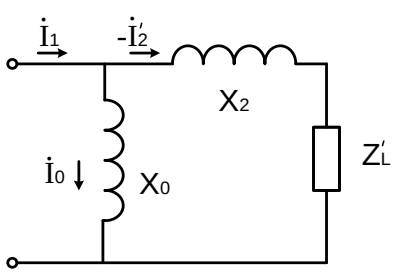

Fig. 2 Simplified equivalent circuit model

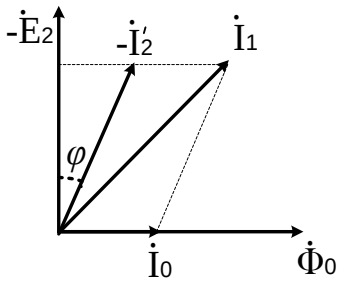

Fig. 3 Equivalent phasor diagram

EQUATIONS

$$P_2 \le \begin{cases} \dfrac{3.14\, fS\mu I_1^2 \cos\varphi}{l(1+\sin\varphi)} & \text{if core is unsaturated} \\ \dfrac{2(\arcsin k + k\cdot\sqrt{1-k^2})}{\pi k^2} P_{2unsat\_\max} & \text{if core is saturated} \end{cases} \quad [1]$$

RESEARCH ON FAULT DIAGNOSIS METHODS OF THE CABLE JOINT

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INTRODUCTION

This paper aims at proposing a method to diagnose the cable joint fault.Figure1 illustrates the transient thermal circuit model of cable joint, which can be simplified to a first-order transient thermal circuit model shown in figure 2 and a first order linear equations [1], [2] through a series of transformation.Meanwhile, in the equations, $x=\Delta T(t_1)$, $y=\Delta T(t_2)$ are the transient temperature rising at the t_1, t_2 respectively which result from testing cable skin or metal sheath temperature (monitoring point temperature) in real-time.According to formula [2], the parameter A and B can be identified by applying the least squares identification to the time series of *x*, *y* and *I*.Then the time constant (τ) and steady-state temperature coefficient (*k*)in formula [3], [4] are identified correspondingly.Consequently, we are able to find the different cable joint faults in terms of the changes of τ and *k*.And results in Table 1 indicates that it is a correct proposition to diagnose the four different types of fault.

FIGURES AND TABLES

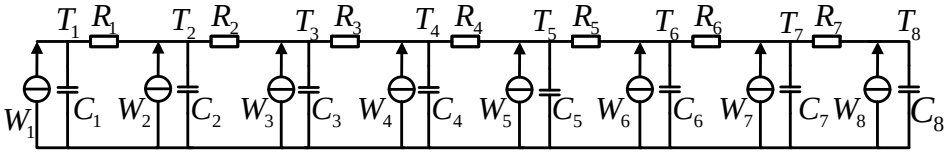

Figure.1 Cable joint transient thermal circuit model

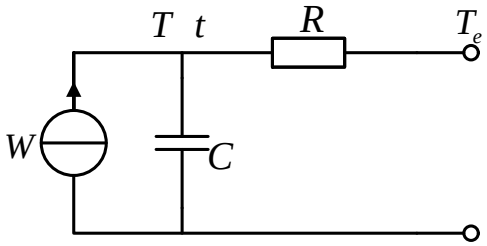

Figure.2The first-order transient thermal circuit model

	τ(min)	$k(10^{-7})$
Normal operation	330	270
Contact resistance increases 1.2 times	330	320
Thermal resistance increases 1.5 times	462	405
Thermal capacity decreases 0.75 times	257	220
Partial discharge	Wave from 400-600	Wave from 220-270

Table.1The parameter identification results in four different types of fault

EQUATIONS

$$\Delta T\ \ t_2\ = \Delta T(t_1)\mathrm{e}^{-\Delta t_m/RC} + WR(1-\mathrm{e}^{-\Delta t_m/RC}) \quad [1]$$

$$y = \mathrm{A}\cdot x + B\cdot I^2 \quad [2]$$

$$\tau = RC = -\Delta t_{\mathrm{m}}/\ln\mathrm{A} \quad [3]$$

$$k = WR/I^2 = \mathrm{B}/(1-\mathrm{A}) \quad [4]$$

Where, $\mathrm{A} = \mathrm{e}^{-\Delta t_m/RC}$, $B = WR(1-\mathrm{e}^{-\Delta t_m/RC})/\mathrm{I}^2$, *I* is the current of cable.

RESEARCH ON TEMPERATURE RETRIEVAL OF THE CABLE JOINT

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INTRODUCTION

Since it is impractical to directly detect the temperature of conductor in real time nowadays, this paper aims at proposing a retrieval algorithm of the temperature of cable joint core, which results from testing cable skin or metal sheath(monitoring point temperature). Figure.1 illustrates the transient thermal circuit model of cable joint, which can be simplified to an arithmetic circuit of the second-order transient thermal circuit shown in figure 2 through a series of transformations, such as ignoring the dielectric loss , sheath loss,etc. Formula [1] shows the complete response of transient time domain process of monitoring point. To analyze the steady-state and transient process of cable joint temperature field, we can get the temperature retrieval calculation formula [2] and temperature retrieval coefficient formula [3] by derivation and calculation .Then the temperature of cable joint conductor can be obtained accurately by using formula [2] to retrieve the monitoring point temperature. The retrieval results are shown in figure 3 which is satisfactory.

FIGURES AND TABLES

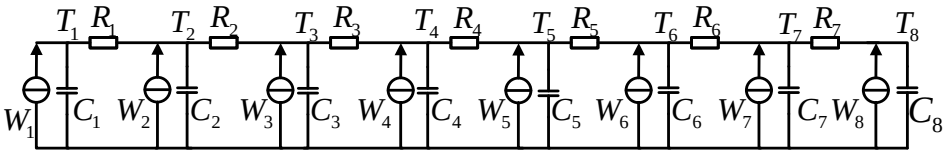

Figure.1 Transient thermal circuit model of cable joint

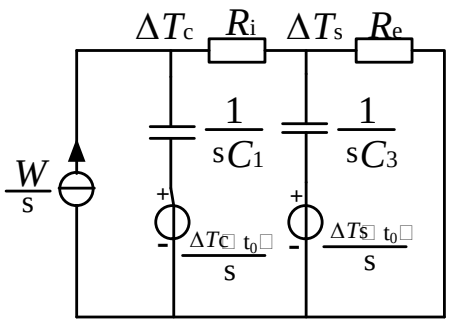

Figure.2 Arithmetic circuit of the second-order transient thermal circuit

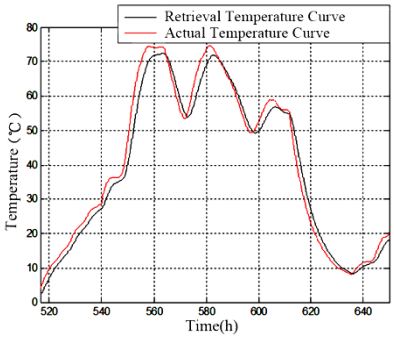

Figure.3 The result of the temperature rise retrieval of conductor in real-time

EQUATIONS

$$\Delta T_S = \Delta T_S^{'} + \Delta T_S^{''} = WR_e + \frac{\Delta T_S(t_0)\ \mathrm{p}_1C_1C_3R_eR_i\text{-}C_3R_e\ -\Delta T_C(t_0)C_1R_e + p_2W_1R_e}{p_1\text{-}p_2}\mathrm{e}^{-p_1\Delta t} + \frac{\Delta T_S(t_0)\ C_3R_e\text{-}\mathrm{p}_2C_1C_3R_eR_i\ + \Delta T_C(t_0)C_1R_e\text{-}\mathrm{p}_1W_1R_e}{p_1\text{-}p_2}\mathrm{e}^{-p_2\Delta t} \quad [1]$$

$$\Delta T_C \approx W(R_e + R_i)(1\text{-}\mathrm{e}^{-\Delta t/\tau_1}) = (1+\beta)\ \Delta T_S \quad [2]$$

$$\beta = R_i / R_e \quad [3]$$

Where, ΔT_C and ΔT_S are the temperature rise of cable joint conductor and monitoring point , respectively. For lack of space, we cannot explain all symbols.

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MAGNETOCALORIC EFFECT IN MN5GE3, MN4FEGE3 AND MN-CO-GE COMPOUNDS

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INTRODUCTION

The technology of near room-temperature magnetic cooling is based on the magnetocaloric effect of materials, which have a magnetic or magneto-structural transition close to room temperature. Due to the fact that the maximum magnetocaloric effect is located near the critical temperatures of magnetic transitions, materials with the Curie temperature T_C near room temperature show a potential for room-temperature refrigeration applications. T_C of Mn_5Ge_3 Mn_4FeGe_3 and $MnCo_{0.95}Ge_x$ (x = 0.95, 0.97, 1.0) [1] compounds lie in the suitable temperature range of 280-325 K. We present a study of $\Delta T_{ad}(T)$ and $\Delta T_{ad}(H)$ of these alloys by a direct method and compare our results with the magnetic entropy change data. We paid special attention to the field dependence of the magnetic entropy and adiabatic temperature change.

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STUDIES ON MAGNETOCALORIC EFFECT IN THE $LaFe_{12.2-x}Si_xCo_{0.8}$ ALLOYS PREPARED BY ARC MELTING

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The series of $LaFe_{12.2-x}Si_xCo_{0.8}$ alloys, with x equaled to 1.0, 1.2, 1.4 and 1.6 were prepared by arc melting technique and subsequent homogenization process. Magnetization results show that the temperature values of ferromagnetic to paramagnetic phase transition occurs near the room temperature for all studied alloys. The magnetic entropy change, as well as adiabatic temperature change was measured in order to determine how the magnetocaloric effect depends on the silicon amount in the cobalt doped LaFeSi alloys. Adiabatic temperature change has been measured by means of magneto-calorimeter in the field change 0-1.7 T, while magnetic entropy in the fields up to 7 T. The highest magnetocaloric effect was observed for x=1.2, which is consistent with the pure $LaFe_{13-x}Si_x$ alloys.

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STRESSES EVOLUTION AT HIGH TEMPERATURE (200°C) ON THE INTERFACE OF THIN FILMS IN MAGNETIC COMPONENTS

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INTRODUCTION:

In the field of electronics, the increase of operating temperatures is a major industrial and scientific challenge because it allows reducing mass and volume of components especially in the aeronautic domain. So minimizing our components reduces masses and the use of cooling systems. For that, the behaviors of the components (in particular magnetic inductors and transformers) that are constituted of one magnetic layer (YIG) representing the substrate and a thin copper film, are studied at high temperature (200°C).

Stresses of these components are studied by using Stoney formula [1] for different conditions (Figure 1). According to these results, measured stresses are lower than 0.2 GPa after copper deposition and when components are annealed at 200°C.These results have been justified by simulation (Figure 2) where Von Mises Stress (VMS) are lower than the Ultimate Tensile Strength (UTS) which correspond to the limit of the adhesion.

In the final paper, authors will present stresses results according to the geometrical copper parameters necessary for the component fabrication.

FIGURES:

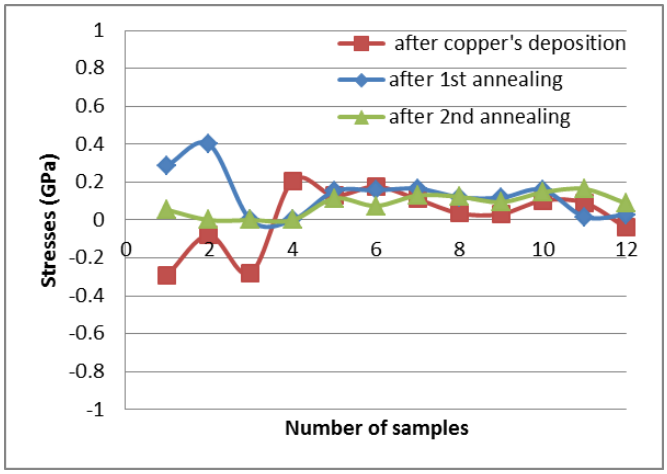

Figure 2: Stresses at the interface copper-substrate for different samples

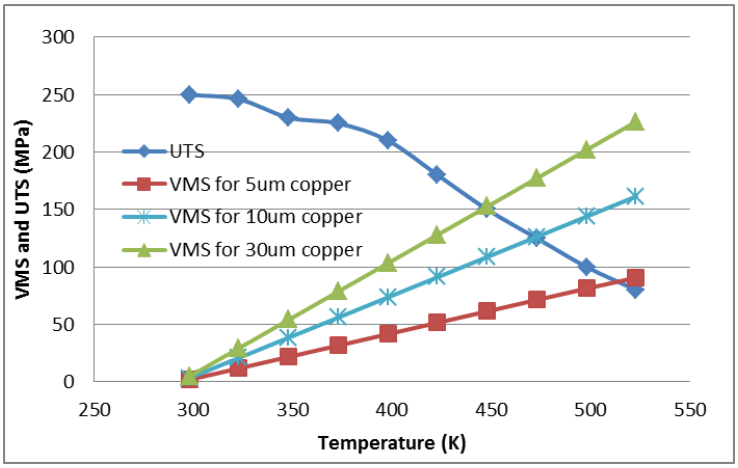

Figure 1: VMS and UTS in function of temperature

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FORMATION PROCESS OF IRON OXIDE NANOPARTICLES OBTAINED VIA SOLVOTHERMAL SYNTHESIS

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Magnetic nanoparticles have a broad field of applications including biomedicine, magnetocaloric refrigeration, magnetic sealing and magnetic storage. For all applications it is of crucial importance that their physical and chemical characteristics, especially their size and morphology, are well defined and controllable.

The solvothermal method allows synthesizing particles with the desired properties. Particles with tunable size and high crystallinity can be obtained employing mild conditions, using environmentally friendly high-boiling solvents.

We monitored the solvothermal synthesis of iron oxide nanoparticles to gain information about the formation process of the particles as well as their physical and chemical properties [1]. Samples were extracted during the heating-up phase and the subsequent reaction. The samples were analyzed via UV-VIS, SAXS, ATR-FT-IR, XPS, RAMAN, XRD, TEM and 57Fe-Mössbauer absorption spectroscopy.

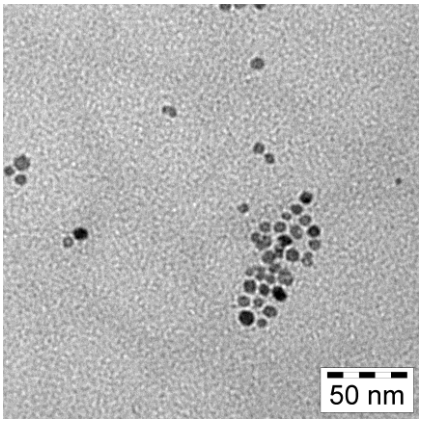

Figure 1 Particles after 2h of synthesis.

We were able to trace the onset of particle nucleation already during the heating-up process. Prolonged reaction time yielded a systematic increase of the particle size. After 2h, the crystallinity and saturation magnetization reached a maximum, followed by a leveling off. The particles obtained after 2h can be seen in Fig 1.

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HIGH-ENERGY ALLOYING AND CHARACTERIZATION OF Ni-Fe

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Conventionally prepared nickel-based alloys are used as soft magnetic materials, exhibiting high permeability and saturation magnetization along with low coercivity. The tendencies to decrease grain size and to obtain unusual physical properties of nanocrystalline metallic materials attract much interest in the last decades. A possibility to prepare Ni-Fe alloys is offered, among others, by a high-energy ball milling of elemental powders. The repeated fracturing and cold welding result in formation of an alloy with crystallites in nanoscale size.

The present work deals with ball milling of Fe and Ni powders of particle size bellow 10 μm in Ar. The milling process is stepwise interrupted and a small amount of powder is analyzed. The changes in the composition, grain size, morphology and magnetic properties are followed up to 6000 min of milling.

Due to the softness of powders in the early stage, the plate-like particles are formed consisting of various combinations of the starting constituents. A formation of bcc-Fe(Ni) phase begins after 120 min, the Ni_3Fe phase is observed after 1500 min, but the pure Ni particles diminish only after 1800 min, well documented by thermomagnetic curve and X-ray diffraction. The final powder shown in figure consists of the crystallites ~10 nm in size agglomerated in large Ni_3Fe particles.

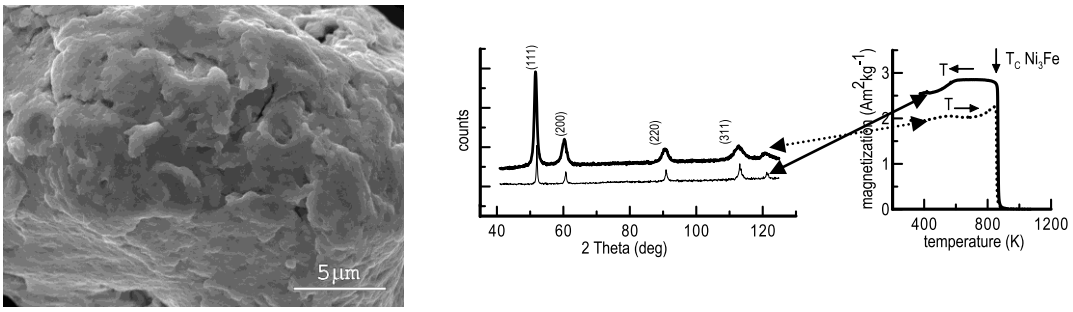

Fig. Morphology, composition and the thermomagnetic curve of the 6000 min milled powder.

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MAGNETIC NANOPARTICLES UNDER ASYMMETRIC STOCHASTIC RESONANCE CONDITIONS

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Stochastic resonance phenomenon has been well investigated in various areas, including magnetic nanoparticles systems. In some previous papers the effect was considered as application to superparamagnetic particles, with noise intensity measure being temperature of the sample and external periodic signal being weak radiofrequency field [1,2]. The influence of additional permanent magnetic field, applied at different angles to the “easy axis”, to dynamic magnetic susceptibility was also thoroughly explored before [3,4] in the framework of the two-state model.

Here we present our calculations for output signal-to-noise ratio (SNR) of the system of fine ferromagnetic (iron) nanoparticles with auxiliary permanent magnetic field applied at arbitrary angle. Along with dynamic magnetic susceptibility, SNR is the most important characteristic of stochastic resonance. As usually we consider thermal switches of the particle magnetic moment as internal noise of the system, and output signal is assumed to be regular part of the magnetic moment motion at frequency of external weak radiosignal. We obtained analytical expressions for the SNR as a dependence on some parameters of the system, including temperature.

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STUDY OF MAGNETIC NANOCOMPOSITES BY NMR AND BULK MAGNETIZATION TECHNIQUES

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Magnetic nanocomposites possess the complex and nonuniform magnetic structure. Therefore it is necessary to use different physical methods to describe their properties. In this work we have applied a combination of local and bulk approaches to understand magnetic properties of some cobalt-containing nanocomposites in more detail. Namely, to test magnetic structure of the samples at molecular level we used NMR and Mössbauer techniques whereas static (SQUID) and dynamic magnetic (M_2, see below) measurements – at bulk level.

NMR in zero magnetic field indicates an existence of the metallic cobalt core in all variants of cobalt-containing nanocomposites. Registration of second harmonic of magnetization of longitudinal nonlinear response to a weak *ac* field (M_2) is very sensitive to appearance of a ferromagnetic component in magnetization due to its noticeable nonlinearity in weak magnetic fields. This technique allowed us to obtain evidences of a presence of antiferromagnetic oxide shell, possessing a weak ferromagnetism (owing to its irregular crystal structure) in cobalt nanoparticles. Mössbauer measurements show that only oxide iron phases exist in bimetallic Fe-Co nanoparticles.

In summary, the techniques described above could be useful addition to common diagnostic methods in testing and certification of magnetic (nano)materials of various kinds.

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SYNTHESIS, STRUCTURAL, THERMAL AND MAGNETIC CHACARTERIZATIONS OF NANOSTRUCTURED Cu-DOPED MANGANITE SYSTEMS

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This work aims the synthesis, characterization and technological applications of nanostructured copper-doped manganite systems. For this end, $La_{0.7}Sr_{0.3}Mn_{1-m}Cu_mO_3$ (m = 0.05, 0.10 and 0.15) nanoparticles synthesized by sol-gel method were studied. The main goal of this work is the development of manganites in nanometric scale to improve their properties by adjusting the magnetic and structural transition temperature to obtain the maximum magnetocaloric effect (MCE) near room temperature.

The synthesis parameters were correlated to the characteristics of produced nanoparticles, in order to improve their quality in relation to the known bulk samples and to evaluate their applicability in the technological area.

The characterizations of these nanosystems were carried out by different techniques, such as X-ray powder diffraction, thermogravimetric analysis and magnetic measurements. The results showed that these systems exhibit a perovskite-like crystal structure. The unit cell parameters were slightly affected by small additions of Cu. The thermal steps indicate no mass loss had occurred. Magnetic measurements indicated a second order transition near the Currie temperature.

These results suggest the present Cu-doped manganites are suitable candidate materials for magnetic refrigerants near room temperature for magnetic-refrigeration technology.

Acknowledgments

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NOVEL SKYRMION STATES IN NANOWIRES OF CHIRAL MAGNETS

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In bulk non-centrosymmetric magnets the chiral Dzyaloshinskii-Moriya exchange stabilizes tubular skyrmions with a reversed magnetization in their centers [1]. While the double-twist is favorable in the center of a skyrmion, it gives rise to an excess of the energy density at the outskirt. Therefore, magnetic anisotropies are required to make skyrmions more favorable than the conical spiral state in bulk materials [2].

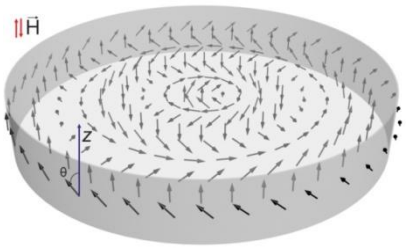

Fig.1. Skyrmion-target in a nanowire.

Using Monte Carlo simulations, we show that in magnetic nanowires unusual skyrmions with a double-twisting core (Fig. 1) and a number of concentric helicoidal undulations are thermodynamically stable even in absence of single-ion anisotropies. Such skyrmions are free of magnetic charges and, since the angle θ describing the direction of magnetization at the surface depends on the radius of the nanowire and an applied magnetic field, they carry a non-integer skyrmion charge $s > 1$. This state competes with clusters of spatially separated $s=1$ skyrmions. For very small radii, the ring skyrmion transforms into a skyrmion with $s < 1$, that resembles the vortex-like state stabilized by surface-induced anisotropies [2].

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SIMULATION AND MEASUREMENT OF THE MAGNETIC FIELD RADIATION FOR A PLANAR INDUCTOR

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INTRODUCTION:

Reducing the size of electronic components (passive components in particular) has become a major necessity since the electronic circuits are minimized. Among these components, we can mention an essential component in radiofrequency applications, high frequencies applications and power electronics: it is the planar inductance, the most disruptive component.

The aim of our work is the characterization of radiation and shielding. So in the following paper we will compare simulation results of magnetic radiation for a planar inductance with measurements results. For that, two structures are fabricated: planar inductors with and without magnetic layer (Figure 1), and then we measure the magnetic field radiation using a bench characterization. These two structures have been simulated and compared with measurement results. Results are illustrated in Figure 2 and Figure 3.

FIGURES:

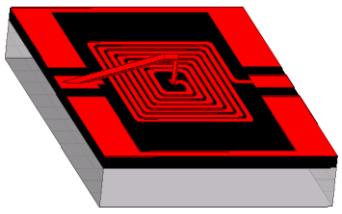

Figure 1: Planar inductance with one magnetic layer.

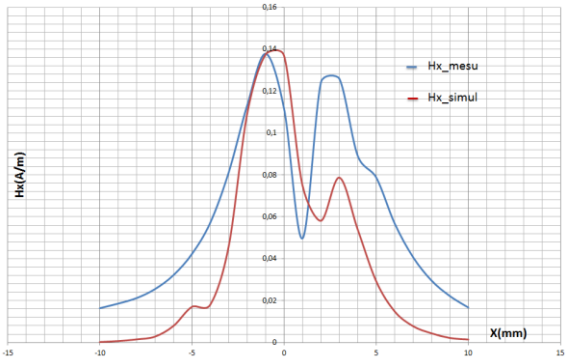

Figure 2: repartition of magnetic field Hx.

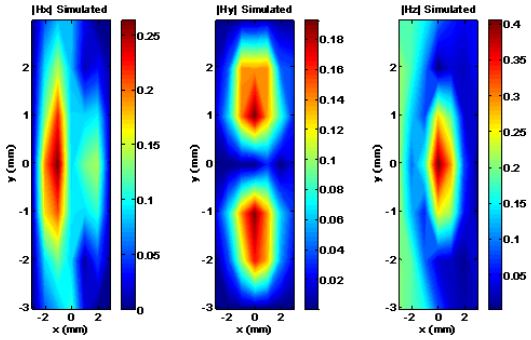

Figure 3: cartographic of magnetic field.

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SUBSTRATE INFLUENCE ON THE STRUCTURE AND MAGNETIC PROPERTIES OF M-N (M=Fe,Co) THIN FILMS

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Iron and cobalt nitrides are potential candidates for spintronic applications due to their expected high magnetization combined with large spin polarization and chemical ability to allow sharp interfaces with semiconducting nitrides.

In this work, we present results obtained for Fe-N thin films deposited by reactive sputtering in $Ar+N_2$ mixtures. Several substrates (Corning glass,TiO_2, MgO, Al_2O_3) were used to study their influence in the films' magnetic properties and structure. For comparison, we also present results regarding Co-N films. All films display strong ferromagnetic behaviour at RT and magnetic anisotropy related with the substrate.

This work was supported by FCT – "Fundação para a Ciência e Tecnologia" through project PTDC/FIS/102270/2008 and grant SFRH/BD/70150/2010.

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TEMPERATURE-DEPENDENT MEASUREMENTS OF THE DIFFERENTIAL CONDUCTANCE WITH FE-COATED W TIPS

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INTRODUCTION

Spin-polarized scanning tunneling microscopy/spectroscopy (sp-STM/S) has been successfully applied to characterize spin-ordering, spin-dependent electron confinement [1], and magnetization reversal of individual nanostructures [2]. However, in spite of its crucial function in SP-STM, quantitative insights regarding the magnetization state of the tip are scarce [3,4].

METHODS AND RESULTS

We performed SP-STM on biatomic-layer-high Co nanostructures grown on Cu(111) in magnetic fields oriented normal to the sample surface, with a Fe-coated W tip. Increasing the temperature from 10 to 30 K, we observe a reduced slope of the differential conductance around zero field. A quantitative analysis of the field- and temperature-dependent differential conductance data in the framework of superparamagnetism as described by a Langevin function gives an excellent description of the experimental results. The analysis suggests that a Fe nano-apex at the W tip, which is composed of 220−300 Fe atoms, determines the magnetic response of the tip.

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MAGNETOMETRY VERSUS MOSSBAUER SPECTYROSCOPY PATHS IN STUDYING SIZE EFFECTS IN NANOPARTICULATE SYSTEMS

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The intriguing variety of magnetic phenomena observed in nanoparticulate systems is derived from the interplay between the intrinsic material properties, finite size effects and interphase/interparticle interactions. While, in a first approximation, the intrinsic properties of the nanoparticles could be thought as deriving from phase composition, finite size effects strongly modulate the magnetic behavior of the system, through both magnetic relaxation and anomalous spin structure at the particle surface. Further on, the magnetic relaxation regime of a system of nanoparticles is sensitive to a large set of parameters (anisotropy constants whatever their sources are, distribution of particle sizes, magnetic couplings or interactions among nanoparticles, inter-phase interactions inside a same nanoparticle, etc.). Therefore, any characterization of a system with respect to its magnetic relaxation behavior requires a multi-pronged approach linking different types of magnetic responses to an as large as possible set of related parameters. We report on a suite of tools and methodologies for such a comprehensive and complementary characterization of the magnetic response in real systems of interacting non-identical nanoparticles, by combining the powerful method of temperature and field dependent Mossbauer spectroscopy with high sensitivity SQUID magnetometry techniques. While Mossbauer spectroscopy at low temperature provides suitable information about the phase composition of the system (only Fe based nanoparticulate systems are considered), information about the particle size distribution (average size and distribution width) is obtained from the dependence of the magnetic hyperfine field distribution versus temperature. Magnetic measurements are discussed with respect to the influence of the interparticle interaction energy which modifies in a specific manner the potential barrier in static measurements and dynamic ones, either they are of Mossbauer or magnetometry type. It is proven also that the material dependent characteristic time τ_0 in the Neel type relaxation can be derived with accuracy only by combining dynamic methods of significantly different time windows, as a.c. susceptibility and Mossbauer spectroscopy. The importance of such efficient magnetic characterization related to bio-medical applications is also revealed.

The financial support through the Romanian program PNII IDEI 75/2011 is acknowledged.

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GROWTH AND MAGNETIC PROPERTIES OF SELF-ORGANIZED (Fe,Co) NANODOTS ON Au(111)

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The elaboration of self-organized nanoparticles with enhanced magnetic properties remains a major challenge since they are forecasted as models candidates for the next generation of hard-disks. Iron and cobalt nanodots are expected to have superior magnetic properties (e.g. high anisotropy and ordering temperature, …).

We have studied the growth and the magnetic properties of nano-clusters made of 3d elements co-deposited on a Au(111) substrate in function of the concentration x. The herringbone reconstruction of Au(111) acts as a guide for nucleation and self-organization of the bimetallic clusters. The evolution of the cluster's morphologies has been investigated by Scanning Tunneling Microscopy and AC-magnetic susceptibility measurements were performed thank to an *in-situ* MOKE set up in order to get the average magnetic anisotropy energy per atom for each Fe_xCo_{1-x} co-deposition.

The shape of the clusters change a lot with the concentration (Fig. 1, a-c), from pure monolayer Fe, to a mixed of mono and bilayer dots for the bimetallic and pure bilayer hexagonal shape for pure Co. All the samples show a superparamagnetic state at low temperature and the highest blocking temperature is around 120K for $Fe_{50}Co_{50}$. Finally, a significant increase of the activation energy is observed (Fig. 1, d) but appears to be lower than the theoretical predictions [1]

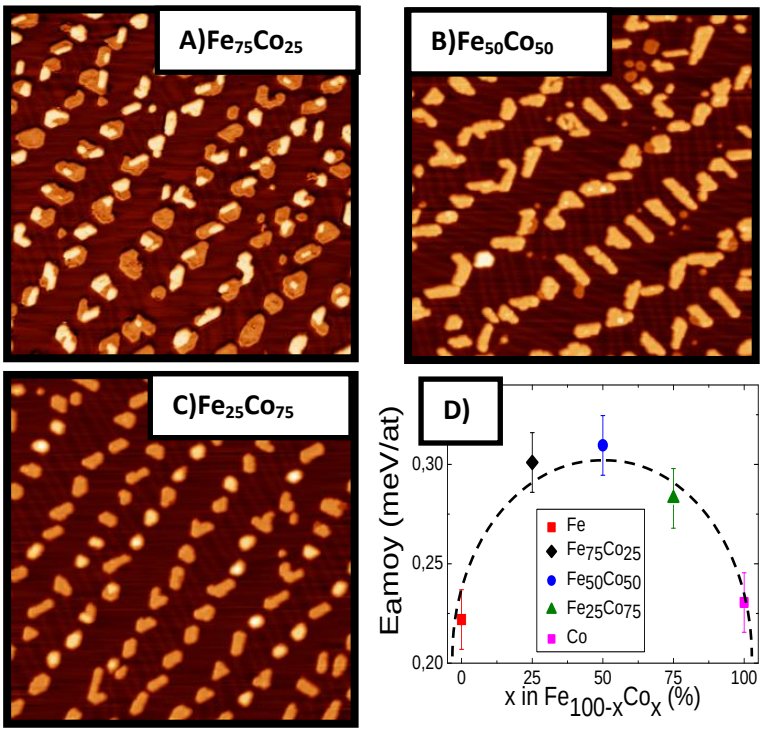

Figure 1 : a) b) c) : 100x100nm² STM images of three different concentrations of Fe_xCo_{1-x}
d) : "Bell" like shape of the mean activation energy per atom (E_{amoy})

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PHASE TRANSFORMATION AND MAGNETIC PROPERTIES OF FeCo FLOWERS

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INTRODUCTION

FeCo alloys are important class of soft magnetic materials with potential biomedical and high frequency applications. The synthesis of composition controlled FeCo through chemical methods is a challenge due to the difficulty in reducing Fe [1]. However polyol process has emerged as a cost effective approach to synthesis FeCo with controlled composition [2]. The synthesis of morphology controlled FeCo by polyol process requires stringent experimental control. The synthesis of flower-like FeCo could be achieved without the requirement of any shape controlling agents. Also the effects of additives such as Cu and Ni in FeCo and size reduction using heterogeneous nucleating agents are attempted.

RESULTS

A one-pot one-step polyol process was designed to synthesis flower-like FeCo. The introduction time of the precursors, the reaction temperature and reaction enhancing agents are found to play an important role in obtaining the desired composition and morphology. The samples were characterized using XRD, HRTEM, VSM and Thermal analysis. The origin of the flower-like shape is suggested to be an outcome of the competing tendency of Fe and Co atoms during growth to attain cubic and spherical shape respectively. The pure Fe which was cubic showed a Curie temperature (T_c) of 765 ^oC and with increasing Co concentration it increased upto 985 ^oC for $Fe_{67}Co_{33}$ and dropped to 939 ^oC for $Fe_{36}Co_{64}$. In the Fe rich region, the bcc to fcc phase transformation temperature is higher than the T_c. The petals of the flower-like FeCo was found to increase with the concentration of Co. This in turn affects the saturation magnetization, coercivity and stability of the alloy.

The size reduction of the FeCo alloy has been attempted using CoPt nanoparticles as heterogeneous nucleating agent. The saturation magnetization and coercively are found to be influenced by the concentration of CoPt. The effect of trace amounts of Cu and Ni in various compositions of FeCo and the corresponding properties are analyzed. The synthesis strategy and composition and morphology dependent magnetic, structural and thermal properties shall be presented.

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REMANENCE ENHANCEMENT DUE TO EXCHANGE COUPLING IN SmCoFeCuZr MAGNETS

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INTRODUCTION

The coercivity of nanocrystalline SmCoFeCuZr magnets based on 2:17 phase can be described by the Stoner-Wohlfarth CLC model [1,2]. Exchange coupling may increase the remanence of the magnets, by means of the double shell model [3]. This model considers that exchange coupling effect occurs in a microstructure where spherical nanocrystalline grains of the hard phase $Sm_2(Co,Fe)_{17}$ are enveloped by a shell consisting in the cobalt-rich $Sm(Co,Cu)_5$ soft phase, and all these nanograins are separated by a high copper, paramagnetic $Sm(CuCo)_5$ phase.

Similar microstructures may be obtained in other systems. A possibility is enveloping $Nd_2Fe_{14}B$ grains by a Fe-alpha soft magnetic layer or shell. This is a feasible way of improving the maximum energy product (BH_{max}) of rare-earth transition metal magnets.

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SPIN STATE TRANSITION OF IRON-PORPHYRIN ADSORBED ON MAGNETIC SUBSTRATES

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The possibility to manipulate the spin state of a single molecular magnet is an important goal in the field of spintronics. Important candidates are organic macrocycle molecules with a magnetic center, like Fe porphyrins (FeP), in which electronic structure and spin can be affected by their adsorption configuration.[1]

We have studied the chemisorption of FeP on several magnetic surfaces, i.e. Co(001), Ni(001), Ni(110) and Ni(111), by means of first principles Density Functional Theory. In all cases we have obtained a change in the molecular spin state from low spin (S=1) of gas phase to intermediate spin (S=2) in chemisorbed configurations. This effect corresponds to a stretch in the Fe-N bonds to more than 2.04 Å produced by strong chemical interaction with the substrates. The variations in the geometric/electronic structures of the molecules affect the square planar ligand field exerted on the 3d-orbitals of the Fe center, and produce the change in the spin state.

We show that experimental techniques, such as spin-polarized scanning tunneling microscopy can detect the change in the spin state.[2]

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STM CONTRAST INVERSION OF THE FE(110) SURFACE

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ABSTRACT

Under certain circumstances, constant-current scanning tunneling microscopy (STM) images show atomic contrast inversion above metal surfaces, i.e., the apparent height of surface atoms can be smaller than the apparent height of the surface hollow position, and consequently, atoms do not always appear as protrusions on the STM images [1].

In this work, we theoretically investigate the nature of the bias-voltage-dependent atomic contrast inversion of the Fe(110) surface by simulating spin-polarized scanning tunneling microscopy based on the three-dimensional Wentzel-Kramers-Brillouin approach and first principles electronic structure data [2,3]. We find an interplay of orbital-dependent tunneling effects [3] and magnetic effects responsible for the contrast inversion. Based on a recently developed theoretical method [4], we predict the bias-voltage-dependent contrast above this prototype magnetic surface.

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ACKNOWLEDGMENTS

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NEGATIVE PERMITTIVITY AND NEGATIVE PERMEABILITY OF FERROMAGNETIC CERMETS

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INTRODUCTION

Double negative materials (DNMs) with simultaneously negative permittivity and negative permeability have attracted extensive attention worldwide in recent years because of their various potential applications in electronic, microwave and optics.

Different from metamaterials which gain their double negative properties not from their composition but from their exactingly-designed structures, random DNMs is proposed from the point of view of materials, i.e. intrinsic properties determined by chemical composition and microstructure.

We have prepared a series of random cermets for the DNMs, which are composed of ferromagnetic metals and/or ferrites (Fig.1). The negative permittivity was realized by controlling the effective concentration of electrons in the cermets, while the negative permeability was realized by the magnetic resonances and the strong diamagnetic response of metal networks. The double negative property was realized by controlling the composition and microstructure of the cermets.

FIGURES

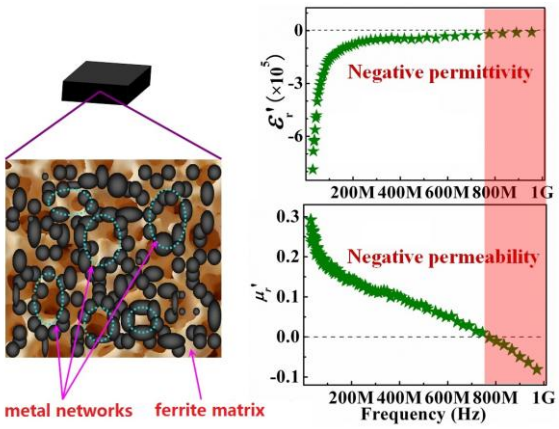

Figure 1 The ferromagnetic Cermets having Negative Permittivity and Negative Permeability

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DIPOLAR COUPLING IN THE Co/Cu/Co NANOSTRIPES GROWN ON STEPPED Si(111) SUBSTRATE

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From the fundamental point of view investigation of planar multilayered nanostripes as compared to electrodeposited nanowires has clear advantages since the interface structure and dimensions of the patterned stripes can be exactly controlled. We investigated magnetization reversal and domain structure of epitaxial (111)-oriented Co(5 nm)/Cu(5 nm)/Co(5 nm) nanostripes grown on Si(111) stepped substrate. The width of the stripes was varied from 500 to 3000 nm. Nanostripes were cut perpendicular to the steps of the substrate. The easy axis of the magnetization was induced by the steps along the short axis of the stripes. Dipolar coupling between Co layers favors antiparallel alignment of the magnetization in the adjacent Co layers and leads to broadening of switching magnetic field interval in Co/Cu/Co nanostripes in comparison with single layer Co(10 nm) stripes [1]. On magnetic-force microscopy images areas with low magnetic contrast correspond to antiparallely magnetized domains (fig.1).

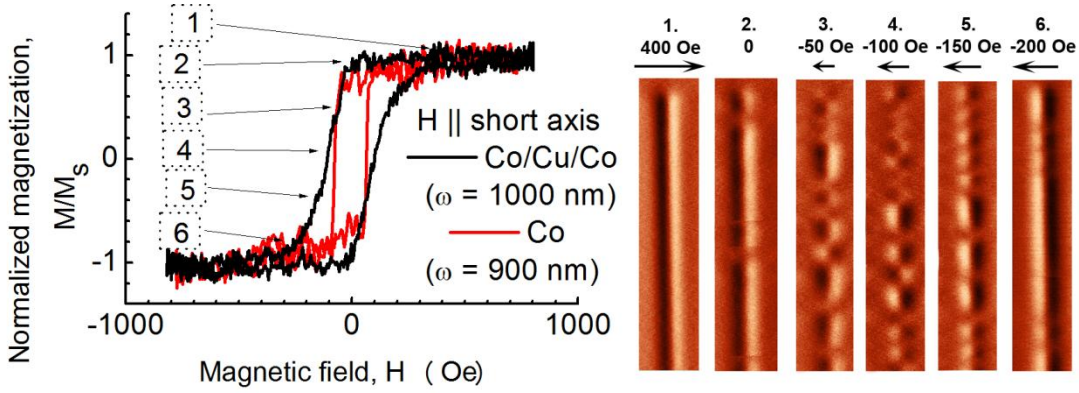

Fig. 1. Hysteresis loops of Co and Co/Cu/Co nanostripes. Domain patterns characterize magnetization reversal in Co/Cu/Co stripes.

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Authors acknowledge the support of the Russian Ministry of Education and Science, the Russian Foundation for Basic Research 12-02-31357-mol-a and the Scientific Fund of FEFU.

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MAGNETIC FIELD EFFECT ON Co NANOPARTICLES REDUCTION

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The effect of weak magnetic fields on the mechanical, thermodynamic, chemical and kinetic properties of both magnetic and nonmagnetic compounds is a fundamental problem of condensed state.

The importance of this issue was discussed in several papers, such as [1]. Currently a number of published papers are devoted to the influence of a magnetic field on the chemical reactions and the properties of their products [2, 3 and references therein]. But till now there is no sufficient clarity about the causes of this phenomenon.

In this report we present the results of our investigations of the processes of Co nanoparticles reduction from salts or oxides at isothermal conditions. The measurements were performed with vibrating sample magnetometer in temperature range up to 600^{o}C in magnetic field up to 0.5 T. The magnetometer could selectively detect the formation of metal Co during reduction process in situ, as the magnetic moment of the sample was proportional to the mass of Co. The structural properties of the nanoparticles were investigated with additional setup. The mechanism of the effect is discussed.

The investigations were supported by RFBR grants (No 13-02-90491, 11-03-00501 and 13-03-00914).

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XMCD/XLD STUDY OF THE MAGNETOELECTRIC COUPLING MECHANISM IN THE MULTIFERROIC COMPOSITE Co/PMN-PT(011)

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Multiferroic composites are promising candidates amongst the strategies to achieve electric field control of magnetism. In compounds consisting of ferromagnetic and ferroelectric (FE) layers strain can couple the FE phase via the piezoelectric effect to the magnetic phase employing magnetostriction.

$[Pb(Mg_{1/3}Nb_{2/3})O_3]_{(1-x)}$-$[PbTiO_3]_X$ (PMN-PT) is a relaxor FE with strong piezoelectric properties near the morphotrophic phase boundary x=0.3 [1] - Wu et al. reported on a remanent in-plane FE polarization for PMN-PT (011) in addition to the two out-of-plane polarization directions [2]. The impact of the FE order of PMN-PT (011) on the electronic and atomic structure of a Co top layer is studied using X-ray magnetic circular dichroism (XMCD) and X-ray linear dichrosim (XLD) for Co and Ti respectively. We observe the development of a magnetic easy axis upon rotating the FE polarization to in-plane due to strain-mediated coupling (see Fig. 1, red curve). The data suggest an additional charge driven magnetoelectric coupling due to electron accumulation/depletion at the Co/PMN-PT interface (Fig. 1,green and blue curve). Moreover, the Ti data shows a change in the spectrum with applied voltage which is described with the help of multiplet calculations.

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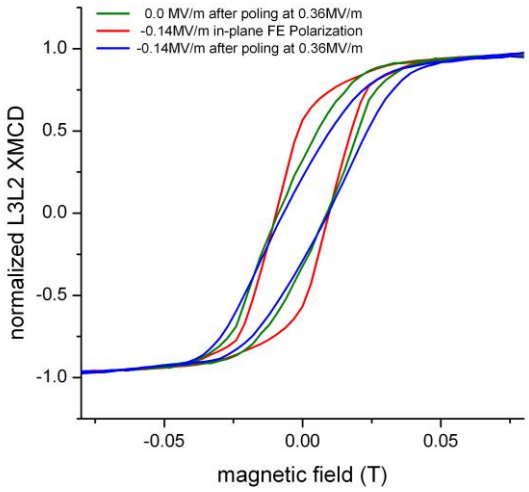
Figure 1: Normalized L_3L_2 XMCD hysteresis curves along the (01-1) crystal direction under different electric fields. A magnetic easy axis develops upon rotating the FE polarization to in-plane (red curve). Additionally the hysteresis shape is dominated by the poling direction (green and blue curve).



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ELECTRON MAGNETIC CIRCULAR DICHROISM – VORTEX BEAMS AND POLYCRYSTALS

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INTRODUCTION

We present recent developments in the field of electron magnetic circular dichroism (EMCD; [1]), an experimental technique that brings a promise of atom and shell specific magnetic characterization at nano-scale. Measurements of EMCD so far rely on using the crystal itself as a beam-splitter (so called *intrinsic* method) and in turn they depend on high-quality single-crystalline samples oriented in a specific Bragg position. EMCD is measured in between the Bragg spots and thus also suffers from low signal-to-noise ratios.

METHODS AND RESULTS

Recent introduction of electron vortex beams into the field of transmission electron microscopy [2,3] has attracted a lot of attention. Authors of [4] presented a suggestion to measure EMCD with high signal to noise ratio, in principle without requiring single crystals in specific orientations. We present a theoretical analysis of the inelastic interaction of vortex beams with crystalline samples and discuss the limitations of the method [5]. Simulations reveal that electron vortex beams provide a magnetic contrast only in an atomic resolution mode, in which, however, they can outperform the *intrinsic* method in terms of the signal-to-noise ratio.

An alternative route is presented, which relies on a parameter-free statistical post-processing of a large number of spectra measured in more-or-less random orientations [6,7]. The method builds on the same principles as the *intrinsic* method, though it neither requires single-crystalline samples nor specific orientations. The individual spectra have been collected by scanning over a larger sample region with a probe beam of diameter 5nm. Detector was slightly tilted away from the incoming beam direction, following the prediction of simulations. Few hundreds of spectra have been acquired on a polycrystalline sample and a clear and quantitative EMCD signal was extracted.

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ENHANCED COLOSSAL MAGNETORESISTANCE IN NANOSTRUCTURED LSMO THIN FILMS

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Numerous efforts have been devoted in the last years to enhance the colossal magnetoresistance effect in $La_{2/3}Sr_{1/3}MnO_3$ thin films as this material exhibits a stable insulator-metal/paramagnetic-ferromagnetic transition above room temperature. An interesting approach is to explore the interplay between substrate and film. Whereas the effect of strain in the physical properties of the film has been widely studied, less knowledge has been obtained about how strain relaxation may lead to different states of the LSMO film. In this work we present our last results on the magnetotransport properties of nanostructred LSMO thin films. Previously we have demonstrated that by fine tuning the dynamics of film growth, a long-range ordered array of antidots can be obtained at the film surface leading to a strain state different from that reported in standard films [1,2]. We show that nanostructured LSMO thin films exhibit an enhanced colossal magnetoresistance effect at low and high fields (higher than 40% at H=1T). We study the influence of film thickness and discuss the origin of the observed enhancement.

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EUO ON CUBIC OXIDES AND DIRECTLY ON SILICON

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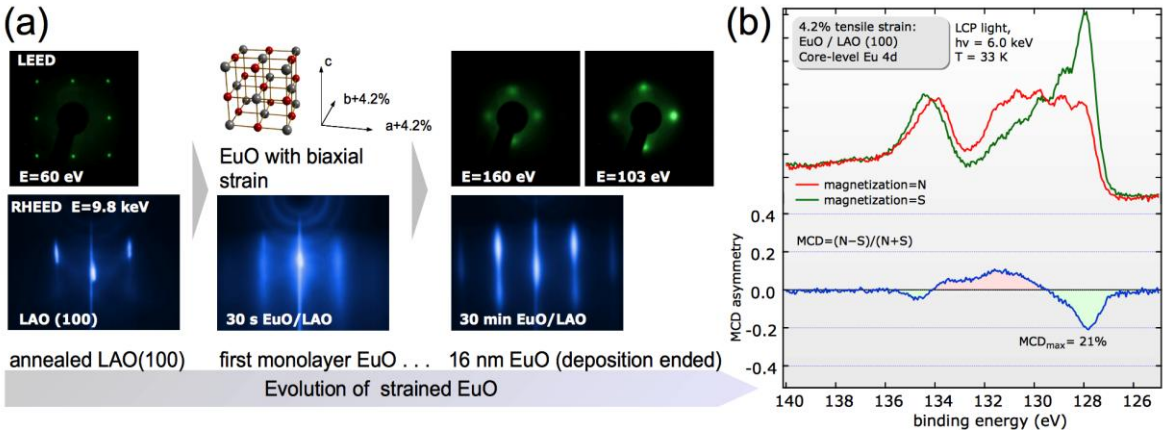
We explore fundamental properties of ultrathin europium oxide (EuO) films. EuO is a model system of a localized 4*f* Heisenberg ferromagnet, in which the ferromagnetic coupling can be tuned by biaxial lattice strain [1]. Moreover, the magnetic oxide EuO is perfectly suited as a spin-selective tunnel contact for silicon spintronics. However, a challenging bulk and interface chemistry of EuO and Si has hampered a seamless integration into functional silicon heterostructures by now.

First, we explore single-crystalline EuO with biaxial lattice strain by a $LaAlO_3$ substrate (Fig. a). In practice, we investigate the magnetic circular dichroism (MCD) in hard X-ray photoemission, which combines element- and depth-selectivity with the local *spin-dependent* probe of magnetic exchange. The well-resolved Eu 4*d* photoemission multiplet (Fig. b) elucidates the intra-atomic exchange interaction by the MCD asymmetry.



Second, we investigate the spin-functional EuO/Si interface [2]. By surface passivation techniques of Si(001), we succeed in engineering structurally sharp and chemically clean EuO/Si heterointerfaces, which directly enhance the magnetism of the ultrathin EuO layer [3]. Those optimized EuO/Si heterostructures are promising for silicon spintronics.

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ENHANCED MAGNETO-OPTICAL ACTIVITY IN 3D MAGNETO-PHOTONIC CRYSTALS

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Photonic-crystals are materials in which the permittivity is periodically modulated on the scale of optical wavelengths modifying their spectral optical response. The addition of a magnetic component into these structures, the so-called magneto-photonic crystals (MPCs), has interesting effects since the interaction of light with magnetic materials provides a way to manipulate the polarization of light. Exploiting and understanding such interplay is relevant from the fundamental point of view as well as in applications. Indeed, the cross link between light and magnetism affords the basis for potentially novel devices in data control of optical communications, optical storage data and sensing. At frequencies close the band edges, the light group velocity is slowed down and thus photons of those wavelengths couple very intensively with the medium. It has previously been demonstrated that the magneto-optical response of one-dimensional (1D) MPCs is significantly enhanced at band-edge frequencies[1]. The achievement of 3D-MPCs is much more complex and the attainment of an optimal magneto-optical response remains a challenging issue.

We will introduce 3D-MPCs in which enhanced magneto-optical responses at near-band edge wavelengths have been achieved. These systems were fabricated following two strategies: i) by infiltrating self-assembled direct and inverse opal structures with monodisperse *ex-situ* synthesized colloidal dispersions of magnetic nanoparticles[2] and ii) by sol-gel microwave assisted *in-situ* synthesis of the magnetic nanoparticles coating the photonic structures[3] (figure 1a). In both cases, high magnetic load and long-range order have been fundamental to obtain large magneto-optical responses at wavelengths near the photonic band-edges (figure 1b). The results demonstrate the potential of exploiting wet colloidal chemistry and microwave assisted synthesis to obtain novel functional magnetic nanocomposites intended for photonic applications by using light polarization in photonic structures as a powerful strategy to customize the magneto-optical spectral response of magnetic nanoparticles.

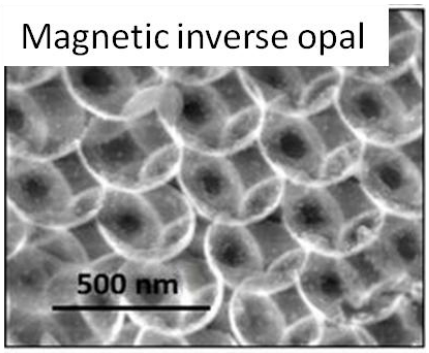

Figure 1a

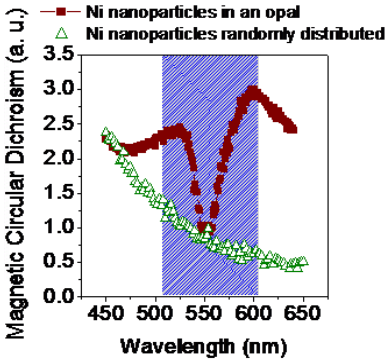

Figure 1b

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SYNTHESIS AND CHARACTERIZATION OF MAGNETIC POWDER OF MAGNETITE

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INTRODUCTION

Magnetite nanopowder is a nanostructured magnetic material which is of great importance due to its electric and magnetic properties at room temperature. Reliant on its structure, magnetite is a typical semiconducting material, which finds various applications in medical diagnostics, catalysis, ceramics processing, magnetic data storage, magnetic separation, and therapies such as cancer treatment.

METHODS

In the present work, three samples of magnetite powder were produced, the first two with the alkaline precipitation method from aqueous solution of mixed Fe(II)/Fe(III) salts, in the absence of stabilizers and the last one with the same method with the use of surfactant. The samples will be referred as 1x, 2x and 4x.

RESULTS AND DISCUSSION

The prepared powders have been characterized using transmission electron microscopy (Fig. 1), IR spectroscopy and x-ray diffraction (Fig. 2) in order the structure, particle size and morphology of magnetite to be examined. The produced magnetite powders have a size range of 8±2nm and the chemical composition of magnetite. All samples had good chemical stability in order to provide a protection layer against oxidation.

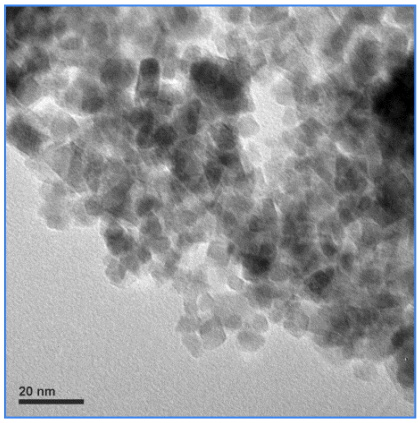

Fig.1: *TEM image of sample 2x.*

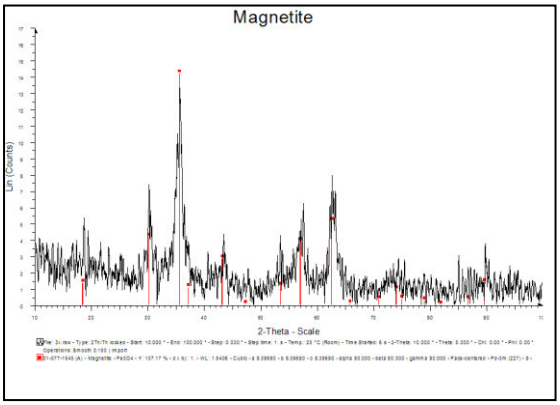

Fig. 2: *XRD image of sample 1x.*

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ANISOTROPY OF EPITAXIAL ULTRATHIN $L1_0$ FePt PROBED BY XMCD

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Advanced magnetic materials based on epitaxial ultrathin layers with controlled growth, structural and magnetic properties are of utmost importance to the understanding and the application of new spintronics phenomena. Double-layer antiferromagnetic/ferromagnetic (AFM/FM) systems showing perpendicular magnetic anisotropy (PMA) are of particular interest for faster and smaller magnetic bits in storage technologies. The PMA of two AFM/FM systems based on FePt $L1_0$ alloys – (A) Pt(001)/MnPt(3nm)/FePt(1.6nm) and (B) Pt(001)/FePt(1.2nm)/CoO(3nm) – are studied here by x-ray magnetic circular dichroism (XMCD). Sample A presents $L1_0$ phase for both MnPt and FePt layers [1], with an exchange bias shift of 8mT at 5K that vanishes after a few cycles. In sample B the CoO overlayer grows with (111) orientation on the $L1_0$ FePt and the exchange bias shift is robust [2]. The XMCD field dependence at grazing and normal incidence shows that both samples present strong PMA and provides a quantitative evaluation of the anisotropy. The magnetic anisotropy is higher in sample B than in sample A, what is related to differences in the growth process and chemical order for the two samples.

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ASYMMETRIES OF GMR IN NiFe/Cu/NiFe/IrMn SPIN-VALVE STRUCTURES

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Magnetoresistance in sub-millimeter-size spin-valves was investigated. Spin-valve structures Si/Ta(22)/NiFe(12)/Cu(t_{Cu})/NiFe(7)/IrMn(t_{AF})/Ta(22), with the lateral size of 200 x 500 micrometers and with the thicknesses of the layers given as a number (in nm) in brackets, t_{Cu} = 0,75 to 3 nm and t_{AF} = 1 to 15 nm were prepared by DC magnetron sputtering with the magnetic field of 400 Oe applied during the depositions. The change in magnetoresistance was negligibly small for spacer thickness t_{Cu} smaller than 1.5 nm, saturated at t_{Cu} >2.0 nm and decayed at t_{Cu} >3.5 nm, vanishing at t_{Cu} >7.0 nm.

Two types of asymmetry were observed in magnetoresistance-vs-applied field, R(Hext), curves in spin-valve structures Si/Ta(22)/NiFe(12)/Cu(t_{Cu})/NiFe(7)/IrMn(t_{AF})/Ta(22), where thicknesses of the layers are given as a number (in nm) in brackets, t_{Cu} = 0,75 to 3 nm and t_{AF} = 1 to 15 nm. The first type is a shape asymmetry when the ascent is smoother than the descent in the R(Hext). The second one is a difference in the height of the resistance peaks in the direct and reverse ramping of the magnetic field. We note that this effect is not a training effect, since it is reproducible in multiple field scans. The effect indicates that the upward and downward reversals of magnetisation in the pinned and free layers are different.

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DEFECTS IN MAGNETISM OF DILUTED MAGNETIC SEMICONDUCTORS TIO_2:CO AND TIO_2:V

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An ambitious idea to create systems for further spintronic devices where the spin of carriers could be used as well as their charge was supported by the theoretical prediction of T.Dietl in 2000 [1] and by pioneering paper of Y.Matsumoto in 2001 [2]. Since that time an extensive search for so called Diluted Magnetic Semiconductors (DMS) is continued and up to now a lot of compounds have been already studied [see 3-4, and references therein]. Nevertheless, there is still no one suitable theory that could explain all experimental facts observed in such systems.

We report about our joint studies of TiO2:Co(1÷3 at%) and TiO2:V(1÷3 at%) DMS thin films (~300nm) prepared by rf magnetron sputtering technique and TiO2:Co(0.5÷4 at%) DMS prepared by ion-implantation. Ferromagnetic order at RT has been confirmed by SQUID or VSM magnetometry; the absence of parasitic ferromagnetic phases has been checked by EDX analysis; Positron Annihilation Spectroscopy at ELBE accelerator has been used to test different types of defects; magneto-optical Transversal Kerr Effect spectroscopy and element-selective XMCD technique has been exploited to probe the inter-band and local magnetic moment of 3d impurity.

The possible difference in exchange mechanisms in TiO2:Co and TiO2:V systems and an influence of unequal defect creation by two preparation techniques on ferromagnetic ordering in DMS studied is discussed.

ACKNOWLEDGMENTS

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NONCOLINEAR UNIDIRECTIONAL ANISOTROPIES AT F/AF/F INTERFACES IN NiFe/IrMn/NiFe TRILAYER STRUCTURES

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Here we report on our investigations of exchange bias in ferromagnetic/antiferromagnetic/ferromagnetic (F/AF/F) trilayer structures with different thickness of F layer. Experimental samples Si/Ta 30nm/NiFe t_F/IrMn 15nm/NiFe t_F/Ta 30nm where t_F = 7nm and 10 nm were deposited by magnetron sputtering in argon at pressure of $3*10^{-3}$Torr with magnetic field of 420 Oe applied in plane of substrate during the deposition. The ferromagnetic resonance (FMR) spectra were measured at different angles between directions of external FMR field and magnetic field, $\mathbf{H_{dep}}$, applied during the samples depositions. Both F/AF/F interfaces in the sample with t_F = 10 nm had a symmetric, centered at 180^o, bell-like shape of angular distributions of FMR resonance field, while in the case of t_F = 7nm structure these distributions were non-symmetric. The data assume that the exchange bias direction is not parallel to $\mathbf{H_{dep}}$. The estimated misalignment angles were 20^o and 24^o for top and bottom magnetic interfaces, respectively. The exchange bias values for the interfaces in the structure with t_F = 7nm were 67 and 70 Oe, while in the case of the structure with t_F = 10nm the exchange bias value increased to 110 and 114 Oe.

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MAGNETIC PROPERTIES OF NONSTOICHIOMETRIC SiMn FILMS

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Here we present results of investigation of magnetic properties of nonstoichiometric $Si_{1-x}Mn_x$ films (x = 0.5-0.55) at the temperature range 6-300 K in magnetic fields up to 3 T. The films were obtained by pulsed laser deposition using droplet velocity separation technique. High-temperature ferromagnetism with Curie temperature > 300 K has been observed in these systems [1-3]. Long-range ferromagnetic order is assumed to be due to nonstoichiometry of alloys and the local magnetic moments of structural defects. The exchange coupling between these moments can be mediated via spin fluctuations in the paramagnetic silicide matrix (Curie temperature of ideally stoichiometric itinerant ferromagnet manganese silicide < 50 K). The study of magnetic properties at low temperatures revealed the presence of several magnetic and structural phases. A multiphase structure of SiMn films is discussed.

The financial support of RFBR is gratefully acknowledged (grants No 13-02-12107, 13-02-12200).

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CHARGE TRANSFER AND MAGNETIC ORDER AT THE $LA_{0.7}SR_{0.3}MNO_3/CARUO_3$ INTERFACE

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Good epitaxial growth characteristics make oxide heterostructures of the perovskite family a model system for the study of emerging phenomena at interfaces. Structural transformations due to lattice mismatch induced interfacial strain as well as electronic reconstruction due to charge transfer may give rise to new spatially confined states of matter. Here $La_{0.7}Sr_{0.3}MnO_3/CaRuO_3$ superlattices with individual layer thicknesses between two and ten unit cells and coherently grown interfaces were fabricated by pulsed laser deposition. Quality of the superlattices was confirmed by atomic force microscopy, X-ray diffraction and transmission electron microscopy measurements. Although single layers of $La_{0.7}Sr_{0.3}MnO_3$ thinner than five unit cells have been reported to being antiferromagnetic and insulating [1], magnetization and magneto transport measurements between 5K and 300K indicate ferromagnetic order near room temperature in the superlattices. The observation of an anomalous Hall effect in the whole temperature range indicates a similar behaviour as in our recent study of $La_{0.7}Sr_{0.3}MnO_3/SrRuO_3$ superlattices [2], in which we concluded on the existence of an interfacial ferromagnetic hole gas. Here, however, we interchanged the ferromagnetic component $SrRuO_3$ by paramagnetic $CaRuO_3$, thus excluding the complexity of anisotropic ferromagnetic coupling and providing clearer results. This may indicate an alternative approach to the fabrication of quasi two dimensional systems.

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DUAL-MODE QUANTITATIVE MAGNETIC FORCE MICROSCOPY

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Groups of spins in CoO, amounting to a fraction of a monolayer of CoO, have been detected in exchange-bias systems [1] by magnetic force microscopy (MFM), at lateral resolutions of the order of 10 nm. Quantifying areal densities of magnetic moments at this high spatial and magnetic resolution requires not only the sensitivity to very small forces, but also the ability to carry out the scan at a tip-sample distance of few nm [2]. At such distance the contributions from e.g. electrostatic- and van der Waals tip-sample interactions are not negligible.

Separating these contributions requires more than one measurement, typically carried out at different applied fields [3]. The technique is correspondingly prone to artifacts stemming from field-induced torques on the cantilever and temperature drift, both of which change the average tip-sample distance by more than a fraction of a nm. New single-pass methods with the ability to separate magnetic and non-magnetic contributions to contrast are highly desirable. Here we demonstrate a non-contact method for the separation of signals from magnetic- and topographical origin using a tip-sample distance control based on two oscillation modes of the cantilever. The method is suitable for use in vacuum.

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FIELD-INDUCED REDUCED COERCIVITY AND POSITIVE EXCHANGE BIAS IN CO/MNF_2 BILAYERS.

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INTRODUCTION

Field-dependent effects are usually found in ferromagnetic/antiferromagnetic (FM/AFM) bilayers. For instance, enhanced coercivities at increasing maximum external field and negative exchange bias (against direction of maximum field) in asymmetric loops were reported in Co/NiO bilayers [1], bellow the Néel temperature (T_N) of the AFM layer. Here we show novel field-dependent exchange coupling phenomena in Co/MnF_2 bilayers [2], with the opposite trends. MOKE measurements reveal both coercivity decreasing as the maximum of applied field increases and positive exchange bias in asymmetric loops acquired at room temperature, well above $T_N(MnF_2)$= 67 K. Element-selective XMCD measurements show antiferromagnetic coupling between the uncompensated AFM moments and the FM ones (both reversing at the same magnetic field) that would explain the aforementioned field-dependent effects.

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DEVELOPMENT OF AN ELECTRICAL MODEL FOR INTEGRATED MAGNETIC INDUCTORS

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Nowadays, the current trend consists in the development of new technologies with the aim of reducing volume, weight as well as production cost. With the aim of decreasing occupied component area, it will be interesting to use magnetic materials to confine the fields [1]. Therefore, our works concern the modeling and the characterization of magnetic planar inductors.

The proposed model is detailed in Fig. 1 for inductors fabricated with one magnetic layer (Fig. 2). The model can take into account, the capacitance between turns and the capacitance between the last turn and the ground plane, the magnetic permeability, the skin and proximity effects of the conductors according to the frequency. The structure of optimization developed to extract the parameters of the model will be presented.

Results of extracted parameters are compared with the simulation parameters (Fig. 3). A good correlation is observed on Y_{11} and Y_{12} parameters on all the broad band frequency.

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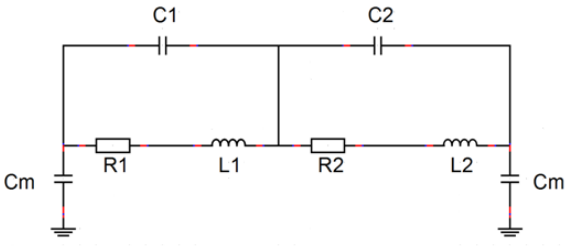

Fig. 1: Developed model

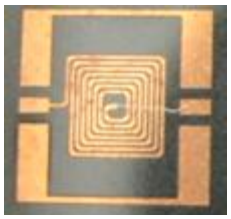

Fig. 2: Inductors realized with one magnetic layer

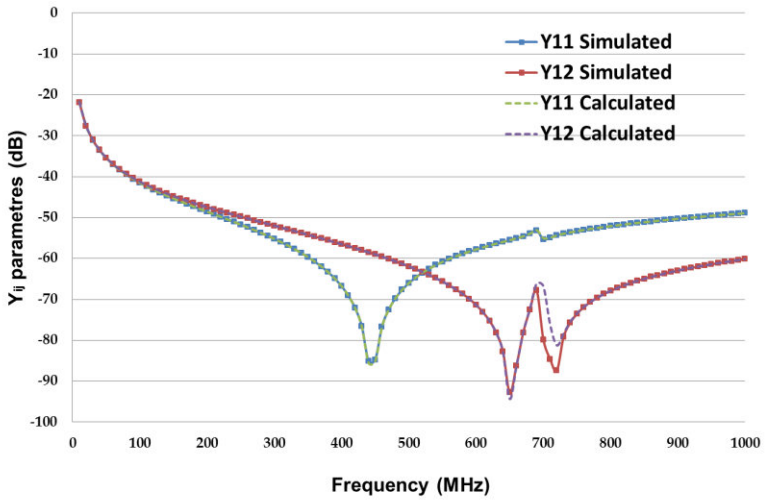

Fig. 3 :Comparison of simulated and calculated Y_{ij} parameters

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DIRECT FIELD DETECTION AND MAGNETIZATION PROCESS CONTROL AS ESSENCIAL CONDITIONS OF ACCURATE MEASUREMENTS

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Magnetic measurements are based on determination of the ferromagnetic material response to applied magnetic field. However, it is technically difficult to properly realize this physically clear concept in practice. E.g. so far, an industrial quality test of the electrical steels is mostly performed by a century-old and laborious Epstein frame. New devices are usually developed in line with these certified methods and optimized to provide relatively stable results for a specific experimental configuration. However, this technical approach makes difficulties for general understanding and interpretation of the results.

Up-to-date digital methods provide new opportunities for the technique development. Our fundamental suggestion is to introduce the principle of direct field measurement in practice. The sample field cannot be reliably evaluated from the magnetization current as it is commonly done; it should be measured directly. For further stabilization of the magnetic response, the magnetization process (magnetic field or flux waveform) should be accurately controlled by a feedback control system [1].

The presentation demonstrates the evident advantages of this approach in case of magnetic hysteresis and Barkhausen noise measurements of construction ferromagnetic steels. The suggested method provides repeatable and physically accurate data even for the measurement in a magnetically open configuration (classical contact problem), which was considered to be impossible so far.

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ENHANCEMENT OF THE MEASUREMENT PRECISION OF VIBRATION SENSOR

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In this paper, accelerometer mathematical model is developed and simulated to choose thebest damping rate value to limit the measurement error to 1%.
From this model, the equations of relative movement modulus and measurement error with respect to damping rate and frequency ratio can be determined.
The developed model is validated by a series of tests carried out by computer simulation. The obtained results have shown that a suitable damping rate can minimize measurement error of relative movement to 1 %. Using the presented model, the damping rate and precision error of the accelerometer can be improved.
From the developed model, the relative movement frequency that suits the accelerometer to avoid resonance case must be equal or less than 1/3 of accelerometer natural frequency. Therefore, to improve damping rate and relative movement frequency, the measurement error must be reduced to obtain a precise value of relative movement modulus; as a result the reel value of structure vibration can be approached.
An accelerometer is a sensor fixed directly on the vibrating structure to measure its vibrations. As it vibrates with the structure, it does not measure the absolute movement y(t) of the structure, but the relative movement z(t) which can be analyzed to extract information on the absolute movement.
The accelerometer is a system composed from a mass, a spring and a damper, defined by m, K and C, respectively fig.1

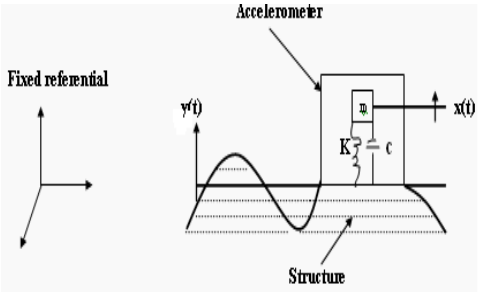

Fig. 1. Modelling an accelerometer

It can be noted that if relative frequency value approaches the accelerometer natural frequency, the resonant frequency ($\omega = \omega_n$) will appears. The accelerometer can operate properly and at the same time to avoid the resonance, the relative frequency must be equal or less than ($\omega_n / 3$). The accelerometer is chosen in relation to the vibration frequency gain. Two tests were carried out in order to choose a better value of damping rate to limit a measurement error to a minimum value.
The obtained results are illustrated by the curves presented in accelerometer damping rate. According to the comparison between figure (2) and figure (3), it can be concluded that the best value of damping rate to limit the measurement error of 1% is 0.675.

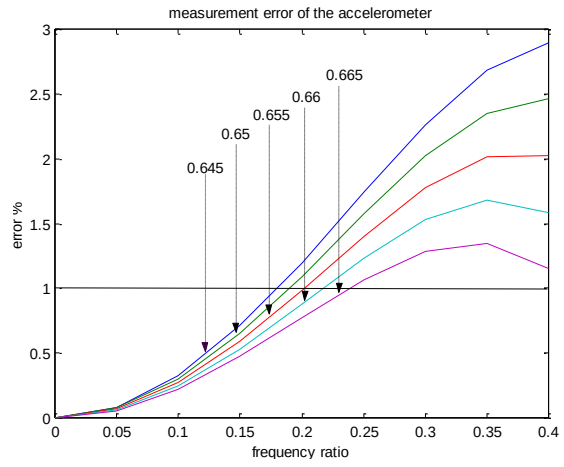

Fig.2. Results of first test

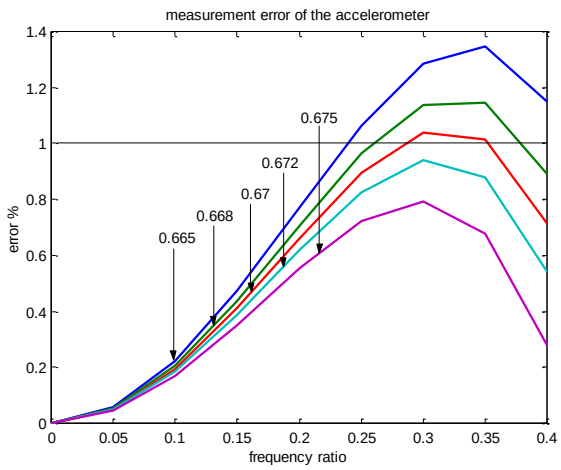

Fig.3. Results of second test.

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BALL-MILLED MAGNETIC MICROWIRES AND ITS INFLUENCE ON MICROWAVE ATTENUATION

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INTRODUCTION

Amorphous glass-coated microwires of 2mm length have been used to produce microwave attenuation composites, which properties depend on microwires aspect ratio and final length [1]. It has been suggested that electromagnetic suppression sheets made of ferromagnetic powder mixed with microwires would show higher bandwidth [2]. This study describes the obtainment of microwire powder (MP) and its use as an additive to 2mm-microwires for the fabrication of new composites.

METHODS

Fe-rich microwires were produced by the Taylor technique [3] and cut into 2 mm fragments (As-cast). High energy ball milling was carried out to reduce progressively the microwires length from 2mm to 30 μm. Composite sheets were fabricated by mixing a commercial paint with a suitable quantity of microwire-powder and microwires with 2 mm length.

RESULTS AND DISCUSSION

Composite sheets of different thickness, containing variable %wt of microwire-powder and 2mm-microwires, have been characterized at high frequency. As shown in Fig. 1, we have obtained attenuation values of -31 dB and a 60% higher bandwidth at -10dB level, as compared with composites made of 2mm-microwire.

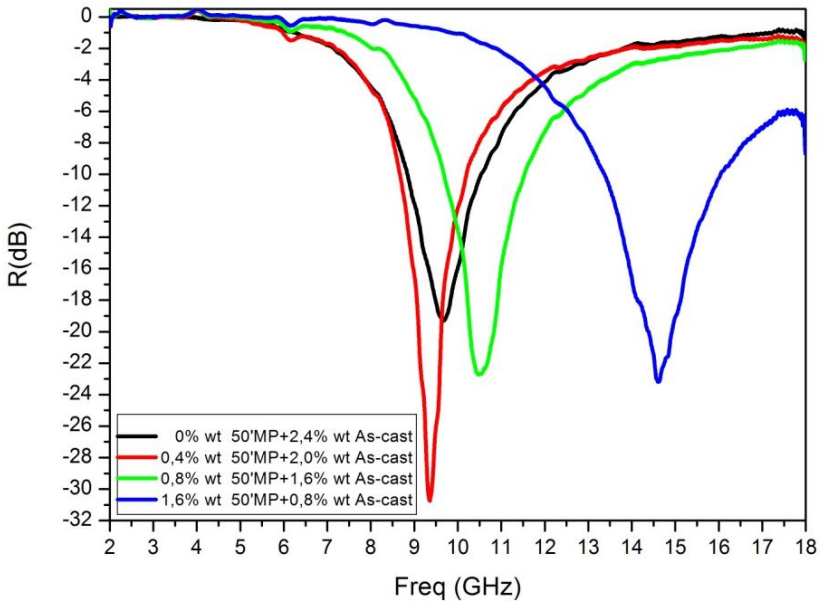

Fig.1. Reflection loss in relation to %wt of 50min microwire-powder and 2mm-microwires

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SYNTHESIS AND MAGNETOELECTRIC PROPERTIES OF FERROMAGNETIC / $PbZr_{1-X}Ti_XO_3$ (PZT) LAYERED HETEROSTRUCTURES

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ABSTRACT

Magnetoelectric properties of layered heterostructures FM/PZT/FM obtained by ion-beam sputtering deposition of ferromagnetic metal (FM), where FM is the cobalt (Co) or permalloy $Ni_{78}Fe_{22}$, onto ferroelectric ceramic based on lead zirconate titanate (PZT) have been studied. The polished ferroelectric plates in thickness from 400 to 20 μm were subjected to finished treatment by ion-beam sputtering. After plasma activation they were covered by the ferromagnetic fims from 1 to 6 μm in thickness. An enhanced characteristics of these structures were reached by means of both the thickness optimization of ferroelectric and ferromagnetic layers and obtaining of ferromagnetic/ferroelectric interfaces being free from defects and foreign impurities. Assuming on the basis of analysis of elastic stresses in the ferromagnetic film that the magnetoelectric effect forms within ferromagnetic/ferroelectric interface, the structures with 2-3 ferromagnetic layers were obtained. In layered heterostructure $(Py/PZT/Py)_3$, the optimal thickness of ferromagnetic film was 2 μm, and outer and inner ferroelectric layers had 20 μm and 80 μm in thickness, respectively. For such structure the maximal magnetoelectric voltage coefficient of 250 mV/(cm·Oe) was reached at a frequency 100Hz in magnetic field of 0.25T at room temperature. The structures studied can serve as energy-independent elements detecting the change of magnetic or electric fields in electronic devices based on magnetoelectric effect.

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INFLUENCE OF RECORDING FIELD DIRECTION ON TRANSITION NOISE OF STACKED MEDIA

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INTRODUCTION

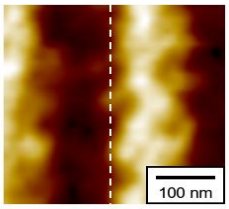
Transition noise is one of the serious problems in high density hard disks. Recording heads have trailing shield which controls recording field direction. We investigated influence of the field direction on the transition noise.

METHODS

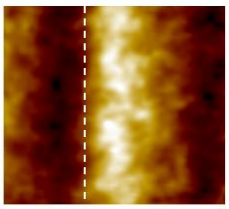
A signal with bit length of 100 nm was recorded on a commercial hard disk using magnetic printing [1]. The printing with perpendicular and in-plane field corresponds to head recording without and with the trailing shield, respectively. Magnetization state was observed with an MFM.

RESULTS AND DISCUSSION

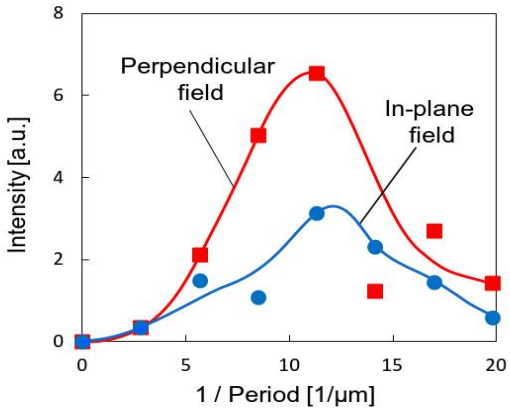
Figure 1(a), (b) shows MFM images for the hard disk recorded with perpendicular and in-plane field, respectively. Figure 1(c) shows FFT spectra along broken lines of (a), (b). For both perpendicular and in-plane field, a peak is observed at period near 90 nm, and the peak intensity for perpendicular field is about twice as high as that for in-plane filed. This result shows that the transition noise for in-plane filed is half of that for perpendicular field. And this reflects the domain structure of the demagnetized recording layer [2], in which stray field from the perpendicularly demagnetized recording layer doubles that from the in-plane demagnetized layer notwithstanding almost the same domain size of 40-50 nm for both the layers.



(a) MFM image for perpendicular field.



(b) MFM image for in-plane field.



(c) FFT spectra of MFM output along broken lines in (a), (b).

Figure 1 MFM analysis for transition area.

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SUPERCONDUCTOR-NORMAL METAL QUANTUM PHASE TRANSITION IN DISSIPATIVE AND NON-EQUILIBRIUM SYSTEMS

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In physical systems, coupling to the environment gives rise to dissipation and decoherence. For nanoscopic materials this may be a determining factor of their physical behaviour. However, even for macroscopic many-body systems, if the strength of this coupling is sufficiently strong, their ground state properties and phase diagram may be severely modified. Also dissipation is essential to allow a system in the presence of a time dependent perturbation to attain a steady, time independent state. In this case, the non-equilibrium phase diagram depends on the intensity of the perturbation and on the strength of the coupling of the system to the outside world [1].

In this work, we investigate the effects of both, dissipation and time dependent external sources in the phase diagram of a many-body system at zero and finite temperatures. For concreteness we consider the specific case of a superconducting layer under the action of an electric field and coupled to a metallic substrate [2-3]. The former arises from a time dependent vector potential minimally coupled to the electrons in the layer. We introduce a Keldysh approach that allows obtaining the time dependence of the superconducting order parameter in an adiabatic regime. We study the phase diagram of this system as a function of the electric field, the coupling to the metallic substrate and temperature.

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SPIN GLASS STATE IN THE $Bi_2Fe_{0.128}Te_{2.844}Se_{0.145}$ TOPOLOGICAL INSULATOR

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In our work the magnetic properties of single-crystal topological insulator $Bi_2Fe_{0.128}Te_{2.844}Se_{0.145}$ using SQUID magnetometer have studied. Figure 1a shows the temperature dependence of magnetization M(T) in magnetic field H=0.1 kOe measured both at cooling of sample from 300 K (FC curve) and at heating from T=4,2 K (ZFC).

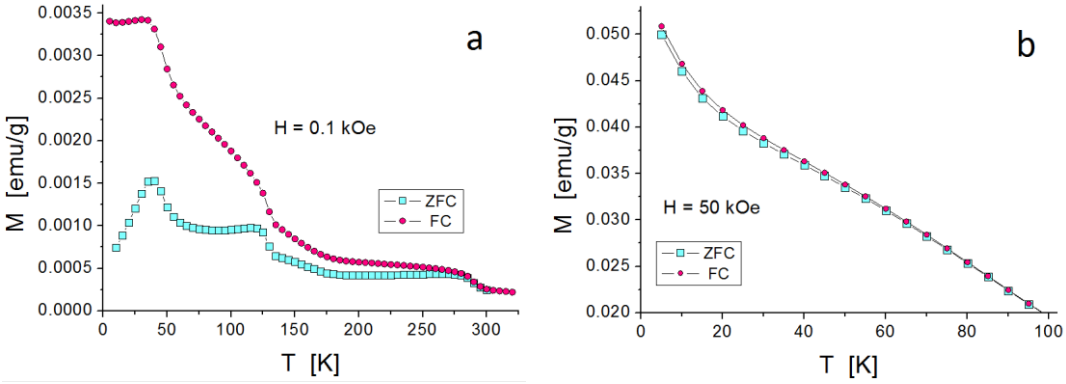

Figure 1. Temperature dependence of magnetization M(T) of $Bi_2Fe_{0.128}Te_{2.844}Se_{0.145}$ single crystal in magnetic field H=0.1 kOe (a) and H=50 kOe (b).

Figure 1a shows the picture typical for spin glass. There's a big difference between ZFC and FC curves and ZFC curve has maximum at T_f=40 K whereas FC curve don't have, and at $T<T_f$ magnetization don't depend on T. The difference between ZFC and FC curves decreases with the field increase and disappears in H~6 kOe. Figure 1b shows M(T) dependence at H=50 kOe. It follows from this Figure that magnetic moment of Fe ion at T=4,2 K is equal to 0.057 μ_B that's very small. It points to absence of long-range magnetic ordering between Fe ions and impossibility of the time reversal symmetry breaking [1] at mentioned doping of Bi_2Te_3 topological insulator.

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CRYSTAL GROWTH AND STRUCTURE OF THE ELECTRON-DOPED MANGANITES $CaMn_{0.9}W_{0.1}O_3$

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INTRODUCTION

Interest to electron-doped manganites on the basis of $CaMnO_3$ is caused by rich phase diagram in which different crystallographic and magnetic phases coexist. Substitution of Mn ions by Mo, W ions with greater valence is direct and strong influence on Mn-O-Mn bond. The purpose of this work is to investigate changes of $CaMnO_3$ structure at Mn replacement with tungsten and to grow $CaMn_{0.9}W_{0.1}O_3$ single-crystal.

METHODS

Polycrystalline samples of $CaMn_{1-x}W_xO_3$ with x=0-0.10 were produced by a standard solid-phase method. The $CaMn_{0.9}W_{0.1}O_3$ single-crystal was grown by floating zone. All samples were investigated by the X-ray diffraction and scanning microprobe.

RESULTS

At room temperature all the samples characterized by an orthorhombic symmetry Pnma (Table 1). The direction of single-crystal growth coincides with the [1 0 1].

W,%	a,Å	b,Å	c,Å	b/√2,Å	V,Å^3
0	5.289(0)	7.452(6)	5.266(0)	5.270	207.57
2	5.296(4)	7.465(4)	5.275(8)	5.279	208.60
4	5.305(2)	7.470(5)	5.281(0)	5.282	209.30
7	5.303(6)	7.488(1)	5.297(3)	5.295	210.38
10	5.322(3)	7.490(2)	5.346(5)	5.296	213.14
10 single	5.335(7)	7.492(2)	5.306(2)	5.298	212.12

Table 1 Lattice parameters of the samples $CaMn_{1-x}WxO_3$

The growth conditions and structure of $CaMn_{0.9}W_{0.1}O_3$ single-crystals have been determined.

ACKNOWLEDGMENT

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X-RAY IMAGING OF ALL-IN/ALL-OUT MAGNETIC DOMAINS IN THE PYROCHLORE $Cd_2Os_2O_7$

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The pyrochlore structure of the 5d transition-metal oxide $Cd_2Os_2O_7$ is long known, however its magnetic structure was only recently revealed to be the 'all-in, all-out' type [1]. This magnetic configuration can exist in two non-equivalent domains ('all-in/all-out' or 'all-out/all-in', fig. 1). It is expected to be related to the particular metal-insulator transition observed, requiring further investigations.

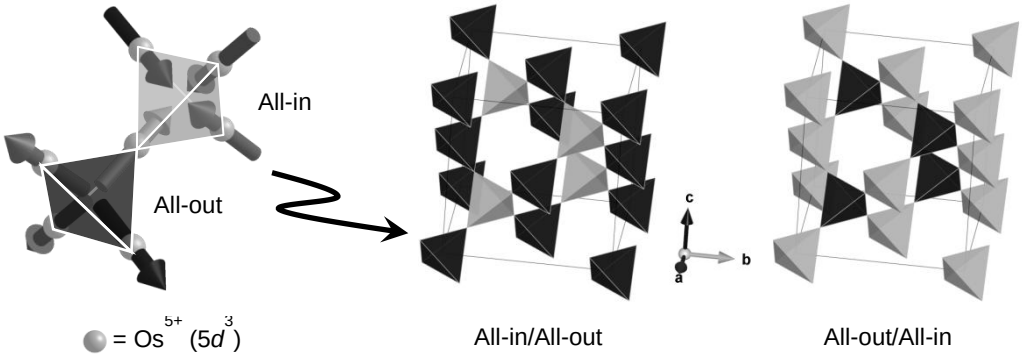

Figure 1. The 'all-in/all-out' (AIAO) and 'all-out/all-in' (AOAI) magnetic structure in $Cd_2Os_2O_7$.

In this study, we show that resonant circularly polarized x-ray micro-diffraction is a valuable novel tool for probing the local distribution of AIAO and AOAI magnetic domains. The technique was applied at SPring-8 BL19LXU in the case of $Cd_2Os_2O_7$ by imaging the interference between the charge and magnetic contribution in the (0 0 10) Bragg reflections at the osmium L_3 and L_2 absorption edges with submicron resolution in direct space.

The two types of antiferromagnetic domains were observed. The orientation of the interface between domains was investigated. Furthermore, the antiferromagnetic domains distribution could be controlled by cooling the sample in a static magnetic field.

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POLARONIC TRANSPORT IN THE METALLIC PHASE OF EPITAXIAL MANGANITE THIN FILMS

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Transport measurements of epitaxial $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) thin films were analysed in the framework of polarons in polar crystals [1] at the both sides of the metal-insulator transition (MIT). LSMO thin films are grown on matching substrates $SrTiO_3$ (100) and $NdGaO_3$ (110) by Channel Spark Ablation [2] and are measured in the temperature range 25 - 400 K.
The resistivity is proportional to the polaronic effective mass increase up to the MIT; the approximation of one dominant optical phonon mode is used for to fit the experimental curve, the raman mode at 425 cm^{-1} has been chosen as very characteristic for the analysed manganite compound [3]. An excellent agreement with the theory was found also in the temperature range below the MIT, where the films show metallic behaviour.
The polaron band transport describes the transport in the whole range of temperature below the MIT, up to room temperature, while an electron-electron scattering term can be added below 80 K. The numerical fits demonstrate the inadequacy of the $T^{4.5}$ or T^5 usually used to describe the transport in LSMO at the metallic side below MIT. The polaronic transport across the MIT is understood in the Charge Carriers Density Collaps (CCDC) picture [4].

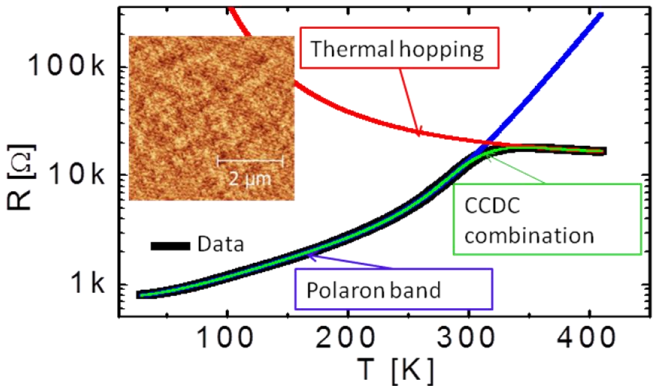

Figure 1: R(T) of a 9 nm thick LSMO/STO film, fits at the two sides of the MIT, and their combination according to the CCDC model; inset: AFM image of the surface, the rms roughness is 0.2 nm.

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MAGNETISM OF PEROVSKITE COBALTITES WITH KRAMERS RARE-EARTH IONS

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The ground state of *Ln*CoO_3 (*Ln* = La, Y or rare earths) is based on the non-magnetic low-spin state of octahedrally coordinated Co^{3+} ions. The magnetic properties at low temperatures are thus associated exclusively with presence of rare earths. The present study is directed to cobaltites with the Kramers ions *Ln* = Nd^{3+} ($4f^3$), Sm^{3+} ($4f^5$) and Dy^{3+} ($4f^9$). The experiments evidence an antiferromagnetic ordering with Néel temperature of 1.25, 1.50 and 3.60 K for $NdCoO_3$, $SmCoO_3$ and $DyCoO_3$, respectively. With increasing external field, the lambda peak in specific heat, indicative of the AFM transition, shifts to lower temperatures and vanishes for field of about 3 T. Starting from this point, a broader Schottky peak is formed, centered in 1 K range, and its position is moved to higher temperatures proportionally to applied field. The origin of the peak is in Zeeman splitting of the ground state doublet, and the gradual shift with field defines effective g-factors for the rare-earth pseudospins in studied compounds. The observed values are confronted with the calculations of crystal field splitting of the rare-earth multiplets. For this sake, the parameters of the crystal field are estimated based on the first principles electronic structure calculation.

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ULTRA-LOW TEMPERATURE MEASUREMENTS OF THE IN-PLANE PENETRATION DEPTH IN $FE_{1+Y}(TE_{1-X}SE_X)$ SINGLE CRYSTALS

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Using a radio frequency tunnel diode oscillator technique, we measured the temperature dependence of the in-plane London penetration depth $\Delta\lambda_{ab}(T)$ in $Fe_{1+y}(Te1_{-x}Se_x)$ single crystals, down to temperatures as low as 50 mK. A significant number of samples, with nominal Se concentration x=0.37, 0.40, 0.43 and 0.45 respectively, were studied and in most cases, we found that $\Delta\lambda_{ab}(T)$ shows an upturn below 0.7 K, indicative of a paramagnetic type contribution. After subtracting the magnetic background, the low temperature behavior of penetration depth is best described by a power law with exponent $n\approx2$ and with no systematic dependence on the Se concentration.

The work was supported by the National Science Foundation and Louisiana Board of Regents through LASiGMA program under Award No. EPS-1003897.

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A PAZZLE OF QUATUM PHASE TRANSITION IN Gd-IMC BY TUNING OF C.E.C

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INTRODUCTION

While the theory of magnetic moment formation in intermetallic compounds has been a controversial subject [1] , but one of the major items of dispute has been whether a model based on localized or itinerant electrons [2] or rather which of the concept of electron fluctuation hybridization or electron localization are dominant [3]. In Gd based materials since there is not crystal field and hybridization the character of c.e can be changed by the exchange interaction between localized 4f electron and the s(d) c.e.[4]. Hence the magnetic phase and electron transportation in 4f system are sensitive to the f-s (d) interaction and can be leads to formation of intra-site exchange “kondo”.

The quantum phase transition an AFM-metal from paramagnetic, by tuning a control parameter in which local moment are Kondo screened by conduction electron.

The phenomena form the basis of exchange dispersion during strong induced spin polarization. Here, we report how unstable broad dynamical curie order transform, define on the stable-s-state of “Gd” could be changed suppressed to AFM and then P.M by chemical pressure (c.e.c), heat treatment , mechanical shape as well as magnetic field at critical composition (c.e.c). Since there is no CFE and hybridization, by contribution of c.e to the magnetic correlation the K_f tuned itself to shift the topological magnetic ions to minimize the correlation length $R_C=2k_fR_{ij}$ at critical point at which ;The system is close to critical value, near the double FM-AFM percolation threshold, where the magnetic ordering $T_0$and condo temperature T_c are coincidence.

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COLLAPSE OF PROTEIN MACROMOLECULE INDUCED BY A FORCE AS AN ANALOG OF REMAGNETIZATION

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Recently, methods to investigate protein unfolding at the single-molecule level have been developed. In experiments, the stretching force is applied between a pair of amino-acid residues and the dependence of the distance between them is measured as a function of the force. Those dependencies share the common property – all of them demonstrate the general feature: when the force reaches some critical value, the protein begins to flow out, i.e., its length decreases readily without further force increasing. That looks like a sharp phase transition and analogous to the coercive remagnetization of ferromagnets.

Describing that transition is also possible in terms of the “magnetic” mean-field theory which predicts the phase transition of a protein macromolecule from the elastic to plastic state under the mechanical stretching. As in the “magnetic” Ising model, the critical force depends significantly on the mean number of links per one amino-acid residue – the larger that number, the higher the force turning the protein in the plastic state. Proteins with the mean coordination number less than some critical value could not exist in the globular form – arbitrarily small force destroys that state.

Outlined results are generally agree with experiments. That gives ground for considering the “magnetic” effective field theory as a model for adequate describing integral mechanical properties of proteins.

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SELECTIVE DETECTION OF URIC ACID USING URICASE ON FERROCENE-NAFION MODIFIED GLASSY CARBON ELECTRODE

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ABSTRACT:

Uric acid(UA) is the primary end product from purine derivatives in human metabolism. Excessive production of uric acid may lead to gout, hyperuricemia and kidney disorder. The main purpose of this research was to develop an inexpensive uric acid biosensor using uricase enzymeas specific detector element, ferrocene as electron mediator and nafion as cation exchanger. Ferrocene was electrochemically deposited on nafion modified enzyme film immobilized on glassy carbon electrode[1]. The film was characterised by SEM, AFM, XRD and FTIR. The analysis was carried out by cyclic voltammetry(Fig 1), amperometry and differencial pulse voltammetry [2]. UA was detected in the concentration range of 0-150 M. The response time was 4-6s. Interference of ascorbic acid was separated from UA. The linearity of the standard curve in the above concentration range was satisfactory and has been used for the quantitative determination of uric acid in real sample. The developed biosensor was easy to use, less costly, sensitive and reliable.

FIGURES:

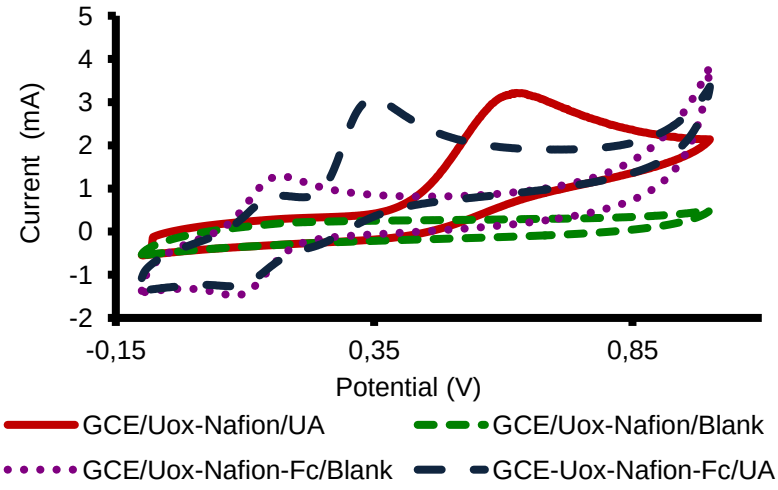

Fig 1: Cyclic voltamogram showing anodic peak for selective oxidation UA.

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MAGNETIC NANAOPARTICLES SYNTHESIZED BY CHEMICAL SLICING METHOD

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Magnetic nanoparticles (MNPs) are potentially useful in adjuvant cancer therapy in the form of magnetic hyperthermia (MH) by localization of treatment to cancerous tumour with minimum side effects to the patient [1]. We propose a novel MNP fabrication method using template-assisted electrodeposition. First, multi-layer Ni_xFe_{1-x} nanowires are fabricated within an AAO template which is immersed in a chemical bath. The composition of the Ni at each layer is determined by the applied potential at the deposition sequence. The nanowires are then etched by HNO_3. Due to the differential etching rate, some of the NiFe layers will be completely removed, while the layers that are not dissolved remain as disc-shaped nanoparticles, as shown in the Figure 1(a). Inset is a magnetic force microscopy image of the magnetization configuration of the MNPs. This approach is able to accommodate more than 200 layers per AAO template, thereby yielding 200 times more MNPs than a lithography substrate of equal size. Micromagnetic simulation was performed to understand the magnetic configurations. Simulation results show that MNPs with diameter 100nm can accommodate two distinct vortex magnetization configurations during the reversal process, as shown in Figure 1(b). The switching between the two configurations is expected to generate heat that can be potentially used to destroy cancer cells.

(a) (b)

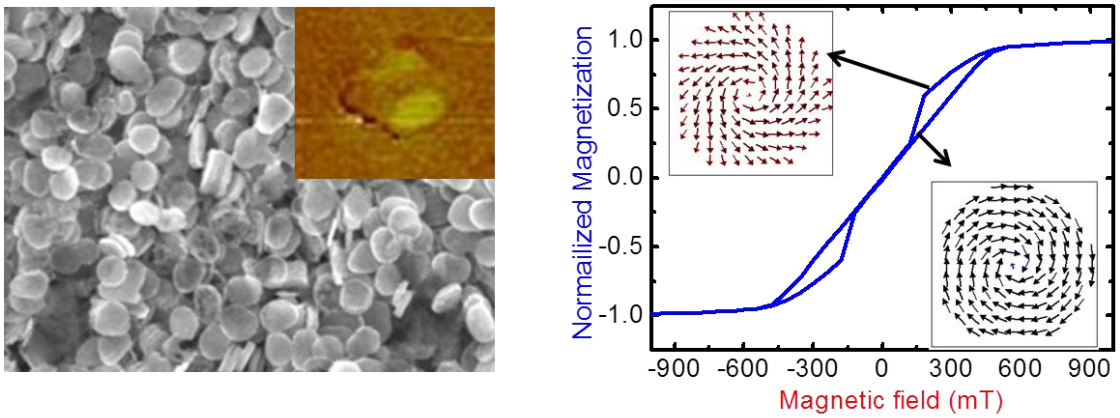

Figure 1 (a) Scanning Electron Microscope image of the MNPs. Inset is the MFM image. (b) The simulated hysteresis loop of the magnetic nanoparticle.

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THE EFFECT OF PULSED ELECTROMAGNETIC FIELD THERAPY ON DELAYED-ONSET MUSCLE SORENESS IN BICEPS BRACHII

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Delayed onset muscle soreness (DOMS) is one of the common painful muscle conditions following unaccustomed physical activity or exercise [1]. Various therapeutic interventions have been applied to reduce the intensity and duration of the DOMS related symptoms. Recently, the pulsed electromagnetic field (PEMF) therapy has been proposed as an alternative noninvasive treatment for DOMS [2]. The main purpose of this randomized, double-blind, placebo-controlled experiment was to compare the effects of the PEMF therapy on DOMS in elbow flexors to the sham treatment at 24, 48 and 72 hours after the DOMS induction exercise. 30 healthy volunteers (23 ± 2.5 ys, 175 ± 5.8 cm, and 74 ± 9.2 kg) were recruited and randomly assigned to PEMF and placebo groups. DOMS was induced in the elbow flexors by repeating slow (60°/s) and fast (120°/s) isokinetic motions. Treatment was applied for 10 mins daily with each of the real and placebo PEMF devices according to group allocation. Overall, application of PEMF was found to be effective in reducing the physiological deficits associated with DOMS including perceived soreness, median frequency and electromechanical delay of the surface electromyography during isometric contraction. However, there were no positive evidences of the PEMF treatment on the isometric peak torque generation compared to the placebo treatment. In conclusion, this study suggests a possibility to use PEMF as a new modality in reducing DOMS symptoms. However, further experiments are required to examine the underlying mechanisms of the PEMF therapy and to determine the optimal treatment dosage and duration.

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ACCESSING INFORMATION ON KIDNEY STONES WITH TECHNIQUES OF APPLIED PHYSICS: POSSIBLE DIAGNOSTIC VALUE

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INTRODUCTION

Nephrolithiasis is a silent impairment that motivates/promotes important urinary/renal complications [1-2]. Extracorporeal lithotripsy is a minimally invasive technique for deconstruction of kidney stones (KS). Here, we investigated KS aiming to find new diagnostic post-operative approaches for prevention from nephrolithiasis recurrence.

METHODS

Scanning Electron Microscopy (SEM), Energy-Dispersive X-ray Spectroscopy (EDS) and X-ray diffraction (XRD) were employed to study KS of a male patient subjected to lithotripsy after a colic episode (right ureteral obstruction and insertion of 'pig-tail' catheter). The KS were isolated from a 48-hour urine collection, after lithotripsy.

RESULTS

The KS had diverging elemental composition and chemical structure. They consisted of both endogenous blood constituents (electrolytes: Ca, P, etc) and exogenous components that accumulate through the dietary/fluid intake (Si and Al).

CONCLUSIONS

Techniques of applied Physics (SEM/EDS/XRD) can unveil precise elemental composition and chemical structure of KS. This information could empower clinicians to provide personalized nutritional/pharmaceutical guidelines to patients for prevention from KS reformation.

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MAGNETIC PROPERTIES OF A NEW QUASI 1D SODIUM COBALT TELLURATE

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A new quasi one-dimensional compound $Na_{3.9}Co_{1.05}TeO_6$ was prepared by conventional solid-state reactions and its structural and magnetic properties were investigated. It represents a novel monoclinic superlattice type derived from α-$NaFeO_2$ which, in turn, is a superlattice of the rock-salt type. All cations and anions are in distorted octahedral coordination. The magnetic ions (Co^{2+}) herein form 1D chain, providing lower-dimensional conditions for magnetic interactions. The compound was found to order antiferromagnetically at low temperatures with T_N~3 K. The magnetization isotherms do not display a hysteresis and saturation in magnetic fields up to 5 T, but indicate a presence of competing antiferro- and ferromagnetic interactions and reveal a sharp spin-flop type transition at T<3 K in applied field of ~ 0.18 T. The ESR spectra show non-trivial behavior with at least three different dynamic regimes over the temperature range investigated. In the paramagnetic phase (80-300 K) we observed a superposition of two Lorenzian-shaped absorption lines probably corresponding to two different magnetic subsystems in the compound. The temperature dependence of their parameters is rather complicated revealing a presence of two anomalies (possible crossover transitions) at about 220 K and 110 K respectively. At lower temperatures, in the pre-ordering phase 20-70 K, the resonance signal weakens progressively and merges into one line, which, in its turn, becomes markedly anisotropic. Eventually, at helium temperature, a strong broad line shifted to lower fields is observed, indicating approaching the long-range ordering transition and concomitant opening of the energy gap for resonance excitation.

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TRANSFORMATIONS OF SPACE-MODULATED STRUCTURES IN $BIFEO_3$ – LIKE MULTIFERROICS

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Multiferroic materials attract a great attention of scientists and technologists. Interplay between spins, charges, orbital and lattice degrees of freedom leads to variety of couplings and phase transitions representing the interest for fundamental research and tailored for a wide range of applications. Although the number of multiferroic materials permanently increases the one of the most studied multiferroics remains bismuth ferrite ($BiFeO_3$) with high temperatures of ferroelectric T_C=1083 K and antiferromagnetic ordering T_N=643 K [1]. Magnetic structure of $BiFeO_3$ is the G - type antiferromagnetic structure subjected to cycloidal modulation with period of 62 nm [2]. Experiments show that cycloid is suppressed in high magnetic fields [3] and is not always observed in the $BiFeO_3$ thin films [4].

We have theoretically investigated the incommensurate magnetic structures and phase diagrams of $BiFeO_3$ – like multiferroics. We predict novel quasi-cycloidal structures induced by external magnetic field or by epitaxial strain in the $BiFeO_3$ films and construct phase diagrams for two essential geometries: magnetic field oriented parallel to the principal crystal axis and perpendicular to this direction. The main control parameters are the magnetic field, the magnetic anisotropy, and the epitaxial strain in the case of films. Phase diagram representing the regions of homogeneous magnetic states ("easy axis" (EA), easy plane'' (EP)) and incommensurate structures (plane cycloids Cy and cone cycloids CC) stability for a case $H_{\parallel} \parallel [111]$ is represented in Figure 1.

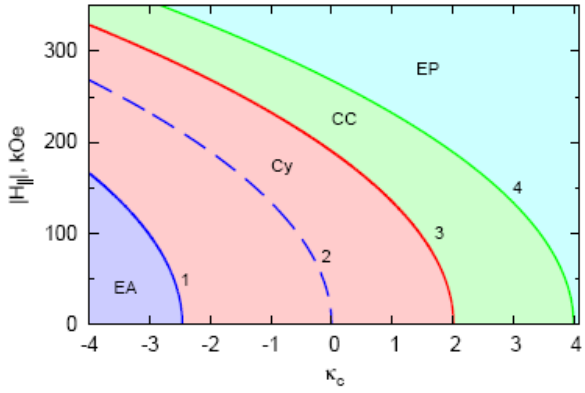

Figure 1. Phase diagram of $BiFeO_3$ film. $H_{\parallel}$ is the magnetic field applied along [111] axis, κ_c is the reduced constant of magnetic anisotropy .

It is shown that the direction of applied magnetic field substantially affects a set of magnetic phases, properties of incommensurate structures, character of phase transitions. Novel conical type of cycloidal ordering is revealed during the transition from incommensurate cycloidal structure into homogeneous magnetic state. Elaborated phase diagrams allow estimate appropriate combination of control parameters (magnetic field, magnetic anisotropy, exchange stiffness) required to the destruction of cycloidal ordering corresponding to the transition into homogeneous structure.

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PHYSICAL PROPERTIES OF UNIQUE MIXED-VALENCE QUASI-ONE DIMENSIONAL LITHIUM-MANGANESE TELLURATE SYSTEM

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Complex Mn oxides represent currently one of the most intriguing classes of materials due to their unique physical properties and potential applications. $LiMn_2TeO_6$, a new member of the family of Mn (II/III) mixed-valence compounds with quasi-1D magnetic structure, was comprehensively studied using neutron powder diffraction, measurements of magnetic susceptibility and magnetization, specific heat, electrical conductivity, dielectric loss tangent and dielectric susceptibility, polarization and ESR spectroscopy. The measurements were performed over a wide temperature ranges and external magnetic and electric fields. Possessing valency of manganese 2.5 this compound is very differs from similar materials exhibiting CMR effects, but with degree of Mn oxidation between 3 and 4 which are intensively studied last years. The transition to a long-range antiferromagnetic ground state occurs in two steps at T_{N1} and T_{N2} of approximately 20 and 13 K respectively as it was inferred from the magnetic susceptibility and specific heat data. This is well consistent with results of neutron powder diffraction studies and is attributed to transition from the incommensurate to the commensurate magnetic phase. At temperatures higher T_2 the magnetic susceptibility follows the Curie-Weiss law, indicating antiferromagnetic interaction between Mn ions. The magnetization curves exhibited a field-induced transition at $T < T_{N2}$ in moderate magnetic fields, suggesting that the magnetic ground state is rather complicated. We propose herein the temperature vs. magnetic field phase diagram that agrees well with our experimental findings. The model of magnetic structure showing that magnetic interaction between MnO_6 chains – ferromagnetic, and within chains – antiferromagnetic is constructed. Room temperature conductivity is unexpectedly low for a mixed-valence compound, 2×10^{-7} S/cm. Value of the polarization is ≈ 100μC/m^2 at 10K.

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EXPLORING THERMALLY-INDUCED STATES IN SQUARE ARTIFICIAL SPIN-ICE ARRAYS

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INTRODUCTION

We present a novel methodology [1] to explore experimentally the formation of thermally-induced long range ground-state ordering in artificial spin-ice systems [2]. This protocol is based on the thermalization of a square artificial spin-ice array of 300x100x25nm nanoislands made of a NiFe alloy characterized by a Curie temperature about 100K lower than that of Permalloy. It consists of cooling down the nanoislands from above their blocking temperature without damaging the sample, being the magnetization configuration resulting by this thermal excitation analyzed by means of magnetic force microscopy. We observe long-range ground-state magnetic ordering regions separated by type II and III vertex excitations chains (Fig.1). This thermally induced demagnetization protocol can be repeated as many times as desired on the same sample, and the heating/cooling parameters can be varied at will. Thereby, this approach opens the pathway to the systematic experimental study of the thermally induced frozen states in artificial spin-ice systems, which has been subject of many recent theoretical studies.

FIGURES

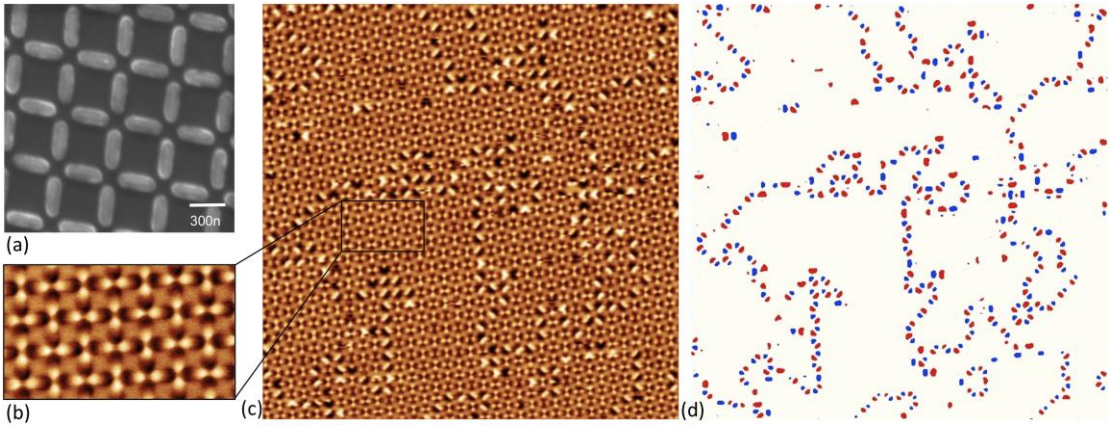

Fig.1: SEM image of our sample (a), followed by a MFM image after our thermal demagnetization protocol has been applied (c), with an inset showing ground-state ordering (b), and the type II and III vertex excitations (blue and red contrasts) forming chains between ground-state ordering regions (white contrast) (d).

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MULTIFERROICITY IN DOPED AND UNDOPED $BaTiO_3$ NANOPARTICLES

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INTRODUCTION

Multiferroics that exhibit magnetoelectric coupling are widely discussed from quite different context [1, 2]. Moreover, nanoparticles (NP) of inorganic materials including nonmagnetic oxides such as CeO_2, MgO, ZnO, SnO_2, and other functional materials like superconductors and ferroelectrics were shown to be ferromagnetic at room temperature. The magnetism in these NP has been suggested to be intrinsic and originates from cation or anion vacancies at the surfaces of the NP. Very recently, it was reported from both experiments and first-principles calculations that typical ferroelectric materials such as $BaTiO_3$ (BTO) and $PbTiO_3$ (PTO) become multiferroic when they are prepared at the nanoscale [3-5]. So, nanocrystalline BTO offers a room-temperature magnetic hysteresis as well as temperature-dependent dielectric constant and a polarization.

Based on a microscopic approach we demonstrate that the unexpected ferromagnetic properties of $BaTiO_3$ (BTO) are due to oxygen vacancies at the surface of the nanocrystalline materials. Such vacancies lead to the appearance of Ti^{3+} or Ti^{2+} ions with nonzero net spin. The resulting different valence states composed of Ti^{3+} or Ti^{2+} offer a nonzero magnetization which decreases with increasing particle size. The system shows a multiferroic behavior below a critical size of the nanoparticles and the related polarization tends to a saturation value when the particle size is enhanced. We also have calculated the temperature, magnetic field and ion dopling dependence of the magnetic and electric properties in doped BaTiO3 as well.

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STRAIN MEDIATED ELECTRIC CONTROL OF MAGNETIZATION IN SELF-ASSEMBLED VERTICAL NANOCOMPOSITE MULTIFERROICS

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Self-assembled nanocomposite $CoFe_2O_4$–$BaTiO_3$ (CFO-BTO) thin films were grown by pulsed laser deposition on (001) oriented $Pb(Mg_{1/3}Nb_{2/3})_{0.72}Ti_{0.28}O_3$ (PMN-PT) substrate. The CFO and BTO targets were ablated alternately to grow vertical nanostructures consisting of CFO nanopillars embedded in BTO matrix, because of flexibility of this method in terms of control over the film composition as compared to single composite target approach [1].

X-ray diffraction scan revealed the presence of the two epitaxially grown phases and was used to find-out the lattice parameters of both constituents. The surface morphology of the CFO-BTO films reveal rectangular CFO pillars protruding out of flat BTO matrix. The magnetic hysteresis loops measured by SQUID magnetometer showed that the highly magnetostrictive CFO phase under epitaxial strain from the BTO matrix, exhibit strong out-of-plane anisotropy. Changes in the magnetic properties, studied under different strain conditions induced by an electric field applied to the PMN-PT substrate, demonstrate the room-temperature control of the magnetization with an electric field [2].

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Microscopic Coexistence of Antiferromagnetism and Spinglass states

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Coexistence of long-range magnetic order with spinglass state has long been a matter of debate. While mean-field theories consider a spinglass freezing of spin components transverse to long-range order parameter in both ferromagnetic (FM) [1] and antiferromagnetic (AF) [2] models, an experimental evidence for uniform coexistence is lacking. $PbFe_{1/2}Nb_{1/2}O_3$ (PFN) is a disordered antiferromagnet that undergoes spinglass transition at T_{SG} <12 K while retaining AF moment. To understand the nature of its ground state, we have investigated PFN by combining Mössbauer spectroscopy and neutron diffraction, probing both local and bulk magnetic properties respectively. These complementary techniques enable us to demonstrate microscopic coexistence of the antiferromagnetic and spin-glass orders in PFN below T_{SG} [3]. We propose that this ground state is a speromagnet-like phase featuring frozen-in short-range fluctuations of Fe^{3+} magnetic moments that are transverse to long-range ordered antiferromagnetic spin component.

This work is partially supported by Swiss National Fund through MANEP.

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MAGNETOCALORIC EFFECT IN A FRUSTRATED BLUME-CAPEL MODEL

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INTRODUCTION

The magnetocaloric effect (MCE) is characterized by the isothermal magnetic entropy change ΔS, when an external magnetic field is varied. Depending on the sign of the temperature derivative of the magnetization, it can be either negative (a conventional MCE observed in regular ferromagnetic materials) or positive (an inverse MCE). In the former case the sample heats up when the external magnetic field is applied adiabatically, while in the latter case it cools down.

METHOD

We consider an antiferromagnetic spin-1 Blume-Capel model on a triangular lattice in an external magnetic field h, described by the Hamiltonian

$$H = -J \sum_{<i,j>} s_i s_j - D \sum_i s_i^2 - h \sum_i s_i \ , \qquad [1]$$

where $J < 0$ and $s_i = \pm 1, 0$. By Monte Carlo simulations we study the thermal variation of the magnetization M, for a range of the parameters h and D, and from the thermodynamic Maxwell equation evaluate ΔS as

$$\Delta S(T,h) = \int_0^h \left(\frac{\partial M}{\partial T} \right)_h dh. \qquad [2]$$

RESULTS AND DISCUSSION

The system is found to display considerable entropy changes near the field-induced phase transitions. Depending on the value of D, the changes can be either negative or positive. The former are typically observed for $D \geq 0$, similar to the spin-1/2 case, i.e., $D \to \infty$. For $D < 0$ the sign of ΔS changes to positive in some field ranges, which tend to expand with decreasing D.

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MAGNETIC ORDER IN Mn AND Co IN $Mn_{0.85}Co_{0.15}WO_4$ BY RESONANT MAGNETIC X-RAY SCATTERING

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INTRODUCTION

In the reference $MnWO_4$ frustrated type-II multiferroic magnetic and ferroelectric orders coexist and mutually interact. At low temperatures (~7.5-12.5 K), the development of an incommensurate (ICM) magnetic Mn cycloidal spin structure (AF2 phase) is responsible for the appearance of a net electric polarization along the crystal *b*-axis [1-3].

A small partial substitution of Mn by Co tends to stabilise AF2 down to the ground state. For more than ~ 7.5% Mn ions replaced by Co the ground state corresponds to a new ICM phase, defined as AF2' or AF5 [4]. For a larger doping the presence of Co drives the appearance of a commensurate (CM) antiferromagnetic collinear phase, called AF4.

In $Mn_{0.85}Co_{0.15}WO_4$, AF4 is observed in the interval 10< T< 17 K. We have performed resonant magnetic x-ray scattering (RMXS) with soft x-rays (Mn, Co $L_{2,3}$ absorption edges) on $Mn_{0.85}Co_{0.15}WO_4$ to independently analyze the magnetic order in Mn and Co ions. A full polarization analysis of the incident and scattered x-rays permits us to provide a complete picture of the order of Co and Mn magnetic moments in the CM AF4 phase. Co spins turn out to be antiferromagnetically ordered and seem to strongly influence Mn spins alignment direction. We discuss these results in the frame of a large Co single ion anisotropy as reported in $CoWO_4$ [5].

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MAGNETIC SUSCEPTIBILITY ANOMALIES FROM MULTIFERROIC COUPLING EFFECTS – APPLICATION TO $CdCr_2S_4$

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INTRODUCTION

Magnetoelectric materials, which present induction of magnetization by means of an electric field and induction of polarization by means of a magnetic field, are the object of intense ongoing research, in aims of novel applications [1]. Recently, the properties of relaxor-type ferroelectrics, such as CdCr2S4, have been the object of intense discussion [2,3]. The coupling between macroscopic properties in multiferroics has origins at the atomic-level, and a comprehensive analysis at the macro and atomic scales will give us further insight on the phenomena behind the properties of these materials.

RESULTS AND DISCUSSION

By a pair distribution function (PDF) analysis of x-ray powder diffraction (XRD) data to directly study the local environment of the Cr^{3+} ion in $CdCr_2S_4$, we show the appearance of random off-center displacements at ~ 120 K, above the (magnetic) Curie temperature of the system, ~ 85 K.

Detailed analysis of inverse magnetic susceptibility show an anomalous behavior, from ~ 120 K down to Tc, which disappears under applied magnetic fields above 1 kOe. This type of behavior is usually referred to as “Griffiths phase-like”.

We here show that the anomalous behavior of the magnetic susceptibility of this system can be described by a modified Landau theory model with linear coupling between the magnetic and polar order parameters [4]. This approach allows a quantitative analysis of these coupling effects, leading to a value of the linear magneto-electric coefficient ~ 1×10^{-2} mV/(cm Oe), which is within typical values for single-phase multiferroics.

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MECHANISM OF SPIN-WAVE DRIVEN MOTION OF DOMAIN WALL IN FERROMAGNETIC NANOSTRIPE

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INTRODUCTION

The control of the domain wall (DW) position with a propagating spin wave (SW) is an alternative to the application of a voltage or a magnetic field along whole the distance of the DW transmission. In contrast to the established prediction of the SW-driven motion of the DW backward relative to the direction of the incident wave propagation, recently, the forward DW motion in nanostripes has been observed in simulations [1]-[4]. This effect is mediated by internal excitations of the DW (Winter-like modes) that overlap and get into the resonance with the propagating SWs. The coincidence of the frequencies of the localized and propagating SWs is possible because of the width-quantization of them in the stripe.

METHOD

The SW-DW interaction is studied analytically. An effective equation of motion of the magnetization waves in the presence of the DW is written in the exchange limit of micromagnetics. It enables the evaluation of the frequencies of the DW excitations. In order to estimate the corresponding (resonance) velocities of the DW, an established theory of the SW-DW interaction in bulk ferromagnets is applied. It predicts the velocity of the SW induced motion of the DW is proportional to the difference of the squares of amplitudes of the reflected and incident SWs. However, the influence of the Fano-like resonance with the localized mode and of the dynamic dipole field of the incident SW on the coefficient of the SW reflection from the DW are included.

RESULTS AND DISCUSSIONS

Formulae for the frequencies of the DW excitations (with dependence on the stripe width and thickness) and the corresponding velocities of the transverse-DW motion (with dependence on the stripe sizes and on the distance between the DW and the SW source as well as on the amplitude and frequency of the magnetic field in the source) are obtained and numerically verified on the basis of [1]-[4]. Limitations in terms of the vortex DW are discussed.

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CHEMICALLY STABLE HEUSLER NANOPARTICLES SYNTHESIZED BY FILLING CARBON NANOTUBES

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INTRODUCTION

Research on nanoscale materials is motivated by the observation that properties of materials may completely change, when scaling a bulk-material down to its smallest size. However, the synthesis of nanoscale materials brings along several challenges, e.g. oxidation due a large relative surface area. This hurdle has so far obstructed the full exploration of the behavior of interesting metallic alloys and especially of Heusler compounds on the nanoscale.

RESULTS

We have filled carbon nanotubes with the Heusler compound Co_2FeGa in the form of crystalline nanoparticles via a wet chemical approach. We observe that carbon nanotubes offer a convenient way to synthesize Heusler materials as chemically stable spherical nanoparticles with a well-defined diameter distribution and meanwhile provide a way to suppress oxidation (see figure 1). The ferromagnetic Co_2FeGa nanoparticles show a pronounced enhancement of the coercive field compared to the bulk material, while the saturation magnetic moment and the high Curie temperature known from the bulk are preserved at the nanoscale.

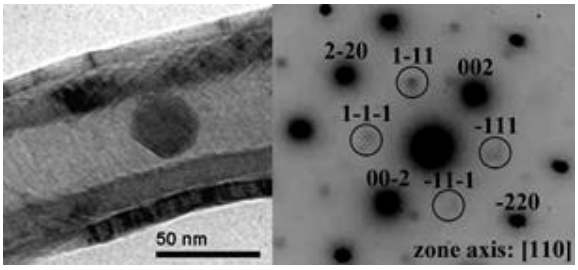

Figure 1: Bright field transmission electron image and electron diffraction pattern of a Co_2FeGa particle inside a carbon nanotube observed from a [110] zone axis.

TUESDAY POSTER

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ROLE OF JOULE HEATING IN NONLINEAR ELECTRICAL RESPONSE OF $Tb_{0.5}Sr_{0.5}MnO_3$ SINGLE CRYSTAL

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Nonlinear electrical behavior and electric field induced changes in resistance (electroresistance) in mixed valence manganites are extensively studied [1,2]. In many systems, Joule heating (JH) is observed to cause colossal electroresistance (CER) and negative differential resistance (NDR) [3]. Systematic experimental investigations to understand the role of JH in nonlinear electrical behavior are few in manganites.

Highly nonlinear I-V characteristics and colossal electroresistance is observed in $Tb_{0.5}Sr_{0.5}MnO_3$ (TSMO50) single crystal at low temperatures. The overall temperature dependence of resistance of TSMO50 is insulating and magnetic studies have revealed a glassy phase at low temperature (~42 K). Two experimental approaches are tried to study the JH effect on TSMO50, first, by measuring the sample surface temperature while performing the dc I-V measurements to estimate the Joule heating, and second, by using pulse currents to reduce the Joule heating effect. In the first experimental approach, a significant change in sample's surface temperature compared to the base is observed while passing currents at low temperatures. The effect of Joule heating is prominent in R-T plots for different applied dc currents. By careful control of the duty cycle, pulsed current I-V measurements could reduce the Joule heating significantly. From the combined experimental results we inferred that Joule self-heating effects play a major role in the nonlinear behavior of transport properties of TSMO50.

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CURRENT-INDUCED DOMAIN WALL MOTION IN ULTRA-THIN LAYER WITH STRONG SPIN-ORBIT INTERACTION

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Current-induced domain wall motion in asymmetric structures like Pt/Co/AlOx trilayers with perpendicular anisotropy has proven to be more complex than the standard description taking into account only the adiabatic and non-adiabatic terms of the spin transfer torque. In fact, the strong spin-orbit interaction and non-centrosymmetric crystalline electric field increase the efficiency of the spin-transfer torque [1]. They induce the existence of an effective magnetic field H_{SO} and an effective torque T_{SO} [2], both in-plane and perpendicular to the stripe axis, whose origin, which can be due to interface phenomena (Rashba effect) or to bulk effects (spin Hall effect), is presently debated [3]. These effects considerably change the domain wall dynamics [4].

In order to determine the symmetry of the different torques and their influence on the domain wall dynamics, we have studied field- and current-induced domain wall motion in $Pt_{3nm}/Co_{0,6nm}/AlOx_{2nm}$ nanostripes, in the presence of in-plane magnetic fields both transverse (H_T) and parallel to the stripes. Domain wall motion was studied using Kerr microscopy. In the case of current-induced domain wall motion, we surprisingly find a continuous variation of the domain wall velocity with H_T, with a linear dependence of the domain wall mobility on H_T. This observation, as well as some other results we obtained, show that the STT, the effective spin-orbit field H_{SO} and the spin-orbit torque T_{SO} have to be taken into account, in addition to the possibility of the presence of Néel walls as recently proposed [5,6].

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SPIN TRANSPORT IN GERMANIUM: OPTICAL AND ELECTRONIC MEASUREMENT OF THE SPIN DIFFUSION LENGTH

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Ge-based spintronic devices have recently deserved great attention, thanks to the compatibility with Si-based electronics, the large carrier mobility, the possibility of optical spin pumping and electrical spin manipulation. Moreover, because of the inversion simmetry, the D'yakonov-Perel' spin relaxation mechanism is inhibited in Germanium, leading, in principle, to a larger spin diffusion length than in the non-centrosymmetric GaAs.
In order to characterize the spin diffusion length of carriers in Germanium, in this contribution we report on both optical and electronic measurements on Fe/MgO/Ge and CoFeB/MgO/Ge heterostructures.
Optical measurements have been carried on by Fe/MgO/Ge(001) spin-photodiodes [1], while electrical measurements (non-local transport measurements and Hanle effect) have been performed on lateral CoFeB/MgO/Ge(001) devices fabricated by electron beam litography.
For electrons a typical spin diffusion length $\lambda_S \sim 1\mu m$ has been measured, while λ_S for holes ($\sim$200nm) resulted 10 times larger than expected. In order to further increase λ_S of a factor $\sim$3, electrical measurements on strained Ge(111) will be performed, in order to show whether the strain is effective in increasing the spin diffusion length of carriers by removing the degeneracy of the conduction band minima, according to first principles calculations [2].

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RELAXATION OF PROPAGATING SPIN WAVES IN YTTRIUM IRON GARNET/PT BILAYERS CONTROLLED BY THERMAL GRADIENTS

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ABSTRACT

The discovery of the spin Seebeck effect (SSE) in structures with the ferrimagnetic yttrium iron garnet, $Y_3Fe_5O_{12}$ (YIG), has opened new possibilities for processing information carried by spin waves. The spin currents generated by thermal gradients through the SSE are usually detected by the voltage generated in a normal metal by means of the inverse spin Hall effect. We present an experimental investigation of the action of spin currents due to SSE on the relaxation rate of spin waves. Propagating spin-wave packets with frequencies in the range of 1-2 GHz, are launched in film strips of single-crystal YIG while a thermal gradient created by a Peltier module is applied across the thickness in the longitudinal SSE configuration. We observe a striking change in the amplitude of the detected spin-wave pulses if the YIG film is covered with an ultrathin platinum layer. Depending on the sign of the thermal gradient, the spin-wave relaxation rate can be increased or decreased, leading in the latter case to an apparent amplification [1]. The change in the relaxation rate is attributed to the action of a spin current generated in the YIG film by the SSE while the role of the Pt layer is to supply or absorb the flow of spins.

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MAGNETO-TRANSPORT IN MnAs/GaAs(100) NANO-RIBBONS

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Hybrid metal/semiconductor systems are interesting in spintronics. In particular, MnAs is a magnetic metal that grows epitaxially on the semiconductor GaAs. A lot of work has been made towards the understanding of charge-transport and magnetism in these systems [1]. Bulk MnAs presents a magneto-structural first-order phase transition at $T_C \approx 40ºC$, where the low-temperature hexagonal ferromagnetic structure α turns into an orthorhombic paramagnetic one β. Films of MnAs/GaAs(100) present α-β phase coexistence from 10ºC to 50ºC due to strains induced by the substrate on the film. Our previous work with MnAs nano-ribbons showed a variation of the domain structure of the samples and its temperature dependence with the confinement orientation and sizes [2],[3].

In this presentation, we report on electrical transport measurements performed onto MnAs/GaAs(100) nano-ribbons of 0.5μm and 0.25μm width, 20μm large, and thickness varying from 30nm to 300nm. The nano-ribbons and the electrical contacts were patterned combining e-beam and optical litography. The Hall-effect and the magneto-resistance of the different samples allows us to investigate the charge carriers nature and the dominant transport mechanisms of the system.

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OPTICAL AND MAGNETO-OPTICAL STUDIES OF MANGANITE-DIELECTRIC COMPOSITES

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INTRODUCTION

Manganites with CMR are representative as promising magnetooptical materials for optoelectronics due to the effects of giant magnetotransmission and magnetoreflection of light in the visible and infrared ranges [1]. The giant magnetotransmission effect has been studied for artificially created magneto-optical composites based on manganites.

EXPERIMENTS AND RESULTS

Two main types of composites were prepared and studied: pressed composites made of a mixture of manganite and dielectric nonmagnetic matrix and sticky ribbons covered by a powder of manganite. The giant negative magnetotransmission effect has been revealed for both of them (Figure 1) with the value of one comparable with the magnetotransmission for manganite films [1].

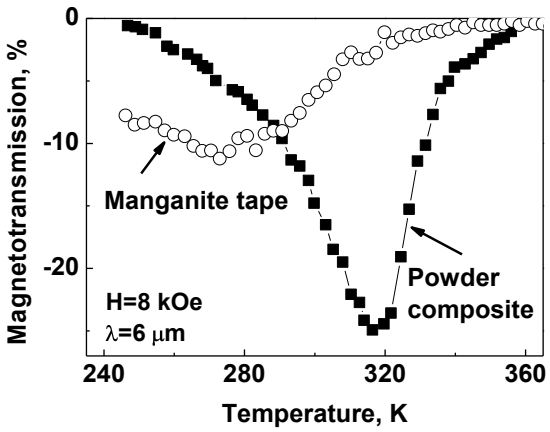

Figure 1. Temperature dependences of magnetotransmission for $La_{0.85}K_{0.15}MnO_3$ composites

The main question that will be discussed whether the magnetotransmission is the result of cooperative magnetization of adjacent manganite particles or just adding up the effects in single particles. The obtained composites are simple for mass-production and therefore may be proposed besides the magneto-optical spectroscopy of strongly absorbing magnetic materials to creation various elements of optoelectronic devices based on magnetotransmission effect.

ACKNOWLEDGEMENTS

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COLLECTIVE VORTEX MODES IN MAGNONIC CRYSTALS: MULTIPOLAR EFFECTS ON DISPERSION CURVES

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INTRODUCTION

It has recently demonstrated through calculations [1] how collective vortex modes in magnonic crystals can dramatically change their propagation properties as soon as a bias field is applied. Clearly, this fact is potentially helpful in the perspective of magnonic-spin-logic devices, in which the propagation/steadiness of the information carrier ("magnon") can be given a different binary digit. Employing the dynamical matrix method, we performed calculations on a squared 2D lattice of dots in the vortex state, varying the in-plane wavevector components to investigate the first Brillouin zone. We computed the dispersion relations for gyrotropic, azimuthal and radial modes. We discuss the dynamical coupling of modes with different cell wavefunctions, which is not purely dipolar as for the modes in saturated states: multipolar contributions are often necessary, and determine the dependence of the bandwidth of a given mode on the lattice parameter. We also discuss how the circular polarization of the modes depends on the Bloch wavevector k and changer as k is changed. When considering a bias magnetic field, in the equilibrium configuration the vortex core sets off the center of the disk: for a class of modes, propagation along the direction of the applied field is slowed down, while perpendicular to the applied field is speeded up. This work was supported by the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement n°n°228673 (MAGNONICS).

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TUNNELING MAGNETORESISTANCE IN ION-BEAM SPUTTERED CoFeB/MgO/CoFeB MAGNETIC TUNNEL JUNCTIONS.

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Magnetic tunnel junctions (MTJs) (size~100 μm^2) with structure Si/SiO2/Ta(5)/NiFe(5) /IrMn(15)/CoFeB(5)/Mg(1)/MgO(3.5)/CoFeB(5)/Ta(5)/Ag(20) (nm) were grown at room temperature (RT) using dual ion beam sputtering via in situ shadow mask process [1]. The MTJs were successively annealed two times in the magnetic field of 1.5 kOe, first at 350°C/30 min. and subsequently at 400°C/30 min. From the fitting of tunneling conductance data recorded at RT via Simmon's relation [2], the effective barrier thickness (t) and average barrier height (Φ) were estimated to be 3.5 nm and 0.62 eV, respectively for the as-deposited MTJs, and 3.5 nm and 0.58 eV, respectively after magnetic annealing. The barrier parameters did not exhibit any change after second anneal cycle. Dynamic conductance curves revealed the minor asymmetry in the positive and negative bias branches, indicating the difference of the quality of interfaces of CoFeB-MgO and MgO-CoFeB. While a low value of tunnel magnetoresistance (TMR) of 0.2 % was observed at RT, at 25 K the TMR % increased to 28.5 %. A typical TMR curve recorded at 25K is shown in Fig. 1(a). At 25K, slightly higher values of Φ and t of 0.65 eV and 3.6 nm were obtained. However, a small dip around zero bias in dynamic conductance, known as zero bias anomaly, is observed, although no observable difference in the behavior of dynamic conductance in antiparallel (AP) and parallel (P) case of magnetization is observed. Temperature dependence of junction resistance in AP and P cases was found to be different only above 150 K, implying the presence of alternate conducting channels within the band gap of the MgO barrier that are not spin dependent. The effect of presence of such inelastic channels is understandably least at low temperatures yielding sizeable enhancement in TMR. A large bias dependence of TMR was observed at 25 K. In particular, the TMR is found to decrease from 28.5% at a bias of 0.75 mV to 5.7 % at 134 mV bias (Fig. 1(b)).

FIGURES

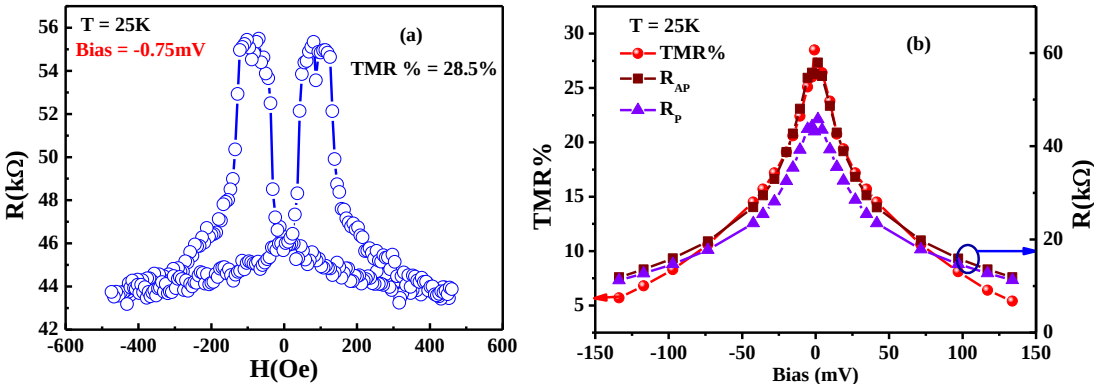

Fig.1 (a) Junction resistance (R) versus applied magnetic field (H) cycled between ±500 Oe and bias of -0.75 mV, and (b) Bias dependence of TMR and Junction

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EXAMINATION OF OXYNITRIDE MATERIALS FOR LOW RA TUNNEL JUNCTIONS

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INTRODUCTION

Recent work [1] suggests that current generation MgO-based magnetic tunnel junctions will not be useable as read-heads in future high density (>2Tb/in^2) hard disk drives due to the limits of achievable resistance-area product. The magnetoresistance (MR) and resistance-area (RA) product of a tunnel junction are related to the barrier height of the tunneling material [2]. With lower bandgap materials, it is possible to increase the thickness of the barrier, without greatly increasing the resistance of the device. This allows the formation of well defined barriers with no pinholes [3]. We examine the use of low bandgap semiconductors, tuned by the addition of oxygen and nitrogen, as possible barrier materials, which are deposited by reactive RF magnetron sputtering.

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MAGNETIZATION REVERSAL IN NANOTUBES ASSISTED BY A CIRCULAR FIELD

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INTRODUCTION

Core-shell nanotube structures composed by an inner conductor wire covered by two shells: (i) an intermediate non-conducting and non-magnetic shell, and (ii) an outer ferromagnetic shell are our systems in consideration [1]. Here, an electric current flowing through the inner wire produces a circular field and a Zeeman interaction with the ferromagnetic nanotube is set up, which modifies the reversal properties along the nanotube axis. Therefore, the understanding of the coercive and nucleation fields as well as remanent magnetization as function of the circular field strength is a necessary task.

METHOD, RESULTS AND DISCUSSION

By means of a toy model and OOMMF simulations, two key results have been found: (i) A complete axial demagnetization when the circular field strength is above a critical field: a magnetization transition from the ferromagnetic ground state [2] to a circular configuration; and (ii) an exponential reduction of the coercive field at very low circular field strength (at accessible electric currents flowing along the inner wire). These properties might be implemented in current-driven techniques to mediate the magnetization reversal process.

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ANOMALOUS HALL EFFECT IN TWO-PHASE SEMICONDUCTOR STRUCTURES: THE CRUCIAL ROLE OF FERROMAGNETIC INCLUSIONS

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The investigation of the anomalous Hall effect (AHE) is wide-use experimental method for diagnostics of magnetic semiconductors. In the conventional interpretation, AHE is the consequence of asymmetric scattering of spin polarized carriers. In this connection, the observation of AHE traditionally considered as a proof of the presence of predominantly spin polarized carriers.

In this work we present the results of theoretical and experimental investigations of peculiarities of AHE in a semiconductor host matrix with ferromagnetic inclusions. Earlier, it was discovered that InMnAs layers obtained by laser deposition in gas atmosphere demonstrated clear hysteresis dependences of the Hall resistance on an external magnetic field $R_H(H)$ up to room temperature [1]. The transmission electron microscopy revealed presence of MnAs inclusions with characteristic size about 50 mn.

We assumed that the reason for hysteresis $R_H(H)$ dependences is the Lorentz force which is determined by magnetic field of ferromagnetic inclusions. Hysteresis dependence of magnetic moments of ferromagnetic inclusions on an external magnetic field results in a hysteresis dependence of $R_H(H_{ext})$. Thus we showed the possibility of a hysteresis $R_H(H)$ dependence (i.e. AHE observation) in thin semiconductor layers with ferromagnetic inclusions in the absence of carriers spin polarization.

The work was supported by the grant RFBR- 12-07-00433-a.

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Co THIN FILM WITH METASTABLE BCC STRUCTURE FORMED ON GaAs(111) SUBSTRATE

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Metastable bcc-Co films have attracted much attention to TMR device applications. In our previous studies [1,2], bcc phase formation was recognized in Co films prepared on GaAs substrates of (100) and (110) orientations by UHV sputtering. In the present study, Co films are deposited on GaAs(111) by varying the thickness and the substrate temperature. In an early stage of film growth at room temperature, a metastable bcc(111) crystal is formed through hetero-epitaxial growth, as shown in the RHEED pattern of Fig.1(a). With increasing the thickness, the bcc phase transforms into an fcc phase [Fig.1(b)]. The bcc phase stability is improved when the substrate temperature is increased [Fig.1(e,f)]. XRD indicates a formation of bcc-CoGa phase when the substrate temperature becomes greater than 400°C, which is interpreted to stabilize the bcc-Co phase. The saturation magnetization, however, deceases with increasing the temperature beyond 400°C due to a formation of nonmagnetic bcc-CoGa phase.

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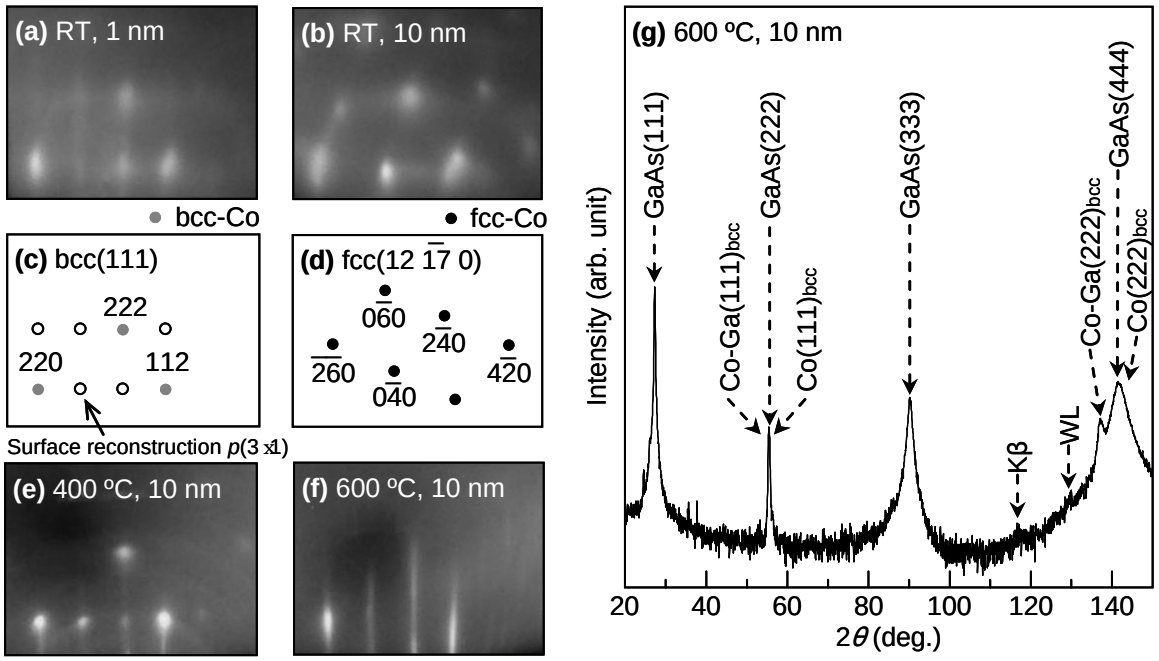

Fig. 1 (a)–(f) RHEED patterns and the schematic diagrams. (g) XRD spectrum.

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SPIN RESONANCE IN SI/GE STRUCTURES WITH QUANTUM DOT RINGS

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In the present work electron states in Ge/Si heterostructures with quantum dot (QD) rings were studied by electron spin resonance (ESR) method. Samples were grown by molecular-beam epitaxy on n-Si(001) substrates with specially prepared nucleation sites. Strain field distribution at the surface of multilayer structure with disk-like SiGe nanomounds formed by heteroepitaxy is exploited to arrange the fourfold symmetric QD molecules typically consisting of four elongated QDs ordered along [010]-[100] directions. New anisotropic ESR signals were measured on ten-layered QD rings structures. Obtained signal has anisotropic line width ΔH. In magnetic field applied along growth direction the narrowest lines with ΔH=0.19 Oe were detected, while in-plane orientation of magnetic field leads to ΔH=0.4 Oe. This anisotropy indicates the existence of tunneling coupling between QDs in rings and the presence of Dyakonov-Perel mechanism of spin relaxation [1]. Small anisotropy of obtained g-factor ($g_{\parallel}$=1.9999, $g_{\perp}$=1.9996) can be interpreted as formation of circular electron states in QD rings.

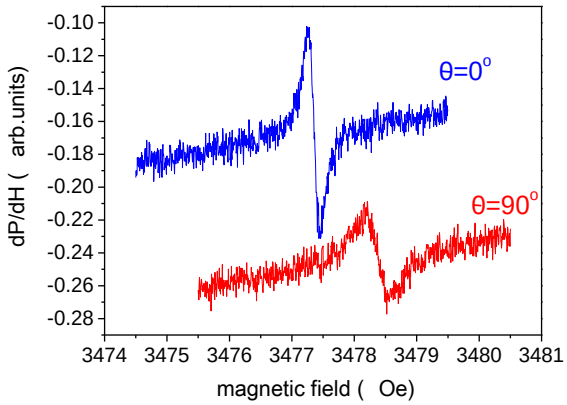

Fig.1. ESR signals measured on ten-layered QD rings structures at T=4.5 K, for θ=0° magnetic field is applied along growth direction of the structure.

This work was supported by RFBR (grants 12-02-90036, 12-02-31077), SB RAS integration project No.83, DITCS RAS project No.3.5.

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Manipulation of Exchange Coupling Induced at Co_2FeSi/Cr Interfaces

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Heusler alloys such as Co_2FeSi are the focus of intense research interest due to their predicted half-metallicity [1]. It has recently been predicted that by modifying the Heusler lattice with interfacial Cr insertions an antiferromagnetic spin structure can be induced [2]. 10nm thick Co_2FeSi films were grown onto an optimized Cr/Ag seed layer using HiTUS sputtering with Cr layer insertions of between 0.2nm and 1.2nm. These films are measured to be extremely magnetically soft with coercivities (H_c) between 7Oe and 22 Oe. After annealing the variation in H_c with Cr thickness shows a remarkably peaked behavior with the maximum of 22 Oe at Cr thickness of 0.6nm. This initial Increase in Hc can be attributed to an increased interfacial anisotropy arising from the anti-parallel alignment of interfacial spins. As the thickness of the Cr layer increases H_c decreases. This is because the additional Cr layers induce bulk-like properties, reducing the exchange coupling.

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COUPLED DIPOLE-EXCHANGE SPIN WAVES IN TRILAYER NANOSTRIPES OF PERMALLOY: BRILLOUIN LIGHT SCATTERING AND THEORY

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Spin waves in stripe arrays consisting of three ferromagnetic Permalloy (Py) layers, dipolarly coupled across nonmagnetic Cu spacers, were studied both experimentally and theoretically. The stripes have the following layering scheme Py(30nm)/Cu(10 nm)/ Py(*d*)/Cu(10nm)/Py(30 nm) and differ by the thickness of the middle Py layer *d* (with *d* = 15, 30, 60 nm). All three layers have the same width *w*, where values *w* = 150 and 400 nm were chosen for different sample sets. Stripes were longitudinally magnetized by applying a magnetic field *H*= 0.03 T and the Brillouin light scattering spectra were recorded by sweeping the wave vector q along the short axis of the stripe. By contrast with the dispersion measured for the continuous (unpatterned) trilayer films, the stripes spectra present a number of discrete peaks, corresponding to the resonant frequencies of the trilayered structures, whose frequency does not change over the whole range of *q* investigated. The data were analyzed using a microscopic Hamiltonian-based theory. The intensity contribution of each mode was evaluated and compared with the measured spectra. A relatively good agreement is found, showing the important role of the spatial quantization of the spin-wave modes and the coupling across the Cu spacers (see figure 1).

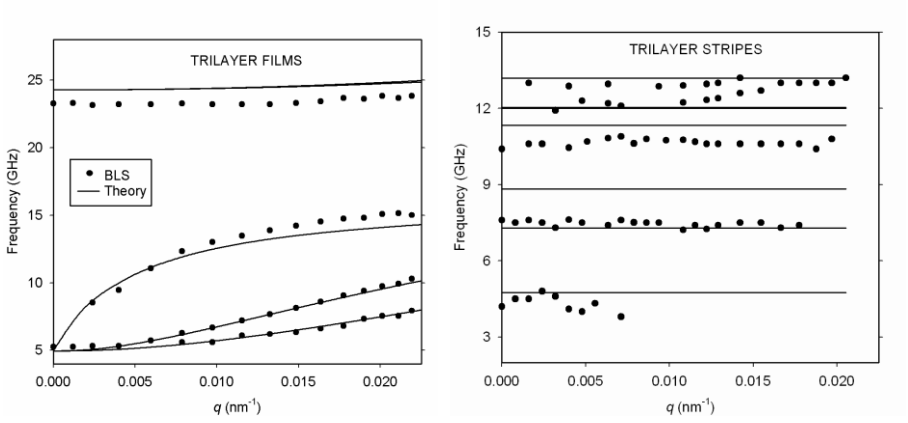

Fig.1 Experimental (points) and theoretical (curves) frequency dispersion for the trilayer film (left panel) and the trilayer stripes having a width *w*=150 nm (right panel). The thickness of the middle Py layer is *d*=15 nm in both the systems.

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SIMULATION OF VORTEX CORES POLARIZATION SWITCHING IN NANOCOLUMNAR CONDUCTING TRIPLEX STRUCTURE

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We present experimental and simulation study of the variation of the switching fields of vortex cores as a function of an injected dc current in a spin valve system containing two vortices, one in each magnetic layer having different thicknesses [1]. We identify the mechanisms responsible for the core reversal under the combined action of spin transfer torque and perpendicular field opposite to the initial core polarity. At low currents, both cores reversals occur through a static reversal of the vortex core. In this regime, the switching fields are defined by the intrinsic material parameters and their dependence with I_{ds} is weak. At large current, the large amplitude gyrotropic motion induced by spin transfer allows for the thick layer's vortex to reach the critical velocity for a dynamical reversal, mediated by the creation of a pair of vortex-antivortex. In this regime, the switching field of the vortex core has a significant dependence on the current. Our results are thus interesting in the perspective of development of non volatile vortex based memories.

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SIMULTANEOUS STUDY OF MAGNETIZATION REVERSAL AND MAGNETORESISTANCE IN UNIAXIAL MAGNETIC ANISOTROPY SYSTEMS

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Magnetoresistive effects and related phenomena in magnetic nanostructures have found widespread applications in magnetic sensing and recording technologies. Even though it is commonly assumed that the magnetoresistance (MR) depends on the magnetic anisotropy, i.e., anisotropic-magnetoresistance, the direct proof that the magnetoresistive-responses are directly related to the magnetization reversal processes is still lacking.

We present a systematic angular-dependent-study on magnetization-reversal processes and magnetoresistive-responses of a FM metal thin film with well-defined uniaxial magnetic-anisotropy. In-plane resolved vectorial-Kerr magnetization curves ($M_{||}(H)$ and $M_{\perp}(H)$) and their corresponding resistance-changes (MR(H)), were measured simultaneously with a new-MagnetoResistance-Optical Kerr-Effect setup [1]. The dependences with the direction of applied magnetic field (α_H) and current (θ_i) with respect to the anisotropy-axis were investigated.

Magnetization-loops strongly depend on α_H, whereas MR curves rely on both applied-field and current flow directions. $M_{||}(H)$ and $M_{\perp}(H)$ curves give the relevant information about the magnetization-reversal processes and lead to the direct determination of the magnetization direction during the hysteresis loop. The maximum (minimum) MR-value is found when the magnetization is aligned parallel (perpendicular) to the current direction. The magnitude and shape of MR(H) are controlled by the orientations of the applied field and current with the magnetic-anisotropy-axis. Remarkably, for a given α_H, constant, negative, or positive hysteretic magnetoresistive-loop behaviors are found depending on θ_i. The data clearly show that both longitudinal and transversal mangetoresistance (AMR and PHE) loops are governed by the orientation of magnetization with respect to the current flow direction.

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Preparation and magnetic properties of high aspect ratio Ni-Fe-Mo flakes composites

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Abstract

Composite magnetic sheets containing ferro-/ferrimagnetic particles are promising candidates for electromagnetic (EM) applications such as EM shielding but permeability levels are usually moderate above to 1 GHz due to Snoek limit [1]. Theoretical approaches show that the high-frequency permeabilities could be enhanced when using flaky-shaped particles (high length to thickness ratio) [2]. In addition, sub-micrometer-thick flakes are required to reduce the eddy current losses.

We present the elaboration of permalloy flaky particles with various aspect ratio and their related microwave magnetic properties. They are obtained from raw spherical powder through a ball-milling process and embedded in composite sheets. Permeability measurements were carried out using a single coil permeameter [0.1-8 GHz] [3]. Permeability levels increase with aspect ratio. Spectra were successfully fitted combining the Landau-Lifshitz-Gilbert equation and the Maxwell-Garnet mixing rule (Fig. 1).

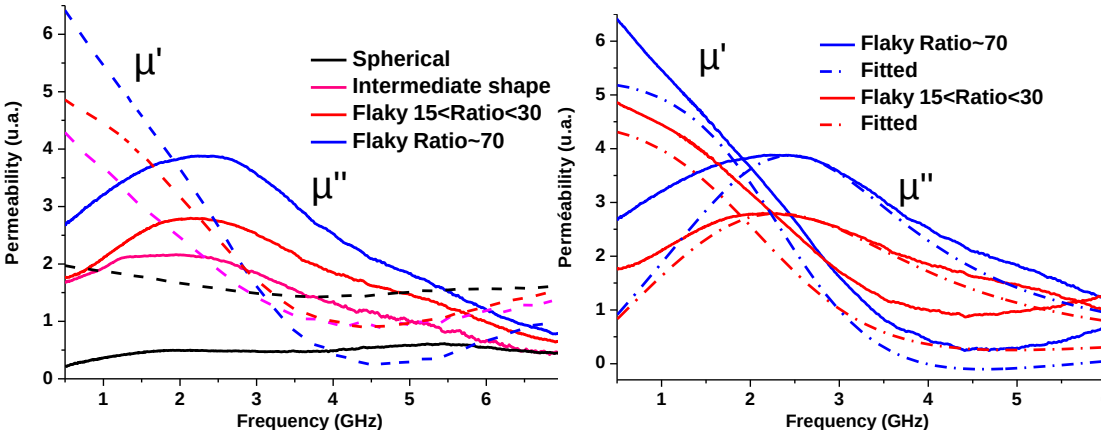

Fig.1. Complex permeability spectra of NiFeMo composites with various aspect ratio: (left) measured, (right) fitted.

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IN-PLANE ANISOTROPY OF THIN YIG FILMS ANTIDOTS ARRAYS STUDIED BY FERROMAGNETIC RESONANCE TECHNQUES

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Two-dimensional periodic antidots arrays of rectangular symmetries lattices were studied experimentally and numerically. 50 x 50 μm squares-shaped holes and different periods were created by the selective chemical etching in 4.5 μm thick epitaxial yttrium iron garnet (YIG) films deposited on (111) gadolinium gallium garnet substrate.

The magnetization dynamic was studied by both X-band ferromagnetic resonance and broadband vector network analyzer ferromagnetic resonance. Angular dependence of the ferromagnetic resonance signal, measured as a function of the in-plane applied magnetic field, shows twofold anisotropy. The micromagnetic simulations and frequency domain calculations of the magnetization excitation were performed to explain experimental data and identify spin wave modes.

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SPIN WAVE DISPERSION IN NIFE ANTIDOT ARRAY WITH ALTERNATING HOLES DIAMETER

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We study the dispersion of spin waves in a Permalloy ($Ni_{80}Fe_{20}$) binary antidot array constituted by two alternated antidot sublattices with different diameters of the circular holes. The diameters of the holes are D_1=300 nm and D_2=150 nm with a center-to-center spacing between adjacent antidots fixed at 425 nm (see inset of Fig. 1). The sample was fabricated using deep ultraviolet lithography, metallization of 30 nm thick Permalloy film followed by the lift-off. The spin wave frequency has been measured with Brillouin light scattering (BLS) applying a magnetic field H = 2.0 kOe along the edge of the square unit cell of the lattice and sweeping the spin-wave wave vector (k) along the perpendicular direction. The measured dispersion has been compared with calculations performed by the Plane Wave Method (PWM) and micromagnetic calculations. Overall, there is a good agreement between the experimental results and simulations over the whole wave vector range investigated (Fig. 1). It is noteworthy that the calculated frequency dispersion of the most intensive modes is characterized by a periodicity which is different from the one expected for the antidot lattice alone and reflects the two families of holes present in the sample. The calculation methods provide not only the mode frequency but also the spatial profile of the magnetic normal modes and their intensity to be compared to the intensity of the BLS peaks. We have found that the observed modes can be classified according to their localization region: modes localized along the field direction in proximity of holes having small and large diamater and modes existing in between the two families of holes.

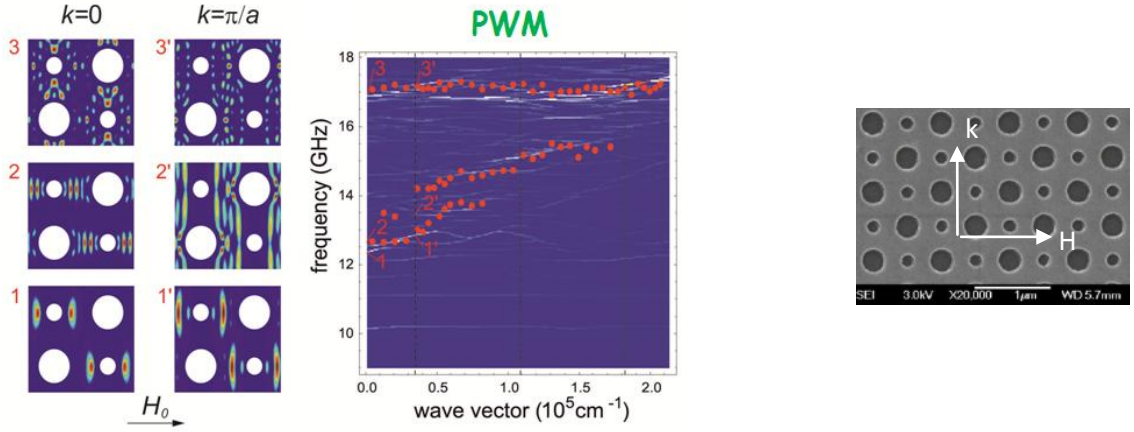

Figure 1. (right) comparison between the measured (circles) and calculated (PWM, colour map) spin wave frequency for the binary antidot lattice. (inset) show the scanning electron micrograph of the sample together with the direction of the applied magnetic field and the wavevector direction. (left) calculated spatial profiles of selected eigenmodes.

This work was supported by the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant No. 318287 "LANDAUER" and by the Ministero Italiano dell'Università e della Ricerca (MIUR) under the PRIN2010 project (No. 2010ECA8P3).

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BLS and Kerr effect studies of Ga^+ ions irradiated Pt/Co/Pt trilayers

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New effect of Ga^+ ion irradiation induced changes of magnetic properties was reported in [1] – ion fluence F adjusted creation of two branches of out-of-plane magnetization states. This effect was found analysing double wedged samples (Co thickness d_{Co} and ion fluence *F)* and constructing 2D diagrams (d_{Co}, *F*) of magnetic parameters. The Pt/Co(d_{Co}=3nm)/Pt nanostructures were grown by MBE in ultra high vacuum for the present studies, with in-plane magnetization state at pristine films. About 1mm wide parallel stripes were fabricated by 30 keV Ga^+ irradiation with different *F* from the range ions $5x10^{12}$-10^{16} ions/cm^2. Nanostructures were studied by Brillion Light Scattering (**BLS**) and both polar and longitudinal magneto-optical Kerr effects (**MOKE)**. Two branches with out-of-plane magnetization states (determined by MOKE technique) are connected with two maxima of uniaxial magnetic anisotropy found by BLS. LMOKE studies also reveal existing of in-plane anisotropy for non-irradiated area which was degraded as *F* was increased. The tuning of spinwave frequencies by irradiation can lead to fabricate new magnonic crystals.

Research supported by Foundation for Polish Science within the Team Programme co-financed by the EU European Regional Development Fund, OPIE 2007-2013.

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DEPENDENCE OF THE NOTCH GEOMETRY ON THE DOMAIN WALL PROPAGATION IN PERMALLOY NANOWIRES

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We have investigated the injection and transmission of vortex domain walls in Permalloy (Py) nanowires through symmetric and asymmetric triangular notches. The nanowires have widths varying from 300 to 800nm, are 30nm thick, and were grown by RF sputtering. The triangular notches have the slope varying from 15^{o} to 45^{o}, on the left or on the right, independently. The distance between the vertex and the nanowire edge was kept constant, 160 nm, for all wires.

The domain wall injection and transmission past the notch were probed by a spatially resolved magneto-optical Kerr system, which is able to measure a single magnetic nanowire, and by magnetic force microscopy (MFM) and micromagnetic simulations.

Our experimental results confirm that the domain wall pinning by the notch depends upon the vortex chirality, as it is well known. We observed that for all notches independent of the size and symmetry. However, the domain wall pinning is sensitive to the symmetry, with the coercivity increasing monotonically with the angle of the notch for asymmetric notches, while it shows a chirality-dependent minimum for the symmetric ones. Other aspects of the domain wall pinning and propagation including the ones obtained by MFM and simulations will be presented as well as details on the sample preparation.

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A Review on Bias and Unbalanced Magnetron Sputtering

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INTRODUCTION

In bias sputtering, electric fields near the substrate are modified in order to vary the flux and energy of incident charged species. This is achieved by applying either a negative dc or RF bias to the substrate. Bias voltages are typically in the order of -102 V[2],[3]. Due to charge exchange collisions, very few discharge ions strike the substrate with full bias voltage. Rather a broad low energy distribution of ions and neutrals bombard the growing film. Bias sputtering can be effective in altering a broad range of properties in deposited films (Table1), including step coverage, residual stress, microstructure, density and adhesion to the substrate.
In unbalanced magnetrons, the magnetic fields are deliberately arranged to allow electrons to escape. These electrons create plasma away from the cathode surface and this plasma can provide the ions for bombardment of the substrate.

FIGURES AND TABLES

Deposition rate and thickness of PbTe films with various bias voltage					
Substrate bias (V)	0	-20	-30	-40	-50
Thickness (nm)	184	233	278	237	235
Deposition rate (nm/s)	0.3072	0.3887	0.4639	0.395	0.3918

(Table1)Deposition rate[1]

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A QUASI-ONE-DIMENSIONAL DISSIPATIVE DROPLET IN NANOWIRE SPIN-VALVES WITH PERPENDICULAR MAGNETIC ANISOTROPY

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Magnetic dissipative droplets [1] are dynamical modes excited in nano-contact spin-valves with perpendicular magnetic anisotropy. These modes find potential applications in novel storage technologies [2]. However, their two-dimensional extent strongly limits its scalability, especially at the desired nanowire limit.

Here, we micromagnetically [3] demonstrate that the dissipative droplet can overcome such limitation by undergoing mode transitions to an edge mode and a novel, quasi-one-dimensional (Q1D) droplet. In addition of being a dynamical mode, the Q1D droplet is found to behave as breather modes i.e., bounded soliton-soliton pairs proper of biaxial, one-dimensional ferromagnets.

These features suggest that the Q1D droplet can open up pathways to nucleate topological solitons as well as providing new possibilities in the prospect of low-dimensional applications in magnetic computation and storage.

Support from the Swedish Research Council (VR) is gratefully acknowledged. Johan Åkerman is a Royal Academy of Science Research Fellow supported by a grant from the Knut and Alice Wallenberg Foundation.

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ELECTRIC FIELD MODULATION OF MAGNETIC ANISOTROPY IN A Co ULTRA-THIN FILM

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The electric–field manipulation of the magnetic anisotropy is expected to be a key technology for realizing ultra-low power magnetic storage devices. To actuate them at room temperature, a metallic magnet is reasonable for recording layer. Here, we report the temperature dependence of the electric–field induced change of the magnetic anisotropy in a perpendicularly magnetized ultra-thin Co film.

We probed the in-plane magnetic field dependence of magnetization under gate voltage V_G by using the anomalous Hall effect. From the magnetization curves for V_G = ±10 V, the temperature dependence of the magnetic anisotropy energy per unit area $E_\perp t$ was determined as shown in Figure 1.

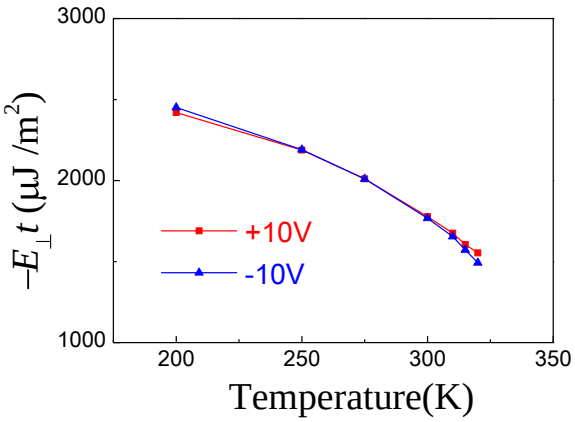

Figure1. Temperature dependence of $E_\perp t$ for V_G = ±10 V.

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MAGNETIZATION PROCESSES IN PERMEABILITY SPECTRA OF FeCuNbSiB MATERIAL UNDER AC MAGNETIC FIELD

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Soft magnetic Fe-based nanocrystalline alloys are well-known ferromagnetic materials with excellent soft magnetic properties, e. g., high permeability, low coercivity and low core loss promising technological applications.

In this work, two soft magnetic $Fe_{73}Cu_1Nb_3Si_{16}B_7$ powder core samples were investigated. Samples were prepared by a milling of amorphous $Fe_{73}Cu_1Nb_3Si_{16}B_7$ ribbon at different temperature conditions: at room temperature (sample R) and cryomilled at temperature of liquid nitrogen (sample L). The results were compared with investigation of the original ribbon shaped sample. Complex permeability spectra were measured with an impedance analyzer from 100 Hz to 40 MHz.

We were examined the effect of the ac current amplitude (and therefore ac magnetic field amplitude) on spectroscopic plots of the complex permeability response of the material. Domain walls exhibit relaxation behaviour as a function of frequency. The decrease of the relaxation frequency due to ac magnetic field could reflect the decrease in pinning force to hinder the domain wall movement and the relaxation phenomenon occurs earlier with the increasing of the amplitude of the ac magnetic field. The results can be interpreted in terms of the dynamics of the domain wall in the powder cores.

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ANOMALOUS DOMAIN WALL DEPINNING BEHAVIOR IN CYLINDRICAL NANOWIRE

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Study of domain wall (DW) dynamics at pinning sites in ferromagnetic nanowires is essential for the memory applications [1]. DWs in cylindrical nanowires have shown promising properties such as the absence of Walker breakdown and zero intrinsic pinning. Here we present an anomalous behavior of DW depinning for field and current induced DW motion. We have considered transverse DWs in a NiFe cylindrical nanowire with a symmetrical notch at the centre. When the DW is driven by a magnetic field, the depinning field increases with notch depth, as shown in figure 1(a). Interestingly, an opposite behavior is observed when the DW is driven by a current. The decreasing depinning current density with increasing notch depth is attributed to the DW deformation. When the notch depth is 20 nm, the DW deformation is found to be higher as compared to the 5 nm notch depth, as shown in figure 1(b). The deformation can also be perceived from the demagnetization energy of the system as can be seen in figure 1(c). At 20 nm deep notch, the DW structure is deformed which results in the increase of the demagnetization energy as compared to the 5 nm deep notch. The deformation assists the current to depin the DW from the notch.

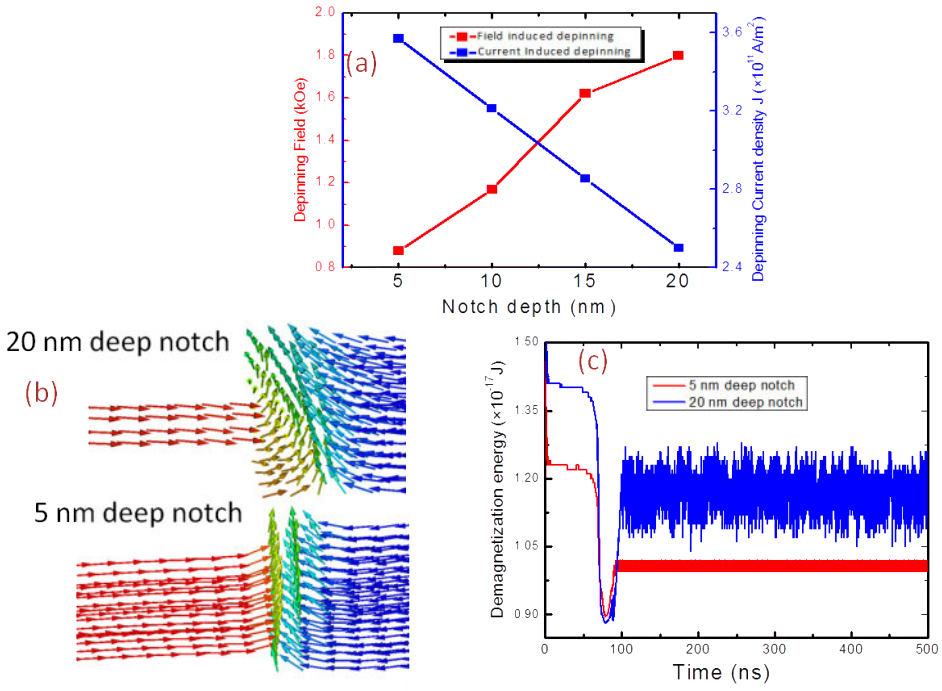

Figure 1(a) The depinning field and current density as a function of notch depth (b) The magnetization configuration of the DW at the notch for 20 nm and 5 nm deep notches (c) The demagnetization energy of the system as a function of time.

[1] M. Chandra Sekhar *et al., Appl. Phys. Lett.* **101**, 152406 (2012).

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POLARITY-DEPENDENT VORTEX DOMAIN WALL COUPLING

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It is important to understand the interaction between magnetic domain walls (DWs) in a system of multiple nanowires as it will determine the maximum density that DW-based devices can achieve [1]. In this work, we report on the interaction between two vortex DWs in a pair of patterned nanowires. Initially, a head-to-head (HH) DW is generated in the lower nanowire and a tail-to-tail (TT) DW is generated in the upper nanowire, as shown in Fig. 1(a). The vortex cores of the two DWs are both pointing to the *-z* direction. Due to their opposite magnetic charges, the two DWs approach each other even without the application of external magnetic field. In this configuration, the two DWs move to the center of the nanowires with an equal speed. The investigation is repeated, with the vortex core of the HH DW switched to +z direction. Interestingly, in this case the speed of rightward motion of the HH DW is shown to be increased, allowing it to move pass the TT DW as shown in Fig. 1(b). A closer observation shows that with the new vortex core direction, an additional exchange interaction is promoted within the HH DW, which allows it to increase its speed along the +x direction.

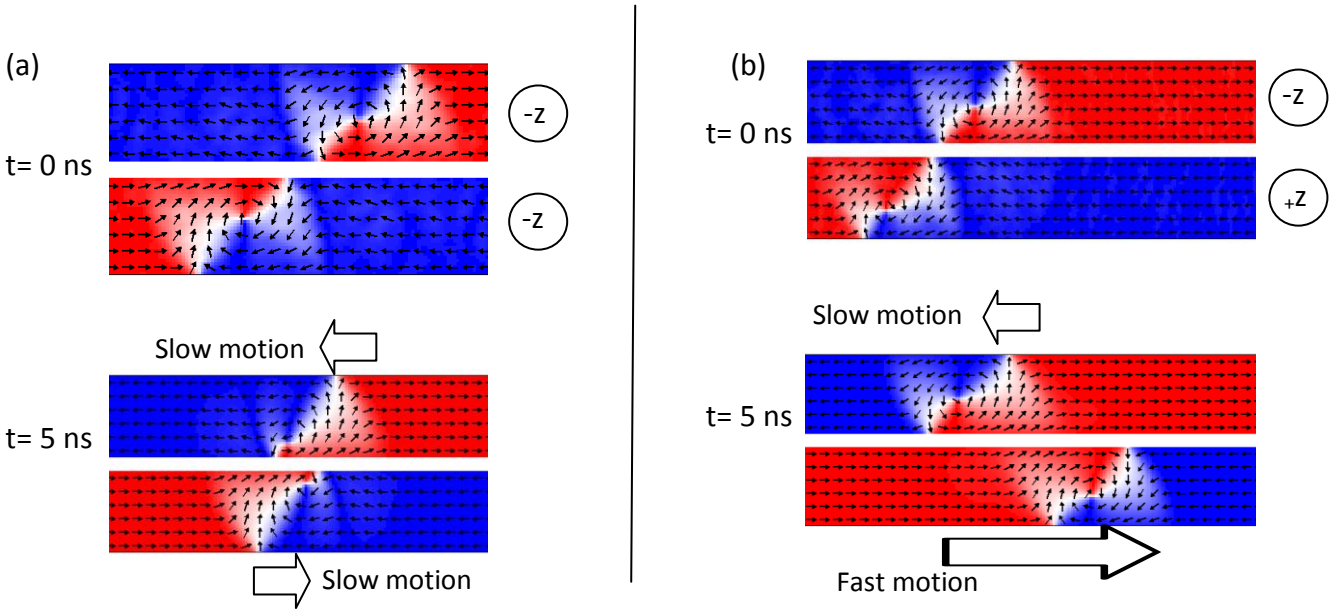

Fig 1 (a) The snapshots of the micromagnetic simulations when the two vortex DWs have the same vortex core orientation. (b) The snapshots of the micromagnetic simulations when the two vortex DWs are oppositely aligned.

[1] I. Purnama *et al.*, App. Phys. Lett. 99 152501 (2011).

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THE RANDOM-FIELD APPROXIMATION TO TREAT THE DIPOLAR-INTERACTION IN SYSTEMS OF MAGNETIC NANOPARTICLES

The dipolar interaction is known to play an important role on the magnetic properties of small magnetic particles. For moderate concentrations the most noticeable effect is an increase of the relaxation time, whereas for sufficiently dense systems some degree of correlational order may be observed. In this paper, a mean-field approximation is introduced to correctly account for these changes. It is based on the interpretation of the dipolar field, produced by an ensemble of particles, as a random field acting on a reference particle. This field contains the statistical moments of the magnetization of the reference particle and is computed assuming a random spatial distribution of the particles. The result is a new term in the free energy of the reference particle, expressed as a cumulant expansion of the random field, carried up to fourth-order. This model correctly predicts both the increase in the relaxation time and a phase transition to a ferromagnetic state for sufficiently dense systems. The dynamics is also studied by introducing this new free energy into the Fokker-Planck equation for the single-particle magnetic moment. The result is a non-linear Fokker-Planck equation, which is solved numerically to illustrate the divergence of the relaxation time at the phase transition.

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[2] Gabriel T. Landi, *J. Appl. Phys.*, **113**, 163908 (2013)

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A SIMPLE CURRENT TRANSFORMING HARVESTER

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INTRODUCTION

Power supply of on-line monitoring equipment is always the hot topic of high voltage line monitoring technology. The draw-out power technology based on the special current transformer induction was widely used, but the circuits of most induction draw-out power devices are too complex. Complex circuit design may influence the stability of the device. Firstly, we analyzed the design of the draw-out power coil. Then we studied the design of draw-out power coil under the influence of non-linear load. This paper puts forward a simply and effectively high voltage line draw-out power device design method which is based on triac voltage control. Introduced the design methods and control principles of current transformer secondary side voltage. Taking advantage of the characteristic that triac zero-crossing shutdown, the second side voltage converts directly into the trigger signal .It is simple and effective to control the second side voltage. The experiment results of the new design verified the reliability and practical.

This article designed a circuit to draw-out power as **Fig. 1**. It consist electromagnetic circuit, voltage control circuit, protection circuit, rectifier circuit, filter circuit, voltage regulator circuit and super capacitor.

Measuring $U_{T_2T_1}$ after access 10 ohm loads at both ends of the triac, the oscillogram of primary current gradually increasing as **Fig.2.**

FIGURES AND TABLES

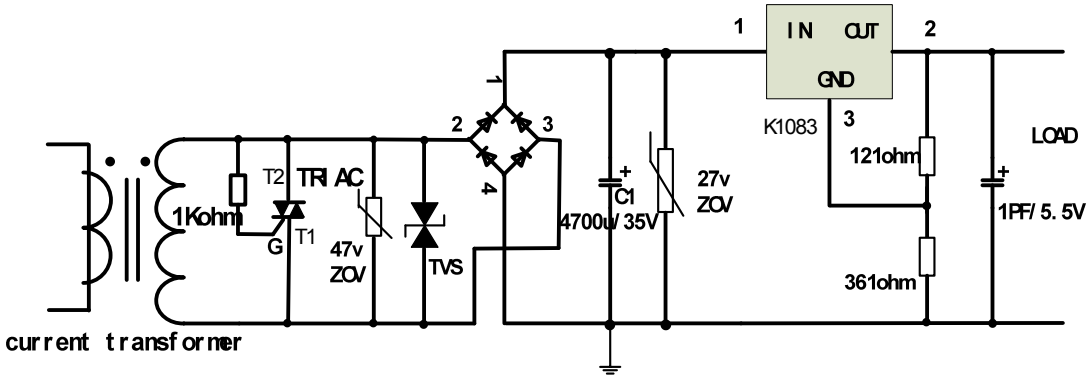
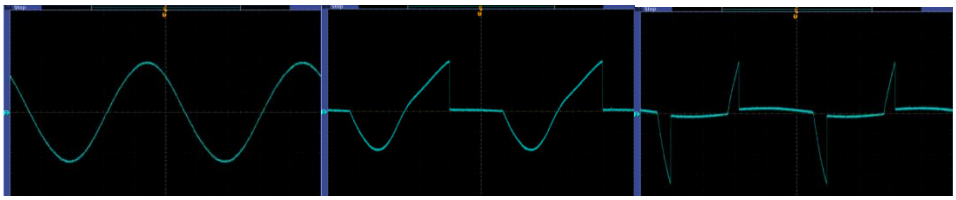


Fig. 1 Draw-out power circuit principle diagram



(a) (b) (c)

Fig. 2 $U_{T_2T_1}$ oscillogram when draw-out power circuit with load

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SPIN WAVE EMISSION BY DOMAIN WALLS COLLISION

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Spin wave (SW) driven magnetic logic devices have attracted much attention because they are capable of processing information at high speeds by controlling either the phase or amplitude of the SWs [1]. Here we report on magnetic field induced SW emission due to collision between two DWs in patterned NiFe nanowires (NW) through micromagnetic simulations. The investigation was carried out on a thin rectangular nanowire of 10 μm length, 6 nm thickness and 100 nm width. Fig. 1 is the schematic diagram of two DWs in a NW. Initially, a head-to-head (HH) and tail-to-tail (TT) DWs are generated in the nanowire. An external magnetic field of 1 mT is then applied to the system to allow the DWs to collide at the center of the nanowire, which results in spin wave generation. Shown in Fig. 2 is the snapshot of the magnetization during the collision process which also shows that the SWs propagate along the length of the NW in both directions. Fig. 3 shows the normalized z-component of the magnetization (M_z/M) as a function of the NW length. We found from the FFT spectra that the SWs have the frequency in the range of few GHz.

Fig. 1: Schematic diagram of DWs collision in a NW

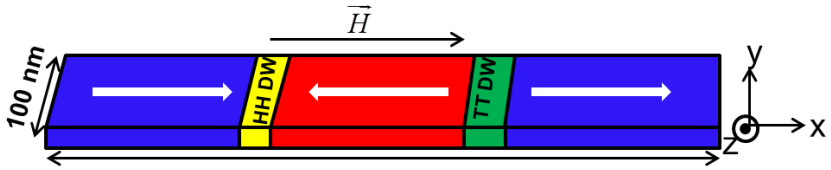

Fig. 2: Snap shot of the simulation across the NW length

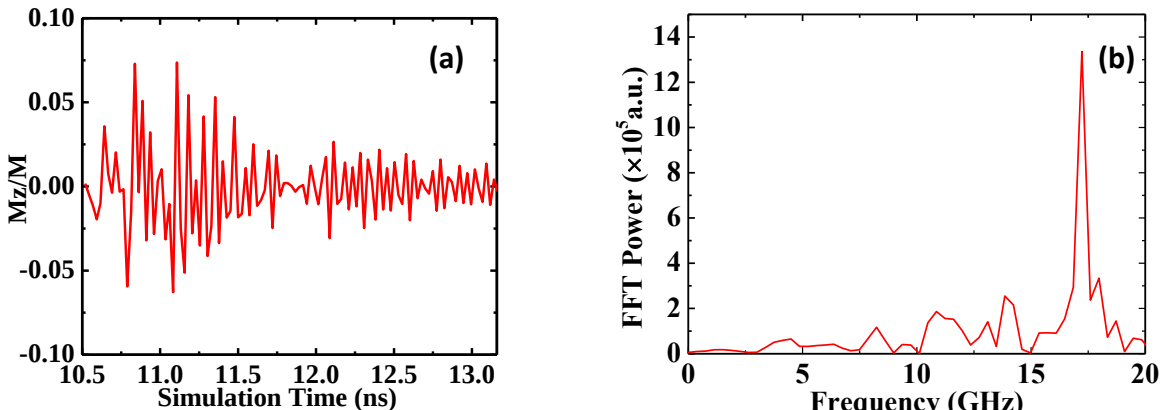

Fig. 3: (a) Plot of M_z/M vs time (ns) and (b) Corresponding FFT power spectrum

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MAGNETIC PROPERTIES OF SINGLE-CRYSTALLINE $ErFe_5Al_7$

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A $ErFe_5Al_7$ single crystal (tetragonal crystal structure of the $ThMn_{12}$-type) was studied in pulsed magnetic fields up to 60 T. The compound is a ferrimagnet with the Curie temperature T_C = 201 K and a compensation point T_{comp} = 34 K [1]. $ErFe_5Al_7$ displays strong easy-plane anisotropy. Anisotropy is also present within the basal plane, the easy-magnetization direction is the [100] axis with the spontaneous magnetic moment M_s = 1.28 μ_B/f.u. at T = 2 K. At low temperatures the compound exhibits two field-induced magnetization jumps along the [100] axis (Fig. 1*a*). Both transitions are accompanied by pronounced anomalies in the sound velocity (Fig. 1*b*). At higher temperatures two magnetization jumps also appear along the [110] axis. The critical fields of the first and second transitions display different temperature variations and have dissimilar shapes (Fig. 1), which implies different nature of the anomalies.

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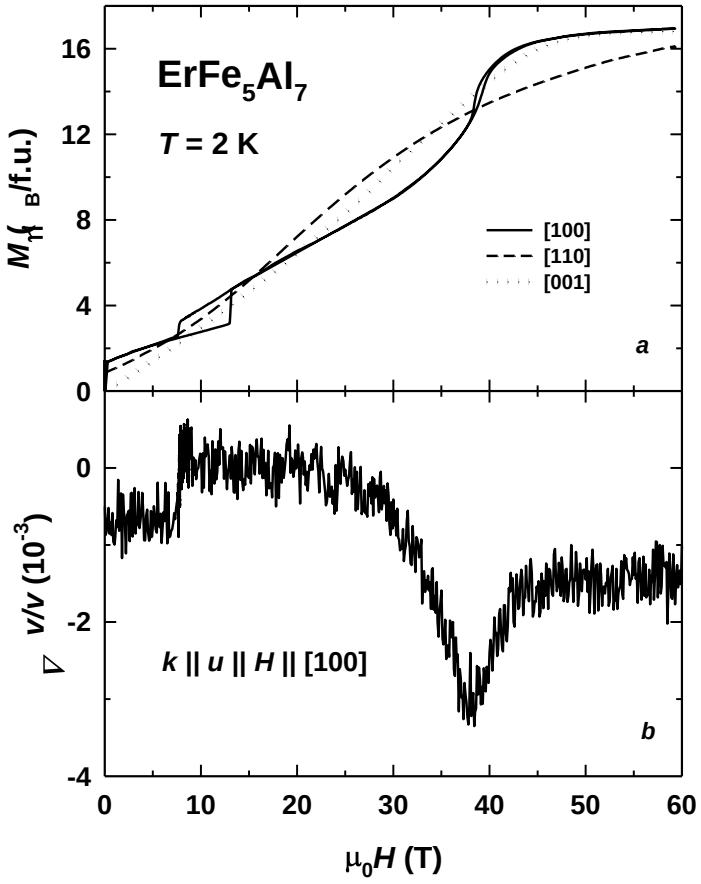

Fig. 1. Field dependence of magnetization along the [100], [110] and [001] axes (*a*) and of sound velocity along the [100] axis (*b*) of $ErFe_5Al_7$ at T = 2 K.

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MAGNETIC PROPERTIES OF ELECTRODEPOSITED AND POST_ANNEALED Co/Ni BILAYER THIN FILMS

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Magnetic films and multilayers are the focus of much attention motivated mainly by their wide range of applications, such as magnetic data storage devices and sensors. Theoretical and experimental studies have shown that magnetic devices with perpendicular magnetic anisotropy (PMA) in both reference and free layers are advantageous for achieving low spin transfer torque (STT) switching current and large thermal stability, which are the most pressing issues for the realization of high-density, high-speed STT switching-based MRAMs[1,2]. The magnetic multilayer structures are normally prepared through physical means of deposition as molecular beam epitaxy (MBE) or sputtering[3]. However, there are already examples of materials produced by electrochemical routes, where their magnetic and transport (GMR) properties are similar to those obtained by the techniques mentioned above. The electrochemical route shares with the other deposition techniques a high sensitivity of the sample magnetic and transport properties on their crystallographic and chemical structure. In addition, electrochemical deposition allows to grow structures with high ratio, which are not possible to obtain by MBE deposition followed by lithographic processes[4]. Therefore, a detailed structural characterization of the electrodeposited films is of prime importance to understand the properties of obtained material.

The presented work investigates Co/Ni bilayer nanocrystalline films produced through temperature-elevated electrochemical deposition, and modified by heat treatment processing (HT), both carried out under external magnetic field conditions. The results indicate an increase of the coercive field of as-deposited bilayer films, when a magnetic field was superimposed during electrodeposition. The high temperature processing caused further improvement of the coercivity, which remained constant under magnetic conditions. The appearance of a weak perpendicular magnetic anisotropy under magnetic HT was observed by means of both hysteresis loops measurements performed in in-plane and out-of-plane configurations, and by magnetic force microscopy. The magnetic properties are discussed in terms of samples microstructure.

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DIRECT MEASUREMENT OF MAGNETOCALORIC EFFECT OF TbFeAl AND GdFeAl

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In recent years, the great attention has been attracted to the magnetocaloric effect (MCE) in materials with different type of magnetic transitions due to possible application of MCE in magnetic refrigeration technique. Previous study of GdFeAl showed very sharp magnetic transition associated with large relative cooling power [1]. We have studied MCE in the intermetallic GdFeAl and TbFeAl compounds using the method of direct measurement [2] of ΔT_{ad}. Both compounds were prepared by melting of constituent elements in mono-arc furnace. The hexagonal C14 phase was verified by X-ray powder diffraction method in both compounds, with the lattice parameters: a=0.543 nm, c=0.880 nm and a=0.537 nm, c=0.872 nm for GdFeAl and TbFeAl, respectively. The ordering temperatures were derived from temperature dependence of heat capacity as T_c= 272 K (265 K in [1]) and 197 K for GdFeAl and TbFeAl, respectively. Direct measurement of ΔT_{ad} was performed in wide temperature range around the ordering temperatures. The maximum MCE with ΔT_{ad} = 1.6 K was observed in the case of GdFeAl at temperature 211 K for the field span of 4.7 T.

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EFFECT OF HYDROGEN AND PRESSURE ON MAGNETIC PROPERTIES OF $NdFe_{11}Ti$

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The insertion of hydrogen into $NdFe_{11}Ti$ to form $NdFe_{11}TiH$ increases the unit cell volume and induces also increase of the Curie temperature, the saturation magnetization M_S and significant changes in the magnetocrystalline anisotropy of the parent compound. To get information about the role of the volume and/or H insertion on the magnetic properties of $NdFe_{11}Ti$ we have studied effects of hydrostatic pressure up to 10 kbar on polycrystalline $NdFe_{11}Ti$ and $NdFe_{11}TiH$ samples. The pressure induced decrease of M_S at 5 K is practically identical for both materials ($dM_S/dp \cong -0.042\ \mu_B$/kbar). The pressure of 7.5 kbar that creates the same volume change (with opposite sign) as insertion of hydrogen (0.65%) induced the decrease of magnetization of about 1.3% that is 7 times smaller than the increase of magnetization caused by insertion of hydrogen. The pressure induced decrease of spin reorientation transition T_{SR} of $NdFe_{11}Ti$, dT_{SR}/dp=-2.36 K/kbar is significantly higher than that of $NdFe_{11}TiH$, dT_{SR}/dp=-0.15 K/kbar. This remarkable different effect of volume changes on T_{SR} will be discussed in terms of different spin reorientation character [1].

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INFLUENCE OF THERMAL TREATMENTS ON THE MARTENSITIC TRANSITION OF Ni-Fe-Co-Ga MELT SPUN RIBBONS

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Recently, the Ni-Fe-Ga off stoichiometric Heusler alloys have drawn much attention as an alternative to the brittle Ni-Mn-Ga Ferromagnetic Shape Memory alloy. The improved ductility of Ni-Fe-Ga based alloys is attributed to the thermally induced secondary γ phase, with (FCC) type structure. However, the formation of the secondary phase changes in an uncontrollable manner the composition of the main phase, causing a large spread of reported values of the martensitic transition temperature (MTT). It was been found that a small Co addition changes the phase equilibrium favoring the γ phase precipitation. Also Co is the most studied substitution element due to its effect in increasing the Curie temperature and the magnetocrystalline anisotropy. Data reported on $Ni_{2+x}FeGa_{1-x}$ ribbons [1] have shown that suitable quenching preparation techniques, like melt spinning, may prevent the formation of the secondary γ phase. Previous analyzes of reported data concerning the influence of thermal treatments (TT) on the MTT, obtained on melt ingots, concluded that by increasing the degree of atomic order, the austenite is more stable and the MT temperature decreases [2].

The present work investigates the thermal stability and the effect of TT of the MT in two alloys with nominal composition $Ni_{53}Co_2Ga_{25}Fe_{20}$ and $Ni_{52}Co_2Ga_{26}Fe_{20}$ prepared as ribbons by using the melt spinning method. The as prepared ribbons with a high atomic disorder show the highest MTT. By corroborating XRD data with DSC and magnetic measurements results we have evidenced that, by increasing the temperature of TTs, the reduction of MTT reflects three different processes: the removing of the quench-in strains, the atomic ordering and the precipitation of the γ phase.

[1] H.Okumura et al.,J.Appl.Phys.,108,(2010),043910
[2] C. Picornell et al., Intermetallics., 16(2008), 751

Abstracts for scientific work should generally follow the format of introduction, methods, results and discussion, references and acknowledgements (if required).

FIGURES AND TABLES

All tables and figures must be cited within the text. Add captions below figures and tables, using the “caption” style. Please number them consecutively using either “Figure” or “Table” prefix. Please ensure that the “wrapping” style in the figures is in-line with the text.

EQUATIONS

If you want to include equations, use the “equation” style for that paragraph and use the “math profile”. Use the MS-word equation editor, with defaults to “times new roman” and symbol “fonts.

$$F=mx\alpha \qquad [1]$$

REFERENCES

All references must be cited within the text. References appearing within the text should be numbered [1],[2],… and given at the end of the text sequentially.

[1] X. JEMS, Adv. 75, 233(2013)

[2] Y.MEMS, EPJ 33, 255 (2011)

A small Co addition changes the phases equilibrium favoring the gamma phase precipitation, but is the most studied substitution element due to the effect in increasing the Curie temperature and the magneto-crystalline anisotropy

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HIGH-FIELD MAGNETIZATION STUDY OF SINGLE-CRYSTALLINE *R*Fe_{11}TiH HYDRIDES

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The effects of hydrogen absorption on magnetocrystalline anisotropy (MCA) and spin-reorientation transitions (SRT) in *R*Fe_{11}Ti [1] with *R* = Tb, Dy, Ho and Er were studied in high magnetic fields of up to 60 T. High-quality single crystals of *R*Fe_{11}TiH with well-controlled hydrogen content were measured along the principal crystallographic directions at 4.2 K. Substantial variation of magnetic anisotropy behavior was observed. The easy-plane MCA was strengthened in $TbFe_{11}$TiH and $DyFe_{11}$TiH as compared to their precursors. In $HoFe_{11}$Ti, the easy-axis type of magnetic anisotropy was replaced by the cone of easy axes after hydrogenation. For *R*Fe_{11}TiH with *R* = Ho and Er, various field-induced SRTs were observed in high fields. The experimental critical field values were used to estimate the inter-sublattice molecular field. Hydrogenation affected strongly the crystalline electric field and changed the MCA type in some cases whereas the strength of the inter-sublattice exchange interaction remained almost unchanged.

The work was supported by RFBR (13-03-00744), Czech Science Foundation (204/12/0150) and EuroMagNET II under the EC contract 228043.

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STRESS AND ANNEALING DEPENDENCE OF MAGNETIC PROPERTIES IN AMORPHOUS-NANOCRYSTALLINE FeSiB ALLOYS

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It is known a partially nanocrystalline structure fabricating in amorphous alloys leads to the appreciable improving of their magnetic characteristics [1]. One way to obtain such nanomaterials is to use severe plastic deformation (SPD) technique. This work focuses on the influence of processes occurred during SPD of $Fe_{78}Si_{13}B_9$ amorphous alloy on the evolution of their magnetic properties and also studies the possibility of improving these properties of the deformed materials.

The structure and phase composition of the specimens were examined by X-ray diffraction and transmission electron microscopy. Magnetic characteristic measurements were performed by vibrating sample magnetometer technique at room temperature.

It was shown crystallization occurs primarily in shear bands and the proportion of the phase increases with the degree of deformation. It was shown that SPD affects the magnetic properties of this material significantly: the coercive force increases with degree of deformation increasing. To decrease coercivity of the deformed samples were annealed at temperatures below the crystallization temperature. It was shown that the heat treatment of deformed alloy at defined temperatures and durations allows reducing stresses added in samples during the deformation process, that allows to improve soft magnetic properties of the deformed sample.

This research was supported by the grant RFBR № 12-02-00537

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MAGNETIC PROPERTIES OF COBALT NITRIDES

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Transition metal nitrides have higher chemical stability and similar electrical conductivity when compared to metal base materials. In the case of cobalt nitrides, the phases with lower nitrogen content are predicted to be ferromagnetic and expected to form good interfaces with semiconductor nitrides, important issue for technological applications in spintronic devices such as tunnel magnetoresistance based sensors.

In this work, cobalt nitrides with composition between Co_4N and Co_3N were obtained in powder form, by nitriding under NH_3 flux cobalt powder previously obtained by reduction of Co_3O_4 nanoparticles prepared by a self-combustion method.

The composition and structure of the nitrides were investigated using X-ray diffraction, transmission electron microscopy and elemental analysis. With the increased incorporation of nitrogen, two different phases, identified as $Co_{4+x}N$ and Co_3N, were detected. Both phases are ferromagnetic and their properties were studied using SQUID magnetometry and ac magnetic susceptibility measurements. The structural and magnetic parameters characterizing each phase were obtained.

This work was carried out with the support of FCT, “Fundação para a Ciência e Tecnologia” through project PTDC/FIS/102270/2008.

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SYNTHESIS AND PROPERTIES OF Fe-B-Si AMORPHOUS SOFT MAGNETIC POWDERS PRODUCED BY MECHANICAL ALLOYING

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Fe-B-Si amorphous soft magnetic powders were prepared in a planetary ball mill using a mixture of iron, boron and silicon elemental powders. The milling process was carried out in argon atmosphere in order to avoid powder oxidation. The particles mean size diameter, determined by Laser Particle Size Analyser, depends on milling time and strongly decreases in the first hours of milling reaching values of about 20 μm [1]. Phases evolution and amorphisation process during milling were investigated by X-ray diffraction. The particles morphology and chemical homogeneity were investigated by scanning electron microscopy and X-ray microanalysis. It was found that longer milling time leads to an important contamination of the powder with iron [2]. The saturation magnetisation of the powders depends on the phases evolution during milling and powder contamination. Differential scanning calorimetry (DSC) investigations were performed in order to reveal phases thermal stability and kinetic of crystallisation.

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INFLUENCE OF Cr ATOMS ON THE CRYSTAL STRUCTURE AND MAGNETIC PROPERTIES OF $Fe_{65}Ni_{35}$ INVAR ALLOY

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INTRODUCTION

The influence of Cr atoms on crystal structure and magnetic properties of polycrystalline $Fe_{65}Ni_{35-x}Cr_x$ (x = 5, 10, 20, 30) alloys were investigated by X-ray diffraction, X-ray photoelectron spectroscopy, SQUID and Mössbauer effect methods. It was found that Cr atoms change crystal structure from the face-centered cubic phase to the body-centered cubic phase. Increase of concentration of Cr atoms cause significantly changes of magnetic properties investigated alloys. For alloys with x smaller than 30 the long-range magnetic order was not observed. Alloy with x = 30 behave as ferromagnetic with high Curie temperature. Differences in crystal structure and magnetic properties of investigated alloys are visible at room temperature Mössbauer spectra and connected with them hyperfine magnetic fields distributions (Figure 1). We suppose that magnetic properties of investigated alloys are results of local environment of Fe atoms and presence of these atoms in two spin states.

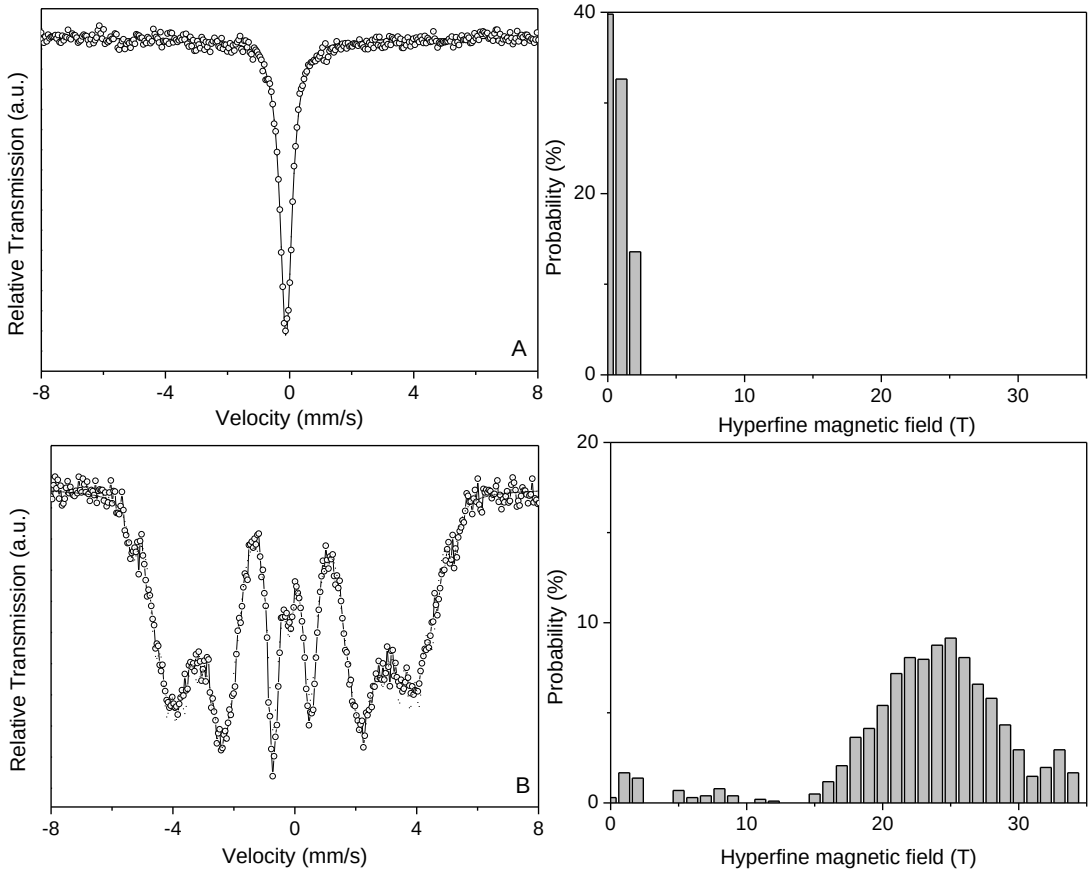

Fig. 1. Room temperature Mössbauer spectra and hyperfine magnetic fields distributions of $Fe_{65}Ni_{25}Cr_{10}$ (A) and $Fe_{65}Ni_5Cr_{30}$ (B) alloys.

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HIGH-FIELD MAGNETIZATION AND MAGNETOACOUSTICS OF U_2Ni_2Sn

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U_2Ni_2Sn belongs to a wide group of intermetallics with tetragonal crystal structure of the Mo_2FeB_2 type. It is an antiferromagnet with T_N = 26 K. Three metamagnetic transitions were observed in high magnetic fields applied along the *c* axis. All transitions are accompanied by pronounced anomalies in acoustic characteristics (sound velocity and sound attenuation) of a U_2Ni_2Sn single crystal. Although the transitions look similar in the magnetization curves, acoustic anomalies are rather different (Fig. 1). The first transition at a critical field μH_{cr1} = 30 T (it is practically temperature-independent and persists up to T_N) produces a step down in sound velocity and does not show off in sound attenuation. The second (μH_{cr2} = 40 T, also temperature-independent) and third (μH_{cr3} = 52 T at 1.5 K and decreases with increasing temperature) transitions exhibit a deep minimum in sound velocity and an anomaly in attenuation. Both are larger at the second transition.

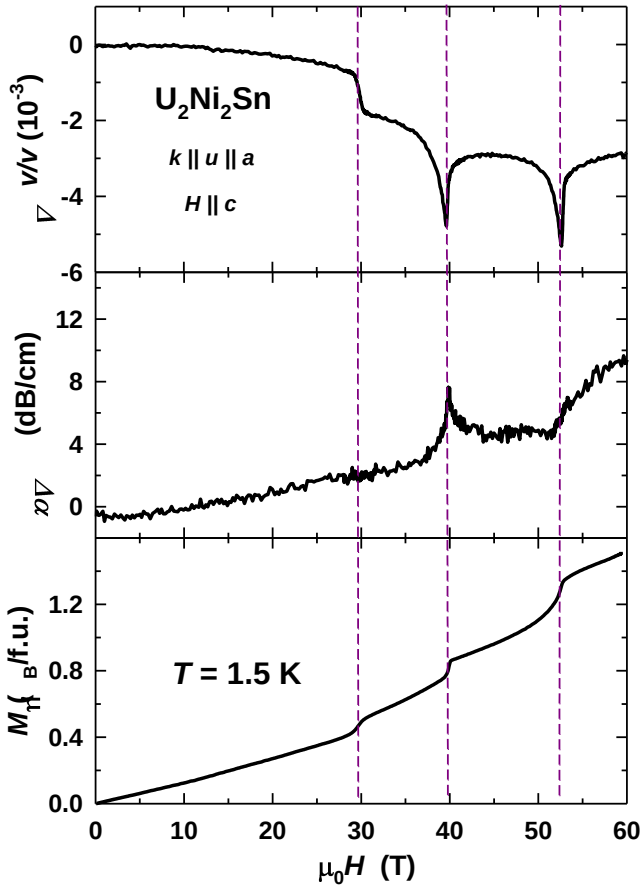

Fig. 1. Field dependences of magnetization *M*, change of sound velocity $\Delta v/v$ and change of sound attenuation $\Delta\alpha$ at 1.5 K. Dashed lines indicate critical fields of metamagnetic transitions.

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MAGNETIC BEHAVIOUR OF COLD-DRAWN SUPERELASTIC Fe-Ni-Co-Al-Ta-B MICROWIRES

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Recently, a new material that can resume its original shape in temperatures ranging from -196 to 249 °C as compared to -20 to 80 °C reported before has been developed [1]. The alloy presents superelastic strain of 13%, twice the maximum superelastic strain obtained in the Ni-Ti alloys.

This work reports results on the magnetic behavior of novel materials with high ductility, excellent magnetic characteristics and superelastic properties in the shape of $Fe_{40.95}Ni_{28}Co_{17}Al_{11.5}Ta_{2.5}B_{0.05}$ rapidly quenched magnetic wires. The samples have been cold-drawn from 170 μm down to 50 μm in several steps and subsequently subjected to applied weights of up to 500g.

The cold-drawing process leads to a decrease in the saturation magnetization and permeability and to an increase in coercivity. The external stresses insignificantly affect the as-cast wire but induce major changes in the 50 μm wire, i.e. drastic increase in the magnetization and magnetic permeability. The observed behavior suggests a change in the sign of magnetostriction constant due to stresses.

- Work supported by the Ministry of Education and Research, NUCLEU Programme, Project PN 09-43 02 03.

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MAGNETIC ANISOTROPY OF RAPIDLY SOLIDIFIED AMORPHOUS NANOWIRES

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Rapidly solidified amorphous nanowires with diameters from 100 to 900 nm have been recently prepared [1]. Here we report on the anisotropy of positive magnetostrictive $Fe_{77.5}Si_{7.5}B_{15}$ nanowires based on the analysis of their magnetoelastic (E_{me}) and magnetostatic (E_{ms}) terms and on ferromagnetic resonance (FMR) studies.

The minimization of both terms determines an axial anisotropy in the inner region. The minimization of E_{ms} would lead to axial anisotropy, whilst the minimization of E_{me} would lead to radial anisotropy near the surface. The increment in E_{ms} in case of orthogonal anisotropies (axial inside, radial near the surface) is larger than the increment in E_{me} in case of uniaxial anisotropy. Hence, the wires display mainly uniaxial anisotropy irrespective of diameter. The results also point to a magnetization ripple near the surface, where radial anisotropy would appear due to the minimization of E_{me}. The ripple is confirmed by FMR, which indicates a deviation of the easy axis from the axial direction. The ripple angle increases with diameter, as shown by FMR spectra of wires with various diameters (figure 1).

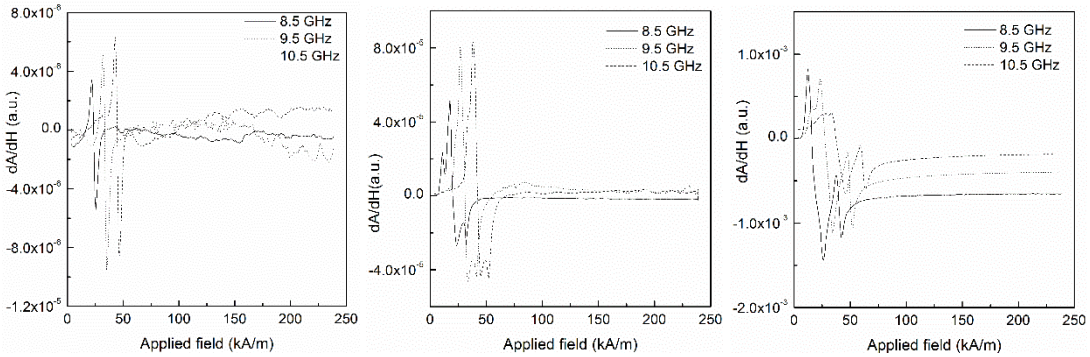

Figure 1. Left to right: FMR spectra of 350 nm, 500 nm, and 20 μm wires (20 μm sample employed as reference).

Work supported by the Romanian Ministry of National Education (Projects PN 09-43 01 01 and PN-II-ID-PCE-2012-4-0424).

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HIGH MAGNETIC FIELD STUDY OF THE INTERSUBLATTICE EXCHANGE INTERACTIONS IN $GdCo_{12-x}Fe_xB_6$ (x=0-3) COUMPOUNDS

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High field magnetization measurements up to 60 T on free powder samples from $GdCo_{12-x}Fe_xB_6$ (x = 0-3) compounds were carried out in order to determine the exchange interaction integral, $J_{Gd\text{-}3d}$ between Gd and 3d (Co,Fe) spins. The $GdCo_{12-x}Fe_xB_6$ borides crystallize in the rhombohedral structure of the $SrNi_{12}B_6$ type (space group R-3m). The systems are ferrimagnets, they order magnetically between T_C = 95 K for x = 3 and T_C = 165 K for x = 0 and exhibit compensation temperature. At the compensation temperature the two antiferromagnetically coupled sublattices cancel out. The compensation temperature (T_{Comp}) is about 50 K and almost insensitive to Fe content. The average magnetic moment $<\mu_{Co+Fe}>$ per mean transition metal atom (Co + Fe) is small and increases with increasing Fe concentration from 0.44 μ_B for x = 0 to 0.51 μ_B for x = 3 at T = 4 K. From high field magnetization curves a value of $J_{Gd\text{-}3d}/k_B$ = -4.65 K is derived for x = 0 whereas mean field approximation yields a much larger 3d-3d exchange integral of $J_{3d\text{-}3d}/k_B$ =105 K. The obtained results reveal a slight increase of - $J_{Gd\text{-}3d}/k_B$ with Fe concentration.

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HIGH-TEMPERATURE MAGNETIZATION STUDY OF TERBIUM IRON GARNET IN STRONG DC MAGNETIC FIELDS

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INTRODUCTION

Terbium iron garnet (TbIG) has been attracting a real attention due to the recent dielectric and magnetic properties [1]. Precise magnetization measurements have been performed on single crystals in high d.c. magnetic fields up to 200 kOe applied along the <111>, <110> and <100> crystallographic directions and in the 150–300 K temperature range.

In the vicinity of the compensation temperature (T_{comp} = 243.5 K) the previous magnetic transitions between collinear and canted induced magnetic structures [2] are observed in the curves $M_T(H)$ and their deviations $M_T(H)$-H/λ where $\lambda=\chi_\perp^{-1}$, is the inverse of the mean susceptibility in the canted phase (Figure 1). Far away from T_{comp}, the magnetic structures are collinear for any direction of H and no significant magnetization anisotropy was found. The magnetization study at high temperature is based on two-sublattice model of the Néel's theory of ferrimagnets.

Such molecular field analysis gives an accurate determination of the mean effective exchange coupling coefficient between the iron and the terbium ions and a better estimation of the terbium-terbium interactions by comparison with previous work [3].

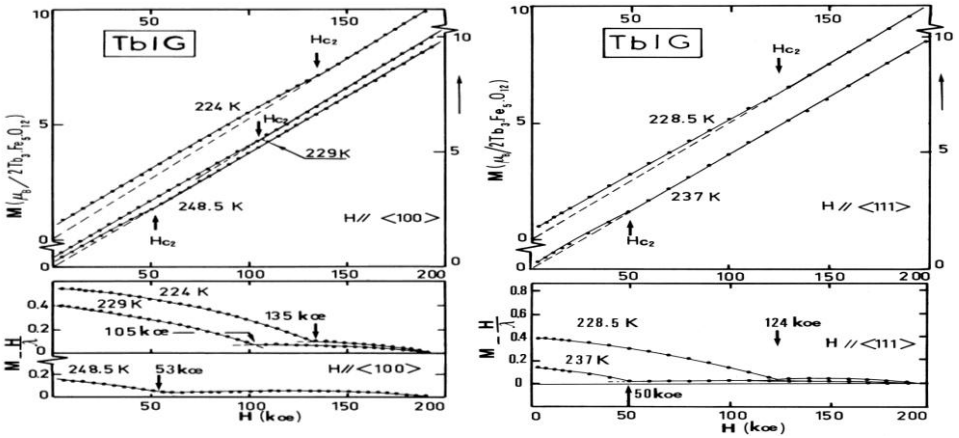

Figure 1. $M_T(H)$ and $M_T(H)$-H/λ curves near T_{comp}.

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STRUCTURAL INSTABILITY AND MAGNETIC PROPERTIES OF CU_2MNGE HEUSLER ALLOY

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Structural instability and ferromagnetism have been disclosed in stoichiometric Cu_2MnGe Heusler alloy. Powder x-ray diffraction and transmission electron microscopy observation indicated that the low-temperature phase of Cu_2MnGe has a monoclinic crystal structure. Structural transformation from the low-temperature monoclinic to a high-temperature cubic B2 structure takes place at rather a high temperature, M_s = 641 K. The structural transformation sequence is complex, involving bainitic transformation and formation and dissolution of precipitates.

Magnetization measurements have showed that Cu_2MnGe orders ferromagnetically at T_C = 278 K. At liquid helium temperature, Cu_2MnGe possesses a magnetic moment of 1.6 μ_B per formula unit. Splitting of ZFC and FC curves observed at temperatures below 230 K is presumably a consequence of the B2 structure of the austenitic phase. It this case the disorder of Mn and Ge sublattices can result in antiferromagnetic interaction between Mn atoms located at 4b and 4d sites. Beside the lack of the $L2_1$ chemical ordering of the high-temperature phase, bainite character of the structural transformation brings about an additional source of chemical (and, in fact, compositional) disorder and thus also affect magnetic properties of Cu_2MnGe.

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MAGNETIC AND MAGNETOELASTIC PROPERTIES OF AMORPHOUS $FE_{75}SI_{10}B_{15}$ WIRES

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INTRODUCTION

The influence of the pretreatment on magnetic and magnetoelastic properties of amorphous $Fe_{75}Si_{10}B_{15}$ wires has been carried out.

METHODS

Under the pretreatment we mean the dc current propagation (density j from 15 MA/m^2 up to 35 MA/m^2) through samples (170 μm in diameter) and applying of tensile stresses (σ from 20 MPa up to 250 MPa) took place simultaneously during 2 minutes.

RESULTS AND DISCUSSION

It was shown the behavior of the field dependencies of the magnetic induction B and ΔE-effect changes significantly due to the pretreatment circumstances. At different pretreatment modes, it has been observed both negative and only positive ΔE-effect. Results of the research can be interpreted in terms of the structure changing and the distribution of the magnetization inside wire, which has been pretreated by dc current of the different densities and application of the tensile stresses.

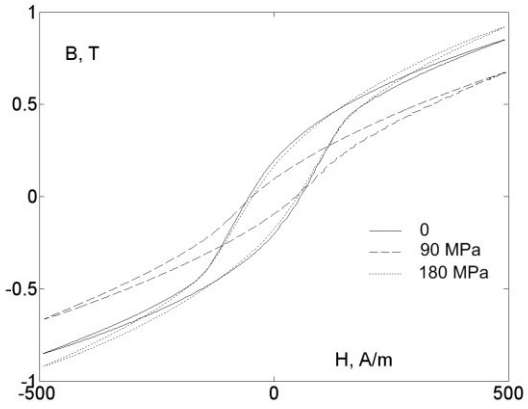

Fig.1. Hysteresis loops behavior of the wire, which has pretreated by dc current density of 31 MA/m^2 while different tensile stresses (σ = 0; 90 MPA; 180 MPa) applied simultaneously.

As been assumed the cause of the positive ΔE-effect and changes of the hysteresis loops squareness in samples is the occurrence of the local plastic deformation. Such a deformation is due to the simultaneous effect of Joule heating and tensile stresses applying.

ACKNOWLEDGEMENTS

This research was supported by Russian Foundation for Basic Research (projects № 11-08-00362 and №12-08-31476_mol-a)

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KINETICS OF MAGNETIC PROPERTIES AND STRUCTURE OF IRON BASED MELT-SPUN ALLOYS

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INTRODUCTION

In this paper the behavior of alloys $Fe_{70}Cr_{15}B_{15}$, doped with Sn and Mo (0,03% Sn; 0,1% Sn; 3% Mo) obtained by melt spinning was studied. Methods of X-ray diffraction, differential scanning calorimetry (DSC), vibromagnitometer, Mossbauer spectroscopy were used. Alloys were held in 10^{-5} Torr vacuum while stepwise annealed in temperature range 100 - 500°C.

RESULTS

By means of DSC it was found that up to 550^0C the structural relaxation processes are within the amorphous state.

It has been shown that in initial state all alloys are paramagnetic, which was confirmed by Mössbauer studies on Fe-57. Rising of annealing temperature to 400^0C (for $Fe_{70}Cr_{15}B_{15}$ +0.1% Sn and $Fe_{70}Cr_{15}B_{15}$ + 0.03% Sn alloys) leads to appearance of ferromagnetic order. Magnetic state of the samples is represented by two components - ordered and disordered. The alloy doped with Mo stays paramagnetic at all steps of annealing.

For samples in ferromagnetic state the coercive force was defined, which is 83Oe and 205Oe for alloys with 0,1% and 0,03% addition of Sn respectively.

By means of X-ray diffraction analysis on each step of annealing it was found that the degree of amorphousity of samples increases from 0,03% Sn to 0,1% Sn and 3% Mo; so processes of structural relaxation during isothermal annealing are sensitive to the composition and amount of alloying elements.

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FePd, FePt, AND CoPt ALLOY EPITAXIAL THIN FILMS WITH FLAT SURFACES ON MgO(111) SUBSTRATES

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High K_u $L1_0$ ordered films have been investigated for various device applications, where flat surface is required. High-processing-temperature is, however, necessary to promote $L1_0$ ordering. In the last JEMS, we reported preparations of $L1_0$ ordered films with very flat surfaces on MgO(001) by employing a two-step method consisting of low-temperature deposition followed by annealing at 600°C [1]. In the present study, the method is applied to the formation of $L1_0$(111) films on MgO(111) substrates. The structure and magnetic properties are compared with those prepared by one-step deposition at 600°C. Epitaxial films of FePd, FePt, and CoPt consist of six variants of $L1_0$(111) crystal, whose *c*-axes are canted 55° from the film normal, as shown in Fig.1(a). Although the preparation method is different, similar order degrees are obtained for all the films; for example, those of the FePd films prepared by one- and two-step methods were 0.26 and 0.33, respectively. However the surface flatness is apparently different between the two methods. Very flat surfaces are realized by employing the two-step method. Fig.1(b) shows an example for FePd epitaxial films.

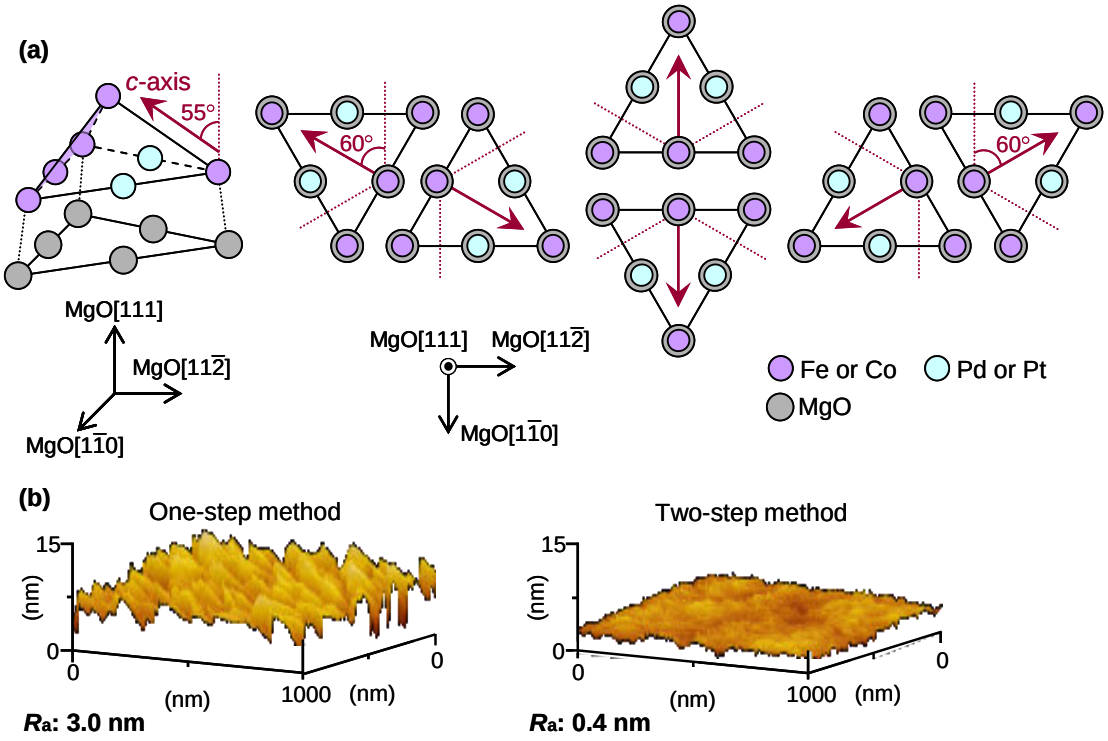

Fig.1 (a) Six $L1_0$(111) variants. (b) AFM images.

[1] A. Itabashi *et al.*: EPJ Web Conf. 40, 07001 (2013).

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MAGNETIC FIELD ENHANCED SOFT MAGNETIC PROPERTIES OF FE-CO ALLOYS

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Reducing the energy consumption is one of the driving forces for the development of improved materials. In this respect, both new metallurgical processes and improved magnetic materials can provide future solutions for a sustainable development. In this work, thermo-magnetic processing is presented as a new technology with the goal of developing improved soft magnetic properties in FeCo alloys unattainable through conventional processing. Developing the permeability of FeCo alloys and decreasing their coercivity are the two main challenges for embarked electrotechnics. In this work, the ferrite phase is found to be stabilised together with a coarse grain microstructure during recristallisation and growth of two FeCo alloy grades under magnetic field. As a result of recrystallization of cold rolled sheets of the Fe-49%Co-2%V alloy, soft magnetic properties are developed through an extended field induced anisotropy. A decrease of ~40% of the coercivity and of 15% of the total losses as compared to the commercial values is reported. Beside, improved functional properties are obtained by a magnetic field induced Goss texture enhancement in the Fe-27%Co alloy sheet. The coercivity is improved by a factor of almost 3.5 compared to the commercial value as well as the induction level. The total magnetic losses are reduced.

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ON THE ANGULAR DEPENDENCE OF COERCIVITY IN NdFeB MAGNETS

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The measurement of the angular dependence of coercivity constitutes an important test for identifying the mechanisms that govern magnetization reversal in hard magnetic materials. This angular dependence is usually determined experimentally by plotting the coercive field, H_c, (taken as the switching field and corresponding to the maximum of the irreversible susceptibility) as a function of the angle between the main direction of grain orientation and the applied magnetic field. In NdFeB sintered magnets, there is a general tendency for the coercive field to increase with angle and this has been taken as a proof that reversal is not governed by coherent rotation but rather expansion of a preformed nucleus.

We have calculated the full magnetization curve of an assembly of exchange-decoupled particles, globally oriented along a given preferred axis. Assuming Kondorsky-like behaviour, the calculated angular dependence H_c reproduces the experimental data. In agreement with previous analysis [1], the lack of full grain alignment leads to significant reduction in the angular dependence of H_c. However, the magnetization variation in region where irreversible reversal dominates is significantly more abrupt than calculated. This is attributed to collective behaviour occurring during reversal.

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UV CURABLE SILICONE SOFT MAGNETIC COMPOSITES WITH VARIOUS ASPECT RATIO SOFT MAGNETIC METAL GLASS FILLERS

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Abstract

Due to the advantages of flexible processing abilities, frequency independent eddy current loss and 3D isotropic magnetic properties, the polymer bonded soft magnetic composites are drawing more and more attentions in medical, informatics and electronic applications. In this study, the UV curable silicone gel was compounded with the various aspect ratio high performance metal glass soft magnetic fillers at different filling contents(10wt%, 30wt%, 50wt%, 70wt%, 80wt%). The effect of filler aspect ratio and filling content on the curing ability, viscosity, thermal conductivity and magnetic properties is investigated and discussed. The influence mechanism was revealed by SEM and XRD morphologic structure analysis. In the end, their application as magnetic core glues is discussed as well.

The Figure 1 shows the SEM images of two different size metal glass fillers at 50wt% filling content of UV curing silicone gel.

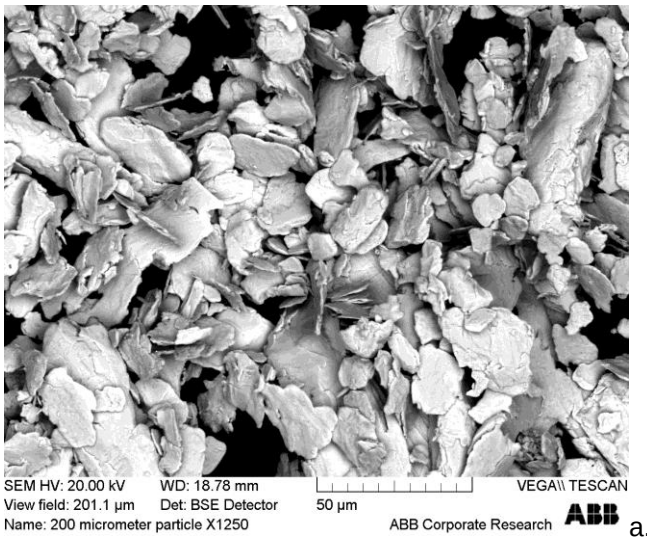

Figure 1. a. the 200 µm diameter metal glass fillers; b. the 1 mm diameter metal glass fillers

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MAGNETIC AND TRANSPORT PROPERTIES OF THE HEUSLER SYSTEM $NI_{2-X}MN_{1+X}SN$

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INTRODUCTION

In the present work we have investigated a new series of polycrystalline alloys of the general composition $Ni_{2-x}Mn_{1+x}Sn$ with x = 0, 0.2, 0.4, 0.5, 0.6, 0.8, 1. The alloys were obtained as single-phase materials by inductive melting of the high purity elements and subsequently annealed at 700°C. $Ni_{2-x}Mn_{1+x}Sn$ crystallizes in the cubic Heusler structure, thus forming a solid solution series from Ni_2MnSn to Mn_2NiSn. The stoichiometric Heusler compounds of this series show ferro- or ferrimagnetic order with T_c ranging from 346 to 550 K, respectively. The magnetic moment at 1.8 K decreases in the series from 4.1 μ_B to 2.3 μ_B due to a decreasing of the valence electrons per formula unit. The cubic symmetry is stable from low to high temperature. Instead of building a non-cubic structure, a miscibility gap; this is an evidence for an entropic stabilization of the cubic phase.

The temperature dependence of the electrical resistivity shows a metallic behavior. The analysis of the Seebeck coefficient of Ni_2MnSn indicates a dominant role of the electron type conductivity. At the same time the Seebeck coefficient is approximately zero due to the compensated conductivity of all the off-stoichiometric Heusler alloys and Mn_2NiSn.

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IRON OXIDE NANOCOMPOSITE MAGNETS PRODUCED BY PARTIAL REDUCTION OF STRONTIUM HEXAFERRITE

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ABSTRACT

Isotropic bulk nanocomposite permanent magnets were produced with strontium hexaferrite, $SrO{\cdot}6Fe_2O_3$, and magnetite, Fe_3O_4, as the magnetically hard and soft components. A novel synthesis scheme based on the partial reduction of $SrO{\cdot}6Fe_2O_3$ was employed.

In two parallel experiments, nano- and microcrystalline $SrO{\cdot}6Fe_2O_3$ particles were compacted into pellets along with a controlled, understoichiometric amount of potato starch as a reducing agent. The pellets were then sintered in a passive atmosphere.

Based on XRD and room temperature magnetic hysteresis measurements, it was concluded that a fraction of the $SrO{\cdot}6Fe_2O_3$ input material had been reduced into Fe_3O_4. In comparison with pure $SrO{\cdot}6Fe_2O_3$ control pellets, these composites exhibited maximum energy product increases in excess of 5 % due to remanence boosting.

The improvement of magnetic properties was attributed to an efficient “exchange spring” coupling [1] between the magnetic phases. Interestingly, as the synthesis scheme also worked for microcrystalline $SrO{\cdot}6Fe_2O_3$, the method could presumably be adapted to yield crystallographically oriented bulk nanocomposite magnets, with theoretically calculated maximum energy product advantages around 10 %.

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LOW TEMPERATURE PHASE TRANSITION IN $DyAl_3(BO_3)_4$ BORATE

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Heat capacity of a $DyAl_3(BO_3)_4$ laser material was measured between 0.1 and 300 K by using the PPMS Dilution Refrigerator and Heat Capacity options. Two specific heat anomalies were found: a sharp λ-type anomaly at T_C = (0.53 ± 0.2) K and a broad maximum near 4K. They were interpreted, respectively, as the anomaly accompanying a phase transition to a magnetically ordered phase and the Schottky anomaly related to excitations of Dy^{3+} ions to four lowest doublets.
The phonon contribution to the specific heat was described in frames of the low temperature approximation of the Debye model. Thus, the specific heat for T > 1.5 K was described by the expression:

$$C(T) = \frac{R}{T^2}\left[\frac{\sum_{i=0}^{4} E_i^2 \exp(-\frac{E_i}{T})}{\sum_{i=0}^{4} \exp(-\frac{E_i}{T})} - \left(\frac{\sum_{i=0}^{4} E_i \exp(-\frac{E_i}{T})}{\sum_{i=0}^{4} \exp(-\frac{E_i}{T})}\right)^2\right] + \frac{12\pi^4 nR}{5}\frac{T}{T_D^3}^3,$$

where T denotes temperature, R molar gas constant, E_i energy (expressed in K) of the levels, T_D the Debye temperature, and n=20 is the number of atoms in the formula unit.

By applying this formula, the energies of the four lowest Dy^{3+} levels and T_D were estimated and a satisfactory description of the experimental data (fig 1.) was achieved.

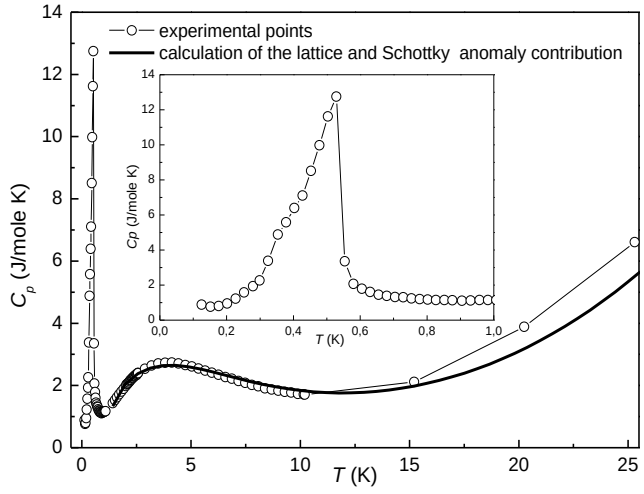

Figure 1 The low-temperature part of the temperature dependence of the $DyAl_3(BO_3)_4$ specific heat.

This work was partly supported by the European Regional Development Fund, through the Innovative Economy Grants POIG.01.01.02-00-108/09 and POIG.02.02.00-00-025/09.

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THERMAL AND MAGNETIC PROPERTIES OF MATERIALS FOR CATHODES OF Li-ION BATTERIES

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Lack of safe and chemically stable cathodes is the main obstacle curbing development of Li-ion batteries. $LiFePO_4$ is a promising cathode material, however, its electrical conductivity must be increased. One attempts to achieve this by partial chemical substitutions of Fe, and P. Studies of magnetic properties and specific heat (from 2 to 300 K, in magnetic field up to 9 T) of the substituted compounds were performed. They revealed the presence of the paramagnetic-antiferromagnetic phase transition in all $LiFe_{1-x}M_xPO_4$ compounds (M = Mn, Co, Ni) - Figure 1. For $LiNiPO_4$, a two-step development of the antiferromagnetic ordering was found. Substitution of P with Mo, changing the stoichiometry to $Li_3Fe(MoO_4)_3$, removes the phase transition and only a Schottky anomaly of the specific heat is observed (Figure 2).

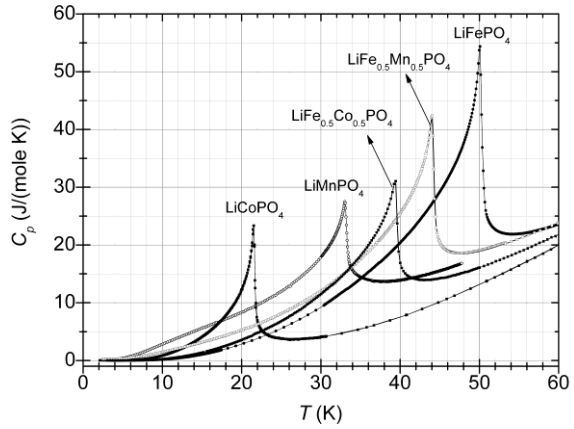

Figure 1. Specific heat of some of the measured compounds.

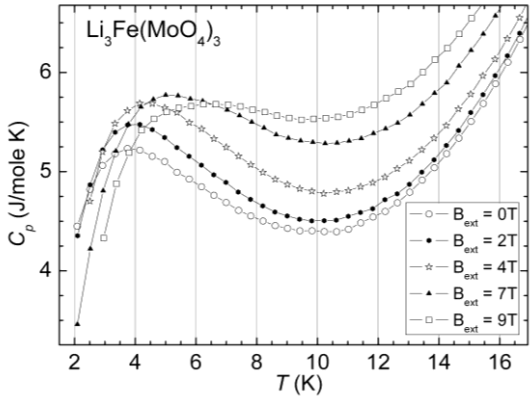

Figure 2. Specific heat of $Li_3Fe(MoO4)_3$ vs. temperature.

This work was partly supported by the European Regional Development Fund, through the Innovative Economy Grants POIG.01.01.02-00-108/09 and POIG.02.02.00-00-025/09.

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MAGNETOCALORIC EFFECT AND THE TEMPERATURE COEFFICIENT OF THE RESISTANCE OF A $La_{0.85}Ag_{0.15}MnO_3$ EPITAXIAL THIN FILM

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Doped-manganite oxides have attracted considerable interest due to their promise for technological applications. [1]

In this work, we report the magnetocaloric effect and temperature coefficient of resistance (TCR) of a $La_{0.85}Ag_{0.15}MnO_3$ epitaxial thin film, grown on a single-crystal substrate of $SrTiO_3$ using the chemical solution approach of polymer-assisted deposition.

Our x-ray diffraction study showed that the film is (001) oriented, and an optical profiler measurement revealed a film thickness of 35 nm. Using isothermal magnetization measurements around the Curie temperature, we have calculated the entropy changes. A maximum entropy change of -2.72 J/kg K, corresponding to a magnetic field variation ($\Delta\mu_0 H$) of 2T, was obtained at room temperature (Figs. 1 a, b). The refrigeration capacity at this field variation reached a large value of 125 J/kg, suggesting that this material has potential as a magnetic refrigerant.

The temperature coefficient of resistance has been calculated from resistivity measurements. A maximum TCR value of 3.01 % K^{-1} was obtained at 309 K (Fig. 1c). This value is slightly higher than those reported in manganite thin films [2], indicating a real potential for thermometry in uncooled bolometric applications.

[1] M. H. PHAN, *et. al.* J. Magn. Magn. Mater. 308, 325 (2007).

[2] F. YANG, *et. al.* J. Appl. Phys. 99, 024903 (2006).

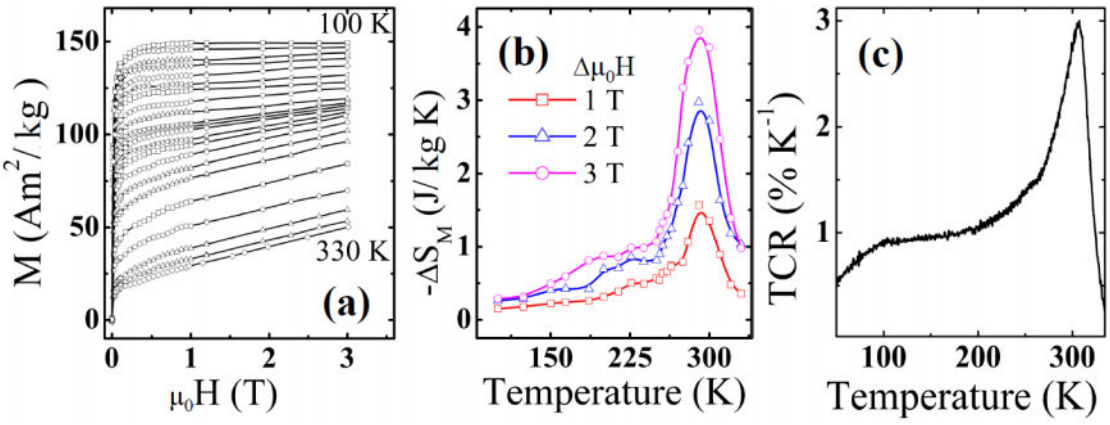

Figure 1. (a) Isothermal magnetization curves at different temperatures as a function of applied magnetic field. (b) Entropy change for $\Delta\mu_0 H$ of 1, 2 and 3 T, and (c) TCR, both as a function of temperature.

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DIRECT MEASUREMENT OF THE MAGNETOCALORIC EFFECT IN (MN,FE)(P,SI)

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The direct adiabatic temperature change ΔT_{ad} reflects the driving force for heat transfer in a magnetocaloric device. Therefore, the evaluation of magnetocaloric effects (MCE) without considering the ΔT_{ad}, may fail to account properly for the applicability of a magnetic material as magnetic refrigerant. In other respects, ΔS is generally determined by indirect measurements, which are known to meet artifacts for first order phase transition, while direct measurements are considered to be more straightforward and reliable. The ΔT_{ad} of (Mn,Fe)(P,Si) compounds was measured directly using thermocouple in a homemade device under a permanent magnetic field of 1.1 T. The maximum ΔT_{ad} value is about 2.2 K for $Mn_{1.25}Fe_{0.70}P_{0.49}Si_{0.51}$. Since the sample goes in and out of field continuously while the temperature is sweeping, the ΔT_{ad} determined from these measurements correspond to the reversible part of MCE, *i.e.* the part useful for real application. As can be seen from Fig.1, the reversibility of the MCE does not undergo any degradation after several magnetization-demagnetization cycles. These results allow the direct demonstration of the promising performances of (Mn,Fe)(P,Si) materials as magnetic refrigerants for real life application.

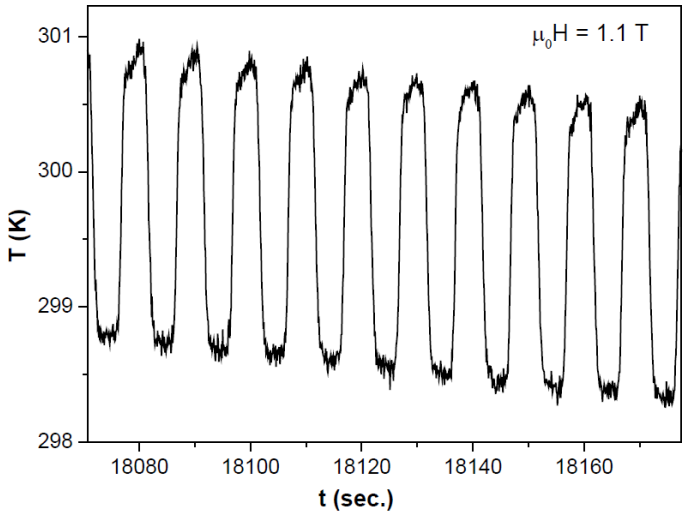

Fig.1 Time dependence of temperature of $Mn_{1.25}Fe_{0.70}P_{0.49}Si_{0.51}$ by the direct method under magnetic field-change of 1.1 T.

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THERMAL PROPERTIES OF THE (Nd,Ca)$BaCo_2O_{5.5}$ CATHODE MATERIALS

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Oxygen vacancy ordered layered cobaltites $RBaCo_2O_{5.5}$ exhibit rich spectrum of magnetic and electronic states. They are also promising as cathodes in fuel cells, due to large O^{2-} ionic and electrical conductivities at elevated temperatures. Substituting Ca^{2+} for R=Nd^{3+} results in a hole doping without the crystal structure modification.

Specific heat studies (relaxation method, PPMS) were performed for the series of policrystaline samples $(Nd_{1-x}Ca_x)BaCo_2O_{5.5}$ (x = 0, 0.02, 0.06, 0.08, 0.16, 0.2) to elucidate the observed phase transitions. Measurements were taken for the temperature range 2 - 395 K in magnetic fields of 0 and 7 T. Specific heat anomalies are shown in Figure 1: (a) the anomaly accompanying the metal-insulator transition, (b) the Schottky anomaly signifying excitations of the Nd^{3+} ions.

The lattice and magnon contributions to the specific heat have been identified.

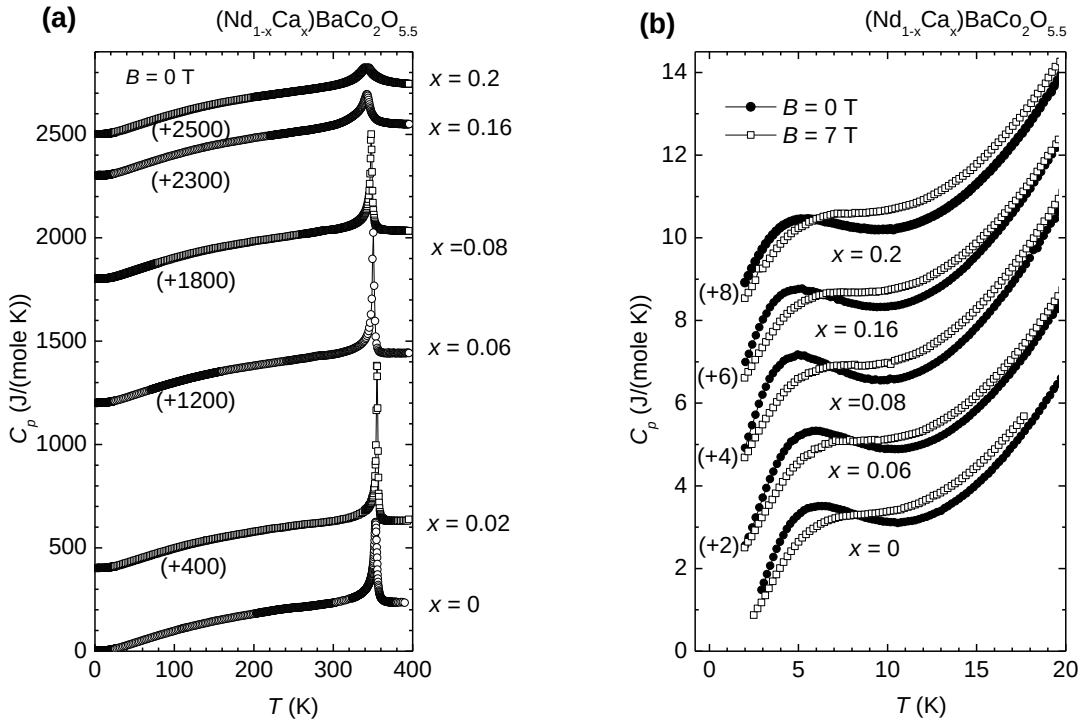

Figure 1. Temperature dependences of specific heat measured for $(Nd_{1-x}Ca_x)BaCo_2O_{5.5}$. For clarity, curves measured for different x are shifted along the C_p axis by the values given in parentheses.

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STEINMETZ LAW IN IRON BASED SOFT MAGNETIC COMPOSITES

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The core loss is one of important quantities describing magnetic properties of soft magnetic materials including soft magnetic composites at DC and AC magnetic fields. The effort to express the core loss as a function of frequency and maximum induction is one of many requirements of the research for many years. The Steinmetz law [1] was originally formulated for the description of core loss at DC magnetic field for laminated FeSi steels at the medium maximum induction

$$W_{DC} = kB_m^x ,$$

where k and x are material constants. The aim of this work is to analyze the coefficients of Steinmetz law in wider induction range (including small values of B_m) for iron based soft magnetic composites.

On the basis of the experimental results the dependences of loss at DC magnetic field for hysteresis loops with maximum induction in very low magnetic fields the exponent in Steinmetz law is x=3. For higher values of B_m in relatively wide range the exponent x is determined as $x \cong 1.5$.

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AN ATOMIC FORCE MICROSCOPY STUDY OF EUROFER-97 STEEL

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INTRODUCTION

In recent years the microstructure, mechanical and magnetic properties of Eurofer-97 steels are studied intensively due to their application in nuclear fusion power plants [1]. Their microstructure is usually accessed by means of electron microscopy. Here we present an alternative approach; Atomic Force Microscopy (AFM).

METHODS

The as-received Eurofer-97 sample has nominal composition 9Cr–1.1W–0.125Ta–0.25V–0.105C–0.6Mn–0.036N (wt.%) [1]. AFM signals on Height (HS) and Phase (PS) that relate to morphological and elastic topography, respectively, were obtained with a Solver-Pro unit [NT-MDT].

RESULTS

The HS detects structures of nano/micro-size grains exhibiting nm differences in height. The PS clearly detects circular particles (CPs) of diameter 50-2000 nm. Interestingly, bigger CPs are randomly distributed, while smaller CPs are sometimes arranged in correlation to grain boundaries. Though we cannot identify the elemental composition of the CPs, based on electron microscopy data we ascribe them to $M_{23}C_6$ (M=Cr,Fe) particles.

CONCLUSIONS

In Eurofer-97 steel, AFM detects $M_{23}C_6$ CPs due to their different elastic properties from the surrounding Fe-Cr matrix.

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ACKNOWLEDGMENTS

A. Möslang (Karlsruhe Institut für Technologie, Germany) is acknowledged for supplying the sample.

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OPTIMIZATION OF QUANTITY AND PLACEMENT OF ACTIVE (MAGNETIC) ELEMENTS IN A BEAM-LIKE STRUCTURE

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INTRODUCTION

The exceptional physical properties of intelligent materials (thermal and magnetic shape memory alloys, magnetorheological fluids) integrated within elements of structures lead to structural characteristics uncommon in nature. Intelligent materials can be integrated with various engineering structures or their elements in order to enable one to control their static, dynamic or damping characteristics.

RESEARCH

The goal of this paper is the assessment of the application effectiveness of magnetic actuators in beam-like structures This was achieved based on a numerical study, in which a laminated beam was investigated. Also the application of various intelligent material actuators was tested as well as their influence on selected dynamic characteristics. A simple damage scenario was considered, in which the negative influence of the damage presence was minimised.

CONCLUSION

The results obtained reveal the influence of the active elements and showed that this kind of actuators can be successfully applied for vibration reduction, tuning and control in the case of engineering beam-like structures.

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SOFT MAGNETIC COMPOSITE COMPACTS OF Fe/Fe_3O_4 TYPE. SYNTHESIS, MAGNETIC AND STRUCTURAL INVESTIGATIONS

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Soft magnetic composite compacts of Fe/Fe_3O_4 type were synthesized in toroidal shapes by classical sintering route starting from mixtures of Fe and α-Fe_2O_3 commercial powders. The atomic percent of oxygen in the starting powders and in the composite compacts varied from 0 to 57 %. The influence of the synthesis conditions (compacting pressure, sintering temperature and sintering time) on the formation of the composite compacts are studied and discussed. High compacting pressure leads to the formation of the composite compacts that have very good densities and magnetic properties. Magnetic induction, magnetic permeability, magnetic losses and electrical resistivity of the Fe/Fe_3O_4 compacts were investigated. The increasing of oxygen amount in the composite material leads to a decrease of the magnetic induction and permeability but, offer a decrease of the magnetic losses due to the increased electrical resistivity. The morphological characterization and iron and iron ferrite phases distribution in the composite compacts were investigated.

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MAGNETIC PROPERTIES OF $Nd_2Fe_{14}B$/α-Fe NANOCOMPOSITES OBTAINED BY MECHANICAL MILLING AND RAPID ANNEALING

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The structural and magnetic properties of $Nd_2Fe_{14}B$/α-Fe hard/soft magnetic nanocomposites were investigated. Previous results have suggested a better interphase exchange coupling for samples milled for 6 hours [1]. The $Nd_2Fe_{14}B$ + 10% wt. α-Fe samples were prepared through mechanical ball milling, followed by rapid annealing between 700 and 800 ºC for different times ranging from 0.5 to 3 minutes (quenched in air and in water respectively). The width of the X-ray diffraction peaks of the hard magnetic phase increases with increasing milling time; the peaks disappearing for 6 h of milling. After annealing, the characteristic peaks of the hard magnetic phase are restored and are more refined for the air-quenched samples. The magnetic behaviour is investigated from hysteresis curves and *dM/dH* vs. *H* plots. It was found that longer annealing times tend to increase the coercive field, while lowering the remanent magnetization. In addition, the samples quenched in water display lower remanence and coercive field values. Taking into account the milling time and annealing conditions, the $Nd_2Fe_{14}B$/α-Fe exchange coupling is analyzed.

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CORE LOSS CHARACTERISTIC OF COMPACTED SUPERMALLOY POWDER

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Supermalloy is a soft magnetic material with extremely high initial and maximum permeability and low coercivity. Supermalloy (usually $Ni_{79}Fe_{16}Mo_5$) is fabricated in the form of thin sheet, in the form which is not convenient for some applications; therefore it is logical to attempt to prepare such material in more “bulk” form.

The aim of this work was to investigate dc (magnetization curves, initial and maximum permeability) and ac magnetic properties of bulk soft magnetic materials in the form of a ring prepared by the compaction of $Ni_{79}Fe_{16}Mo_5$ (wt. %) powder obtained by milling of small swarfs for 1 or 100 hours in planetary ball mill.

From the frequency dependences of the core loss (dc to 50 Hz) were calculated the components of the loss: dc loss, classical loss and domain wall eddy current loss.

From the studying compacting powder of the supermalloy, we conclude that the magnetic properties of these material show strong dependence to its initial powder and annealing conditions. The studied alloy shows good soft magnetic properties that can be tailored to the need of certain requirements by adjusting the processing routes such as compaction, and heat treatment conditions.

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ORIGIN OF THE TUNABLE PHASE TRANSITION PROCESS BY SI SUBSTITUTION IN $MN_{1.25}FE_{0.70}P_{1-x}SI_x$ COMPOUNDS

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Tunable magnetoelastic transitions and giant magnetocaloric properties have been achieved in $(Mn,Fe)_2P_{1-x}Si_x$ compounds.[1] The phase transition is accompanied by changes in the density of states of the Fe/Mn 3*d* electrons, which is sensitive to its nearest neighbors. Replacement of P by Si changes the chemical environment around the Fe/Mn atoms due to different valence electron numbers. Besides, the site preference of Si predicted by density functional calculations would further influence the local electronic and magnetic structures.

In the present study, temperature-dependent neutron diffraction is used to obtain local magnetic moments and interatomic distances as a function of temperature in $Mn_{1.25}Fe_{0.70}P_{1-x}Si_x$ compounds. A preferred occupation of Si on the 2*c* site has been experimentally found, consistent with our first-principle calculations. The Si substitution-induced variations in the phase transition process are discussed based on interatomic distance, local electronic structure and local magnetic moment.

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MAGNETOCALORIC EFFECT AND ITS IMPLEMENTATION IN CRITICAL BEHAVIOR STUDY OF $LA_{0,67}BA_{0,33}MN_{0,9}CR_{0,1}O_3$ MANGANITE PEROVSKITE

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Magnetic properties and magnetocaloric effect of the $La_{0,67}Ba_{0,33}Mn_{0,9}Cr_{0,1}O_3$ perovskite are investigated. The maximum values of the magnetic entropy change ($-\Delta S_M$) at 324 K are 4.20 $JKg^{-1}K^{-1}$ and 1.56 $JKg^{-1}K^{-1}$ for magnetic field variations of 5 and 1 T, respectively, which are closely related with a second-order magnetic phase transition from the ferromagnetic to the paramagnetic state. The reversible magnetocaloric effect, with a relatively broad operating temperature range, makes of $La_{0,67}Ba_{0,33}Mn_{0,9}Cr_{0,1}O_3$ an attractive candidate for room-temperature magnetic refrigeration [1]. The critical behaviour [2] around the transition temperature is investigated in detail using both the standard Kouvel-Fisher procedure as well as the study of the field dependence of the magnetocaloric effect. Results indicate that the critical exponents deduced from our experiments are reliable, and that the present sample exhibits a three-dimensional Heisenberg behaviour with short-range interactions [3].

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MICROSCOPIC INSIGHTS INTO THE MAGNETISATION REVERSAL PROCESS IN HEXAGONAL NANO-SCALED ANTIDOT LATTICES

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Antidot lattices in magnetic materials can be a way to form artificial magnonic lattices as an approach towards spin-wave filters for spintronics [1]. Introduction of an antidot lattice provides a significant modification of the magnetic properties like coercivity and magnetic anisotropy [2].

Angular and spatially resolved MOKE measurements as well as magnetic x-ray microscopy (MAXYMUS@BESSY) were conducted in order to gain insight into magnetisation properties of antidot lattices in in-plane (Fe) and out-of-plane (GdFe) systems.

MOKE measurements with high spatial resolution, shown in figure 1, indicate that the easy axes orientation is governed by the antidot lattice geometry, resulting in a six-fold symmetry. The increase of coercivity by about two orders of magnitude is not limited to in-plane magnetised samples, but also present in out-of-plane systems, suggesting domain wall pinning at the antidots as origin of the increase.

X-ray microscopy reveals a strict confinement of domains within the antidot lattice as shown in figure 2. The antidot lattice also influences the magnetisation reversal process, discriminating two processes for easy and hard axis orientation.

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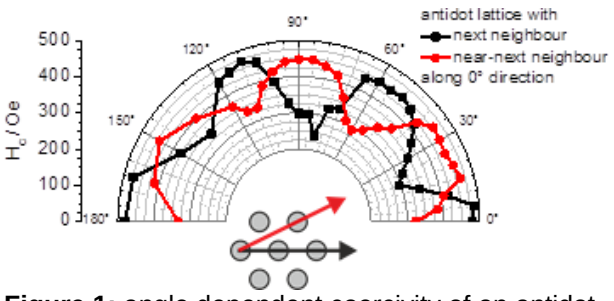

Figure 1: angle dependent coercivity of an antidot lattice in an iron thin film sample

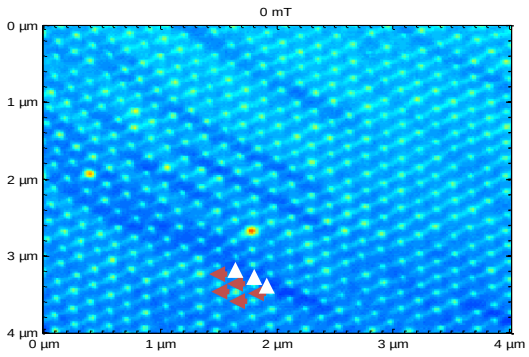

Figure 2: microscopic image of domains with rotated magnetisation expanding into the antidot lattice in an iron thin film sample

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DIRECT IMAGING OF MAGNETICALLY DEAD LAYERS IN $La_{0.67}Ca_{0.33}MnO_3$ BY OFF-AXIS ELECTRON HOLOGRAPHY

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The optimization of manganite thin film growth parameters to exploit their exceptional physical properties (spin polarization, CMR) [1] is sometimes limited by the difficulty to obtain direct information from their magnetic state, therefore relying on indirect or averaged macroscopic data. We report the direct imaging by electron holography at low temperature (100 K) of the magnetic state of epitaxial $La_{0.67}Ca_{0.33}MnO_3$ thin films grown on (100)-oriented $SrTiO_3$ substrates, which allowed to determine the presence of a surface non-magnetic layer (see Fig.1). Magnetization measurements suggest that this "dead" layer could be in fact antiferromagnetic. We evidenced that this suppression of ferromagnetism is related to substrate-induced epitaxial strain, as the unstrained case (with LSAT substrate) is fully magnetic upon identical growth conditions. Growth parameters can also be tuned to recover ferromagnetism at the surface.

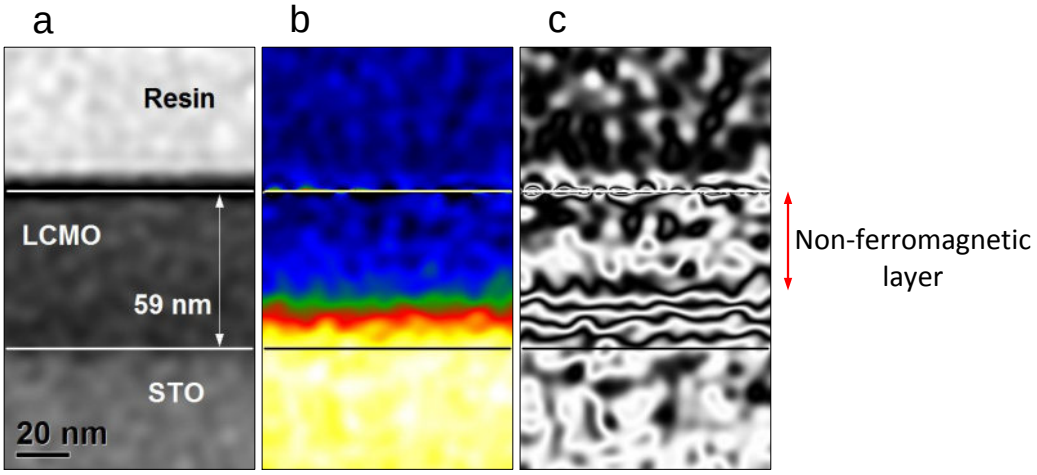

Figure 1. Electron holography at 100 K of epitaxial $La_{0.67}Ca_{0.33}MnO_3$/ $SrTiO_3$ with dead layer. (a) Amplitude and (b) magnetic phase images. (c) Magnetic flux image inside the manganite.

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Thin films of the ε-Fe_2O_3 polar magnet by pulsed laser deposition

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Magneto-electric ε-Fe_2O_3 is a metastable structural intermediate between the well-known maghemite (□-Fe_2O_3) and hematite (□-Fe_2O_3). It presents a non-centrosymmetric crystal structure (*Pna2₁*) where Fe^{3+} cations occupy four distinct crystallographic sites with their magnetic moments antiferromagnetically coupled along *a*, which result in a ferrimagnetic ordering. In particular, □Fe_2O_3 combines two appealing characteristics: its huge room-temperature coercivity of 20 kOe [1] and a coupling of its magnetic and dielectric properties [2]. Despite these properties, appealing from the fundamental and applied point of view, ε-Fe_2O_3 is commonly stabilized in the form of nanoparticles, constituting a challenge for its prospective application in devices. Here we present results on the preparation of □-Fe_2O_3 as thin-film using pulsed laser deposition combined with an innovative seed-layer technique to allow stabilization of high quality epitaxial ε-Fe_2O_3 films on conducting single crystalline substrates.

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CORE-SHELL MULTIFERROIC NANOFIBERS PRODUCED BY THE ELECTROSPINNING TECHNIQUE

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Multiferroic ferroelectric-ferromagnetic composite materials presenting a coupling between the electric and magnetic degrees of freedom have been attracting much scientific and technological interest. When reduced to the nanoscale they can be used as building blocks for nanoelectronic devices, with a coupling either to the electric polarization, to the magnetization, or to both. In this respect, nanofibers prepared by electrospinning present a high surface-to- volume ratio and unique structure. Electrospinning is based on the high voltage jet drawing of a polymer solution or melt through a capillary (needle) and has been shown to be a very convenient approach for nanofibers production of polar and magnetic materials.

In this work we present a procedure for fabricating randomly and uniaxially aligned core-shell multiferroic composite nanofibers with a ferromagnetic core ($CoFe_2O_4$ or $La_{2/3}Sr_{1/3}MnO_3$) and ferroelectric shell ($BaTiO_3$), by electrospinning. Their crystalline structure was studied by X-ray diffraction and Raman and the fibers morphology was characterized by SEM and TEM. The magnetic properties where studied using a SQUID magnetometer. Conventional sol-gel precursors mixed with a polymer have been used to fabricate the barium titanate, cobalt ferrite and $La_{2/3}Sr_{1/3}MnO_3$ solutions. A high temperature annealing step was performed to vaporize the polymer and coalesce the fibers grains. The fibers were polycrystalline and the Raman spectra presented modes characteristic of the tetragonal-$BaTiO_3$ (ferroelectric) structure. Their magnetic behavior will be discussed in terms of its correlation with the structural properties of the fibers.

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IRON OXIDE NANOPARTICLES WITHIN POROUS SILICON FOR MAGNETICALLY GUIDED DRUG DELIVERY

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INTRODUCTION

The aim of this work was to create a biocompatible superparamagnetic nanocomposite applicable for magnetically guided drug delivery. Therefore Fe_3O_4-nanoparticles have been infiltrated into porous silicon. Both materials offer low toxicity and investigations concerning the cell-viability have been carried out. The magnetic properties of the system have been optimized concerning the blocking temperature T_B and the magnetic moment which means that T_B has to be far below room temperature and the magnetic moment should be as high as possible. Due to the fact that T_B is not only dependent on the particle size (diameters between 4 and 10 nm have been investigated) but also on the magnetic interactions between the particles there are two main routes to fabricate such a composite with desired T_B - first a modification of the pore-loading with a concomitant variation of the distance between the particles within one pore and second a variation of the porous silicon morphology influencing the distance between particles within adjacent pores. To ensure that there is no remanence after the external field has been switched off, magnetic coupling between the particles has to be kept sufficiently low. A variation of magnetic inter-particle interactions with regard to the superparamagnetic behavior of the composite will be presented.

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TAILORING OF SELF-ASSEMBLED MICROMAGNETIC NANOCOMPOSITES

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INTRODUCTION

In the frame of this work porous silicon templates prepared by a sophisticated technique are filled with diverse ferromagnetic metals to fabricate self-assembled three dimensional arrays of nanostructures (wires, particles) with distinct magnetic properties. There are multiple possibilities to tailor the magnetic behavior (e.g. material, morphology, inter particle distance, interfaces). One critical parameter for this purpose is the roughness of the pore walls and the surface of the metal structures, respectively. To vary the morphology of the templates magnetic field assisted etching has been employed and a decrease of the dendritic pore growth has been achieved resulting in smoother pore walls. Within the pores of these templates ferromagnetic metals are deposited and the modification of the magnetic properties compared to metal structures embedded in conventional etched (without magnetic field) porous silicon templates has been figured out. The magnetic anisotropy between easy axis and hard axis magnetization could be increased significantly and furthermore the magnetic behavior becomes comparatively hard magnetic. These properties can be ascribed to less magnetic coupling between the nanostructures and modified stray fields due to less dendritic metal nanowires. The magnetic behavior of three dimensional metal nanowire/nanoparticle arrays with regard to morphological parameters as well as to the influence of the inner interfaces of the composites will be presented.

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EXPLOITING CHEMICAL ORDER-DISORDER PHASE TRANSITIONS FOR PRINTING DISCRETE MAGNETIC PATTERNS IN THIN FILMS

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We demonstrate the chemical order → disorder phase transition in thin films of $Fe_{60}Al_{40}$, leading to increased ferromagnetism [1, 2]. Disorder is induced by exposure to impinging ions. The ion-induced saturation magnetization (M_s) is a function of the displacements per atom. Very small amounts of atomic displacements are necessary to reach the maximum M_s. This implies that depth homogeneity of M_s is achieved at low-fluence and –energy, and deleterious effects such as interface intermixing and surface-sputtering are avoided. Irradiation through shadow masks is employed to induce ferromagnetism selectively and fabricate a magnetic pattern with sub-50 nm resolution possessing multiple stable and switchable magnetic configurations. Discrete magnetic elements are thus embedded within topographically flat thin films (Figure 1).

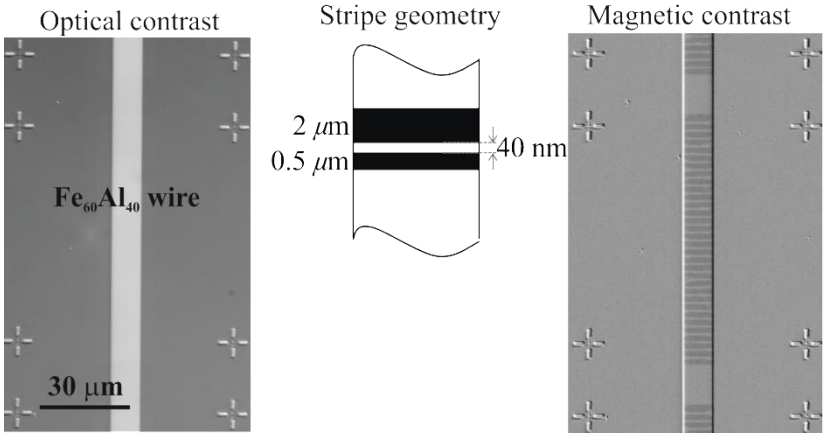

Figure 1: Magnetic stripes patterned on to $Fe_{60}Al_{40}$ wire

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MAGNETIC AND STRUCTURAL TRANSITION IN ONE DIMENSIOMAL HEMATITE NANOPARTICLES

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INTRODUCTION

Hematite nanoparticles are very attractive materials due their wide possibility of being applied as components in various industrial products [1]. Their weak ferromagnetic properties have received enormous attention for their implications in medical applications and cancer therapy [2].

Hematite nanorods were synthesized using an aqueous solution under hydrothermal conditions and thermal treated at different temperatures.

Their magnetic behavior was measured and the magnetization as function of magnetic field (*H*) and temperature (*T*) were investigated. The weak ferromagnetic response was only observed at room temperature for samples thermal treated at temperatures higher than 673 K, while a typical antiferromagnetic behavior is evident at 2 and 50 K. The T_M value was calculated from Zero-field-cooled magnetization versus temperature curves measured at 50 Oe. A shift of Morin transition for samples treated at 1073 K to lower values (compared with all samples produced here and hematite *bulk*) occurred mainly due variation of the crystalline anisotropy and defects generated by thermal treatment.

ACKNOWLEDGMENTS

Financial support from FAPESP, CNPq and UFABC.

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SYNTHESIS AND MAGNETIC PROPERTIES OF Co@Fe CORE-SHELL NANORODS

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The design of magnetic nanowires (NWs) and nanorods (NRs) with controlled length, diameter, chemical composition and surface state is interesting for various applications such as magnetic recording or biological detection [1, 2]. The polyol process is a liquid phase process that yields monodisperse size cobalt NRs with diameter and length in the range 10-20 nm and 50-300 nm, respectively [3]. These particles crystallize with the hcp structure, the c-axis parallel to the long axis. The morphological and structural properties of these rods induce coercitive fields as high as 0.7 T at 300 K, thanks to additive shape and magnetocrystalline anisotropies.

Recently, we have studied the growth of an additional magnetic layer at the surface of the rods to increase their magnetization, to make them biocompatible or to increase their magnetic anisotropy. We report here the growth of an iron-based shell by the decomposition of $Fe(acac)_3$ at the surface of cobalt NRs in oleylamine and their characterization by HREM, chemical mapping and Mossbauer spectroscopy. Depending on the experimental conditions core shell Co@Fe, Co@FeC_x or Co@Fe_3O_4 NRs were obtained with a shell thickness in the range 1-10 nm. We show that it is possible to grow a complete layer of bcc Fe around the hcp Co rods (Fig. 1). This coating increases strongly the saturation magnetization while the coercivity is only slightly reduced. Thermal treatments have been done in order to optimize the properties of the Co@Fe core-shell NRs.

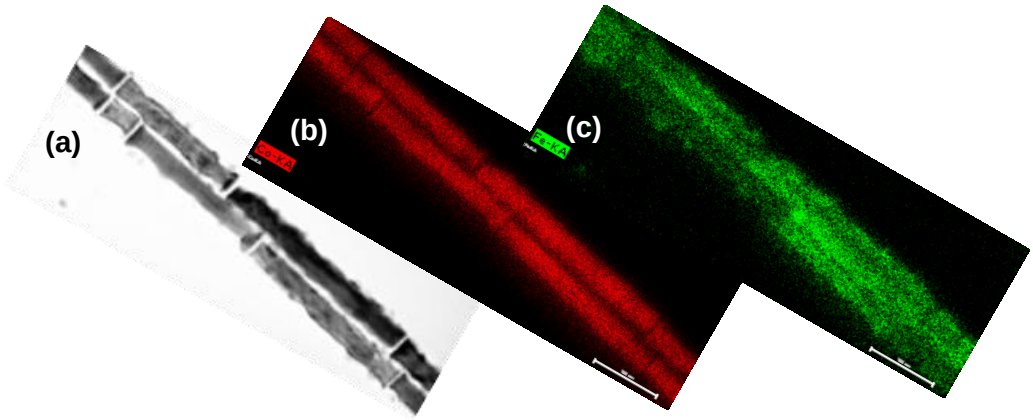

Figure 1: Bright field TEM image of Co nanorods coated with iron (a) ; Co (b) and Fe (c) mapping inferred from EDS analysis.

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EXCHANGE BIAS PROPERTIES OF CORE-SHELL FERRITE NANOPARTICLES

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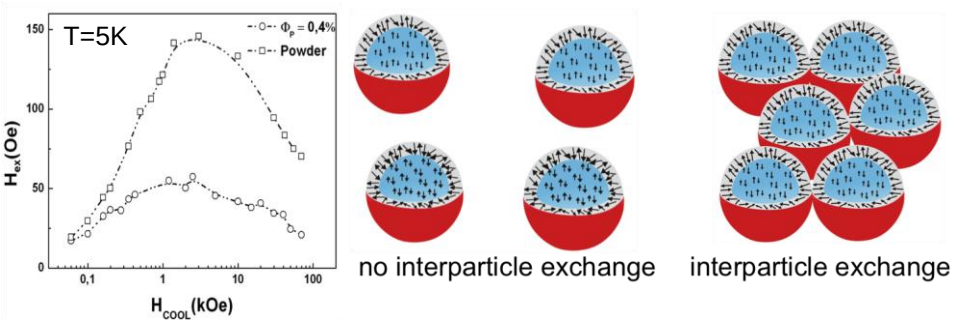
Low temperatures magnetic properties of assemblies of ~3 nm-sized nanoparticles (NPs) based on core/shell ferrites $CoFe_2O_4$@γ-Fe_2O_3 and $MnFe_2O_4$@γ-Fe_2O_3 are investigated [1]. The dependencies of the exchange bias (EB) on the cooling field, nanoparticle volume fraction, ferrite core composition and temperature are studied. The interparticle interaction is tuned by the NPs volume fractions, ranging between 0.4% and 13.9%. After cooling under field, hysteresis loops shift along H, expressing the coupling between the spin-ordered cores and the disordered surface layers. EB field is optimum for a cooling field of the order of the anisotropy field and is larger for $CoFe_2O_4$@γ-Fe_2O_3 NPs, as a consequence of larger core anisotropy. EB thermal dependence is well fitted by a reduced exponential behavior. A comparison between frozen dispersions and disordered powder allows us to distinguish the influence of intra- and inter-particle interactions on the EB. Interparticle collective effects dominate in the powder while an intra-particle EB, hindered by dipolar interactions at large volume fraction, is observed in frozen dispersions [2].



H_{cool}-dependence of EB-field

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We acknowledge CAPES/COFECUB n°714/11, PICS n°5939 ,FAP/DF, CNPq and CAPES.

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MAGNETIC HYSTERESIS AND SPIN CONFIGURATION IN MAGNETOSTATICALLY INTERACTING MULTILAYERED NANODISCS

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The remagnetization process of nanostructures depends on their size, shape and array configuration [1-3]. In this study we investigated the remagnetization in multilayered nanodiscs $(Py/Cu)_N$, where $N \in [1 \div 5]$. The thicknesses of Py and Cu layers were 22 nm and 5 nm, correspondingly. We have fabricated two series of nanodisc arrays with diameters D=600nm and 1000nm.

The study of the magnetic structure by magnetic force microscopy (MFM) has shown that in single Py nanodiscs at magnetic field H=0 the vortex state is formed. In nanodiscs with N=2 the C–state is observed (Fig.1a). In nanodiscs with N≥3 the vortex state is realized (Fig.1b). The saturation field H_s depends linearly on N, Fig.1c. In multilayered nanodiscs the hysteresis loops has inflections due to the nucleation and annihilation of vortex states in magnetostatically interacting Py layers at different fields, Fig.1c.

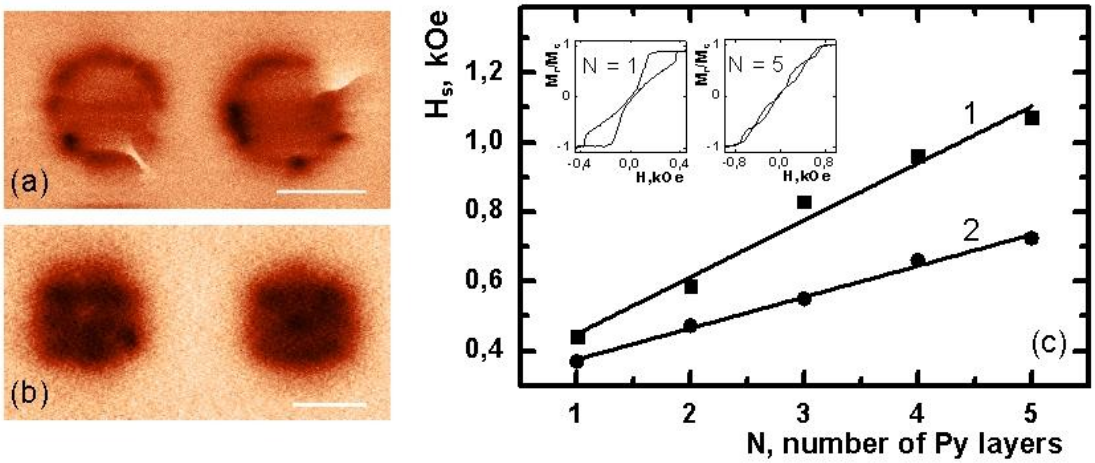

Figure 1. MFM images of nanodiscs with N=2 (a) and N=3 (b). Scale bars are 500 nm. (c) Saturation field as a function of N for nanodiscs with D=600nm (line 1) and 1000nm (line 2).

ACKNOWLEDGMENTS

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Exchange Bias Coupling Strength in Static and Dynamic Experiments: Multilayer Films of FeNi/IrMn

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ABSTRACT

In this work is presented a detailed study of the static and dynamic magnetic response of $[FeNi/IrMn]_n$, exchange biased multilayers films. With the aim to study the impact of the structural contribution on the magnetic properties (namely interface, roughness and crystalline defects), the samples were prepared with different layer repetition number and thicknesses. In the static *dc*-magnetization experiments, First Order Reversal Curve method was the main tool to quantify and map the internal fields and interactions. Dynamic properties were revealed through X-band and broadband Ferromagnetic Resonance spectroscopy. From each technique the effective internal bias field values were determined, and the correlation between static and dynamic properties was discussed.

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ENERGETICS AND MAGNETIC INTERACTIONS OF MN PAIRS ON RECONSTRUCTED GAAS(001) SURFACES: A FIRST PRINCIPLES STUDY

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In the recent paper [1], we assigned the presence of uniaxial anisotropy of (Ga,Mn)As to a symmetry breaking associated with a surplus of Mn dimers along the [-110] direction, whose energy on the growth (001) surface, comparing to [110] pairs, is lower by 1 eV. In this work, we address the question whether it would be possible to affect the dimers orientation by different growth conditions. In particular, we have considered the influence of possible surface reconstructions occurring under As-rich conditions [2] upon the surface dimer energetics. We have found from extensive ab initio studies employing the Siesta code [3] that for the As-terminated surfaces: (2x1), β(2x4), and β2(2x4), the lonely Mn pair along [110] has a lower energy by 0.3 eV than in the case of [-110] orientation. Interestingly, our results show that the [110] pair is coupled ferromagnetically, whereas the ground state of the [-110] dimer is generally magnetic singlet, S =0.

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ELECTRONIC STRUCTURE OF THE CR(001) SURFACE AND CR/MGO INTERFACE

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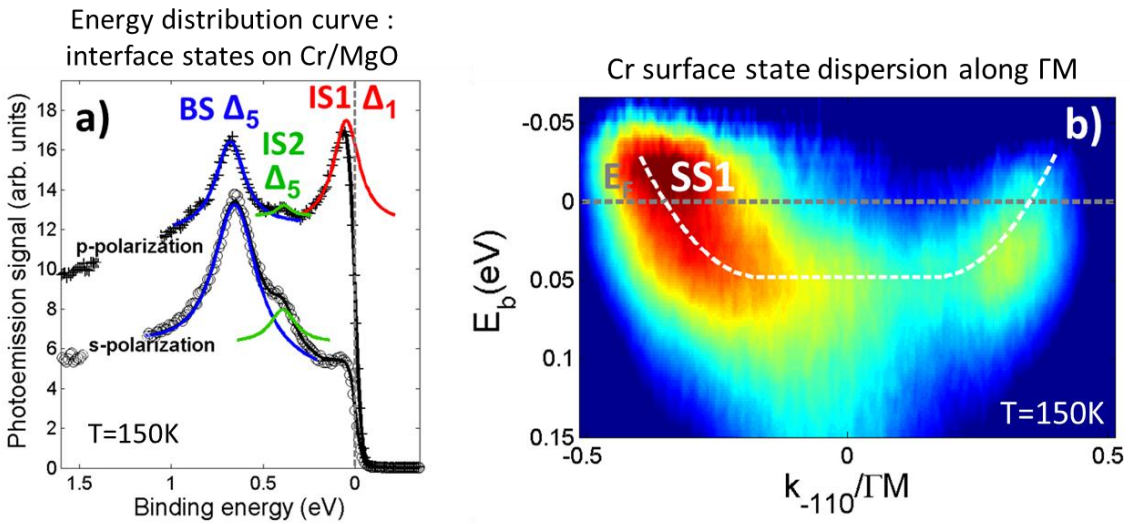
Interfaces electronic properties have a crucial role for spin transfer torque in antiferromagnets as for the tunnel coupling we observe in Cr/MgO/Cr symmetry-conserving fully epitaxial heterostructures[1],. We have thus undertaken a detailed study of the Cr surface and Cr/MgO interface electronic properties by symmetry- and angle-resolved photoemission spectroscopy on a Cr(001) surface covered or not with 1.5 monolayers MgO. The experimental bulk dispersions are in good agreement with the theoretical band structure, and characteristic antiferromagnetic features like the antiferromagnetic gap at the X point are observed. By carrying out normal emission measurements, we have detected two 2D localized states for the Cr(001) surface that persist at the Cr/MgO interface (Figure a).: a Δ_1 state at very low binding energy, that is usually associated with Cr surface magnetism, and a resonant Δ_5 state that shall play a crucial role for transport and coupling in Cr/MgO epitaxial systems. Thanks to the in-plane dispersion of the Δ_1 surface state in Cr (Figure b), we show that this resonant state becomes a pure surface state near the Fermi level (it crosses no bulk band).



a) EDC showing the Δ5 bulk state (BS), Δ5 and Δ1 interface resonant states (IS) in Cr/MgO b) In-plane dispersion of the surface state for the Cr surface

[1] M.-A. Leroy et al. submitted to Nature Communications

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HOW THE Gd_2C CAN BE MAGNETO-CALLORIC

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INTRODUCTION

Although the magneto caloric character of Gd-C alloying with Gd2C-IMC has been the subject of numerous experimental [1,2,3] and theorical investigations [4], the results are contrary and it is not fully understood phenomena, where crystal structure Gd2C-IMC has not been reported on the phase diagram.

Since the stability of crystal structure (it is better to say closely related structure) is consequence of valence band theory [5],The phenomena which they are related to minimizing energy such as phase stability, the formation of some chemical compositions and crystal structure should be as curtained[6].

In order to investigate the existence and stability of magneto – crystalline structure of Gd2C, the effect of chemical pressure is considered. In this method Al+3is replaced in Gd2Al by C+4, where there is not any CFE hybridization. The results of X-Ray diffraction of prepared sample and calculations of cohesive energy, D.O.S, μtot show that

1-The crystal structure of Gd2Al changed from orthorhombic to simple cubic at critical composition of x=0.25 , x=0.5, where the stability of x=0.25 (whit one site of C) is more Than x=0.5

2-In these IMC inter atomic space of Gd is changed from 3.16Å (Gd2Al) to 2.75Å (Gd2Al0.7C0.25) and 2.68Å (Gd2Al0.5C0.5).

3-The binding energy (of 4f) is effected by the chemical pressure where the triplet peak of 4f of (Gd2Al0.7C0.25) can be changed to duality by decreasing of sharp-peak to increasing wide spectrum in Gd2Al0.5C0.5 .

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ETECTION OF GROUND STATES IN FRUSTRATED MOLECULAR RINGS BY THE IN-FIELD LOCAL MAGNETIZATION PROFILES

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Among areas where molecular magnetism contributes is a geometrical spin frustration, as reported [1] by the synthesis and characterization of unusual nine-metal rings, using magnetic measurements and inelastic neutron scattering, supported by density functional theory calculations. We demonstrate [2] by means of exact numerical methods that the ground state of nine-membered frustrated homometallic chromium based rings with a single bond defect can be unambiguously determined by the in-field local magnetization profiles which exhibit characteristic patterns. The strength of the coupling corresponding to the defect can be determined by both total and local magnetization measurements on single crystals with the field perpendicular to the ring. This approach is illustrated with a recently synthesized ring Cr9Cl2 which is experimentally characterized by low temperature magnetic measurements and analyzed by means of the microscopic quantum model. The strength of the coupling corresponding to the defect is estimated by fitting the magnetic susceptibility of a powder sample and independently confirmed from the experimental intersection point of total magnetization profiles preserving the typical values of the remaining parameters which are well established for known chromium rings.

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SIZE DEPENDENT MAGNETISM IN $Sm_{0.27}Ca_{0.73}MnO_3$ NANOPARTICLES

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Most of recent studies of charge ordering (CO) suppression in nano-sized manganites concerned intermediate-bandwidth manganites. In this paper we discuss the CO suppression and magnetic properties of low-bandwidth $Sm_{0.27}Ca_{0.73}MnO_3$ nanoparticles (NPs) with 20 - 80 nm average particle size. We report that with decreasing particle size, CO transition gradually shifts to lower temperatures and almost disappears for 20 nm NPs. This accompanied by monotonous increase of the relative volume of the ferromagnetic (FM) phase. Field-induced transition from antiferromagnetic to FM state in 80 nm particles appears at the same magnetic field as in the bulk. In 20 nm particles the transition is strongly suppressed due to increasing surface spins disorder. Magnetic hysteresis loops show size-dependent exchange bias effect. Exchange fields, coercivity, remanence asymmetry, and magnetic coercivity depend on cooling magnetic field and temperature. The thermoremanence (TRM) and isothermoremanence (IRM) curves provided fingerprints of irreversible magnetization [1], originating from the glassy component, see Fig. 1. The fitting of the power law ($M_{TRM} \propto H^{\lambda}$) to TRM data and to the difference ΔM = TRM – IRM give values of λ = 0.31 and 0.2 respectively, indicating that the cores of SCMO20 NPs behave as two-dimensional diluted antiferromagnet.

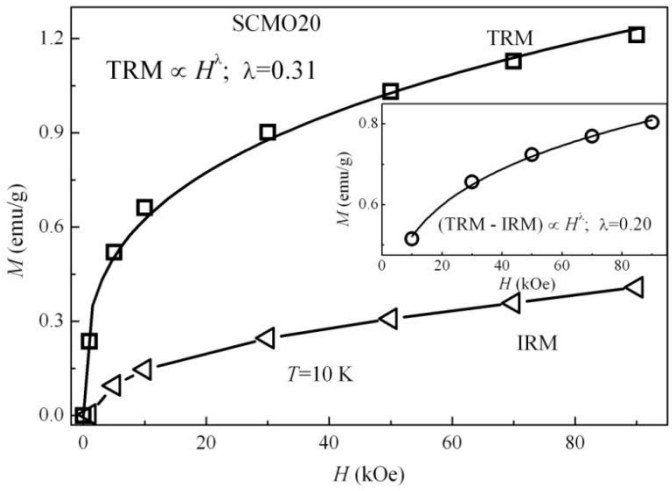

Fig. 1 TRM/IRM versus field for SCMO20 at 10 K. The solid line is the best fit of the TRM data to the power law. Inset shows fitting of power law to ΔM = TRM – IRM.

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MAGNETIC STRUCTURE OF COMPENSATED FERROMAGNETIC-MULTIFERROIC INTERFACE

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The magnetic structure of compensated ferromagnet - multiferroic $BiFeO_3$ interface was considered. The energy of the magnetic order parameters interlayer interaction was obtained. The main contribution to the energy is related to the order parameter induced in the layer with the lowest exchange interaction energy.

The ferromagnetic layer magnetization switching in the ferromagnet-multiferroic system is completely defined by exchange interaction. An electric field action leads to a turn of the multiferroic layer polarization vector and to a turn of the antiferromagnetism vector associated with the polarization, following by a turn of ferromagnetic layer magnetization by 90 degrees due to the exchange interaction at the ferromagnetic-multiferroic interface.

In the case of comparable interlayer and intralayer exchange integral values, the spin canting angles at the interface are of order of π/2. Surface distortion of the order parameters decreases with the distance to the interface on the atomic scale. The law of decreasing is determined by the type of surface cut and the type of crystal lattice.

The existence of weak ferromagnetism and linear magnetoelectric effect are not required for realization of a magnetoresistive memory, switched by the electric field. The key point is that the reorientation of the polarization vector, caused by electric field, involves reorientation of the antiferromagnetism vector.

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OPTICAL AND MAGNETORESISTIVE PROPERTIES OF THE LSMO THIN FILMS ON GGG SUBSTRATES

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The variation of optical and magnetoresistive properties of La-Sr-Mn-O films with the thicknesses 50 -100 nm at different regimes of annealing procedure is investigated. The films were deposited onto single crystal $Gd_3Ga_5O_{12}$ (111) substrates by dc magnetron sputtering of ceramic $La_{0.7}Sr_{0.3}MnO_3$ target in argon-oxygen atmosphere [1]. The optical conductivity was calculated from the optical transmission data for energy spectrum range of 1-5 eV. Magnetoresistance was measured in the temperature range 80–310 K. The film thickness was measured by the multiangle ellipsometry method at the wavelength 632.8 nm [2].

The oxygen deficiency is typical for unannealed films. This deficiency leads to significant differences of their properties from the properties of epitaxial films [3].

We have revealed that annealing procedure in air at temperature 870 K has small influence on the films properties, but increase of temperature up to 1170 K improves the optical homogeneity of the films. The values of the refractive index and optical conductivity of the films after annealing become close to the ones of the epitaxial films with stoichiometric composition. The optical conductivity spectra of the annealed films have the same structure as epitaxial $La_{0.7}Sr_{0.3}MnO_3$ films, but the spectrum picture is shifted by ~ 0.5 eV to higher energy.

Dc properties of the films are characterised by a relatively low value (180 K) of temperature maximum of resistance and widened temperature range of negative magnetoresistance. Such characteristics are typical for polycrystalline films [4].

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MAGNETIC PROPERTIES OF MAGHEMITE NANOPARTICLES COATED WITH FUNCTIONAL BIOCOMPATIBLE POLYMERS

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Iron oxide nanoparticles coated with a functional biocompatible polymer are considered as very promising materials for biotechnology and medical applications. This work is focused on γ-Fe_2O_3 particles synthesized in the presence of oligoperoxide surfactants that resulted in a narrow particle size distribution as well as tailored functionality and reactivity. In order to achieve the shell of required functionality polymerization of NVP-GMA monomer mixtures, initiated from oligoperoxide copolymer, was carried out. The nanoparticles obtained consist of magnetic γ-Fe_2O_3 cores and organic shells containing peroxide and other reactive functional molecules. Three systems with the same core sizes and different shell thicknesses have been studied. It will be shown that the magnetic behavior of the particles is mostly affected by dipole-dipole interactions which strength decreases with increasing shell thickness. On cooling these interactions, along with randomness in the particle positions and easy axis orientations, cause slowing down of the relaxation processes and finally freezing of the nanoparticle systems to a spin-glass-like state. But at the room temperature the particles exhibit vanishing coercivity or even superparamgnetic behavior, suitable for biomedical applications.
This work was partially performed in the laboratory founded by POIG.02.02.00-00-025/09.

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$Nd_{3-X}Bi_xFe_4GaO_{12}$(X=2, 2.5) FILMS ON GLASS SUBSTRATES PREPARED BY MOD METHOD

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INTRODUCTION

Bismuth-substituted garnet films are well known that they have large magneto-optic effects. However, there is no report on highly bismuth-substituted iron garnet films with perpendicular magnetic anisotropy. In this paper, we report $Nd_{3-x}Bi_xFe_4GaO_{12}$ (x=1, 2, 2.5) films with perpendicular magnetic anisotropy.

METHOD

$Nd_{3-x}Bi_xFe_4GaO_{12}$ (x=1, 2, 2.5) films were prepared by metal organic decomposition (MOD) method. $NdBi_2Fe_4GaO_{12}$ (Bi2:NIGG) and $Nd_{0.5}Bi_{2.5}Fe_4GaO_{12}$ (Bi2.5:NIGG) films with a thickness of 200 nm were prepared on buffer layers ($Nd_2BiFe_4GaO_{12}$). Thickness of $Nd_2BiFe_4GaO_{12}$ films on glass substrates were 120 nm. MOD process consist of spin coating of MOD solution (3000 rpm, 60 seconds), drying (100°C, 30 minutes), pre-annealing (450°C, 30 minutes), annealing for crystallization (700°C, 3 hours). Samples are characterized by XRD, MO spectroscopy and VSM.

RESULTS AND DISCUSSION

Figure 1 shows Faraday hysteresis loop of Bi2:NIGG and Bi2.5:NIGG films measured at wavelength of 520 nm. Both samples show square-shaped hysteresis, indicating perpendicular magnetic anisotropy. Faraday rotation angles of Bi2:NIGG and Bi2.5:NIGG films are 1.6 and 2 degrees, and those coercivity are approximately 0.35 and 0.36 kOe, respectively.

ACKNOULEDGEMENTS

This research was supported by National Institute of Information and Communications Technology (NICT).

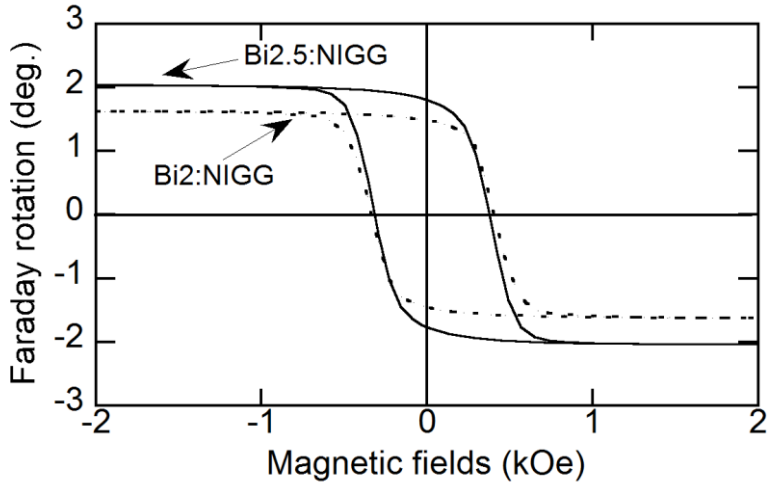

Fig. 1. Faraday hysteresis loops of Bi2:NIGG and Bi2.5:NIGG films

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AN Fe_2Dy_3 SINGLE MOLECULAR MAGNET WITH HIGH ENERGY BARRIER

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We have turned our attention recently to search for SMM behavior in Fe-4f compounds which combine the high-spin Fe(III) with larger anisotropic lanthanide ions, and some of the compounds display SMM behavior[1,2]. Herein, we report the synthesis, structure and magnetic properties of a new Fe-4f SMM which is formulated as $[Dy^{III}_3Fe^{III}_2(\mu_3\text{-}OH)(\mu_4\text{-}O)(teg)_2(piv)_8]$ (**1**). The structure of **1** consists of a Dy_3Fe cubane with an external Fe attached at one corner yielding an Fe_2Dy_3 core (Figure 1, left). The magnetic measurements of **1** show slow relaxation of magnetization under zero dc field (Figure 1, right). Fitting the data to an Arrhenius law gives an energy barrier of 78K. To the best of our knowledge, this energy barrier is the highest observed in Fe-Ln systems.

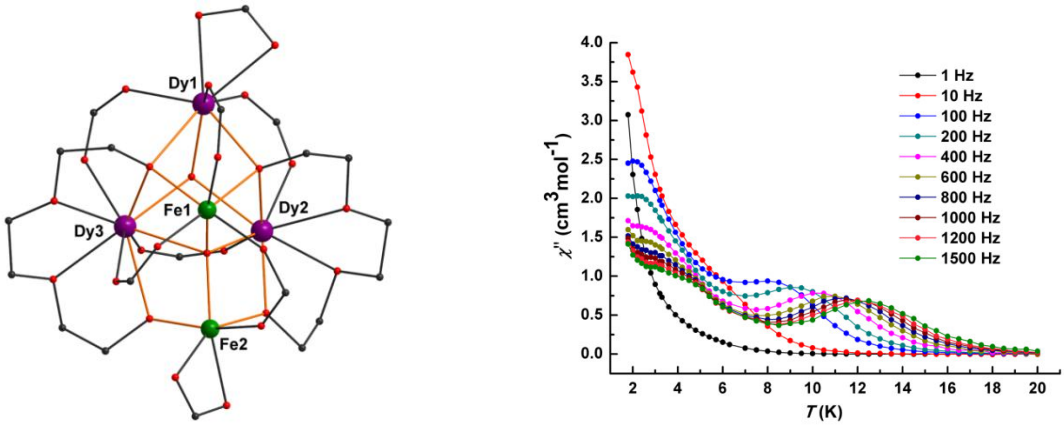

Figure 1. The structure of **1** (left) (with the pivalate CH3 groups omitted for clarity) and temperature dependence of out-of phase ac susceptibility (right).

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INVESTIGATION OF RASHBA EFFECT AND SPIN HALL EFFECT BY HALL MEASUREMENTS IN FERROMAGNETIC METAL LAYERS

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INTRODUCTION

Recently, the role of the Rashba effect and the spin Hall effect (SHE) in the magnetization dynamics in a ferromagnetic metal layer has been actively discussed. Here, we perform a Hall measurement to investigate these effects in an in-plane magnetized Pt (1.5 nm)/Fe (0.6 nm)/Pt (X nm) films.

RESULTS AND DISCUSSION

Hall resistance differences between with positive and negative current were measured as a function of θ, the angle between the applied current and the in-plane magnetic field. Figure 1 shows the results with X = 0.0~2.9 nm. The sign and shape of the angle dependence vary as X changes. These results can be explained by current-induced magnetization tilting due to Rashba effect and SHE. In the talk, we will show it is possible to estimate these effects quantitatively from these measurements.

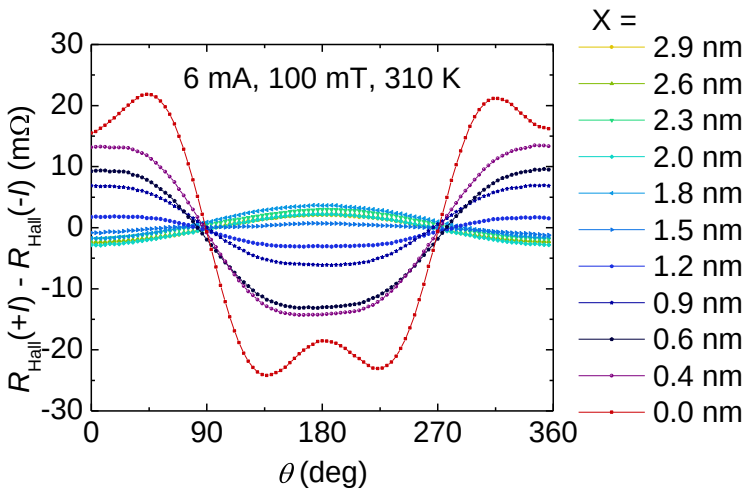

Fig.1 Differences of Hall resistance R_{Hall} between at current I = +6mA and I = +6mA

ACKNOWLEDGEMENTS

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TEMPERATURE DEPENDENCE OF FERROMAGNETIC RESONANCE MEASUREMENTS IN NANOSTRUCTURED ARRAYS

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Ferromagnetic resonance spectroscopy is a powerful technique to analyze the dynamic properties of nanostructured materials due to the fact that the resonance field depends directly on the anisotropy field strength and its angular spread [1]. Nickel and Permalloy nanostructured dot and line arrays have been prepared using interference lithography. The film thickness is of 50 nm for different lattice periods. Temperature dependence of the ferromagnetic resonance measurements have been carried out at a frequency of 9.5 GHz as a function of magnetic field from 85 K to room temperature. The dependence of the absorption lines with temperature for a permalloy and nickel based samples is shown in the following figure:

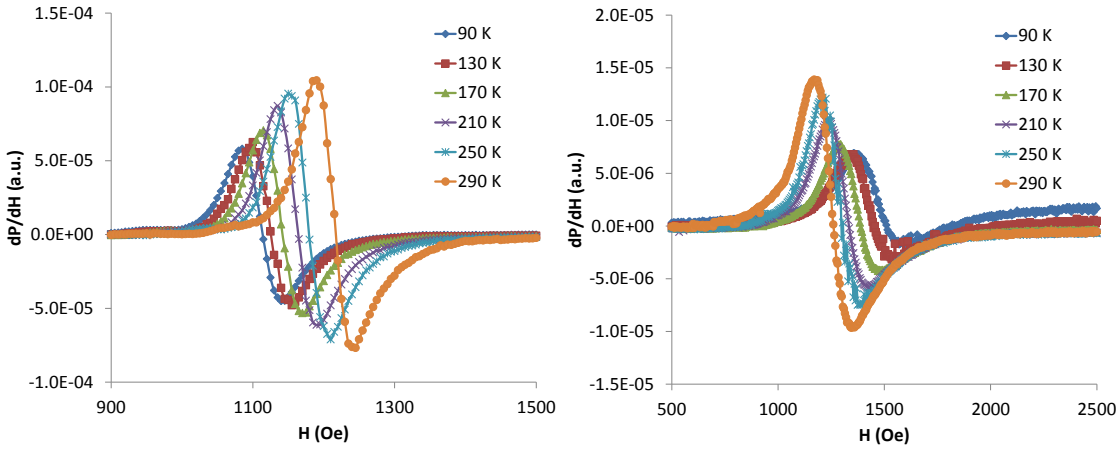

Figure 1. Temperature dependence of the FMR for permalloy (left) and nickel (right) line arrays

Nickel and permalloy based samples presents a different temperature dependence of the resonance field, with decreasing and increasing values respectively with higher temperatures. Resonance linewidth in permalloy is nearly constant while nickel arrays presents a small decrease with increasing temperatures.

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WIDEBAND FERROMAGNETIC RESONANCE IN NANOSTRUCTURED PERMALLOY ANTIDOT SAMPLES

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INTRODUCTION

Dynamic properties of magnetic nanostructures have recently been intensively studied due to their potential application in high density perpendicular recording media or magnetic sensors. The highly oriented arrays of magnetic antidots are excellent model materials to study magnetism of low-dimensional systems. Antidot arrays of Permalloy have been prepared by the sputtering of $Ni_{80}Fe_{20}$ onto anodic alumina membrane templates. The film thickness is of 138 nm and the antidot diameters of 15 nm, for a hexagonal lattice parameter of 105 nm.

The anisotropy field can be investigated by various techniques. One of these techniques is the ferromagnetic resonance spectroscopy (FMR) due to the fact that the resonance field depends directly on the anisotropy. Ferromagnetic resonance measurements have been carried out at as a function of frequency frequency from 1 to 10 GHz for magnetic fields up to 10kA/m. The sample was placed in coplanar waweguide with the sample plane parallel to the magnetic field. The frequency dependence of the resonance field can be used to calculate the magnetization saturation and anisotropy field under suitable approximations.

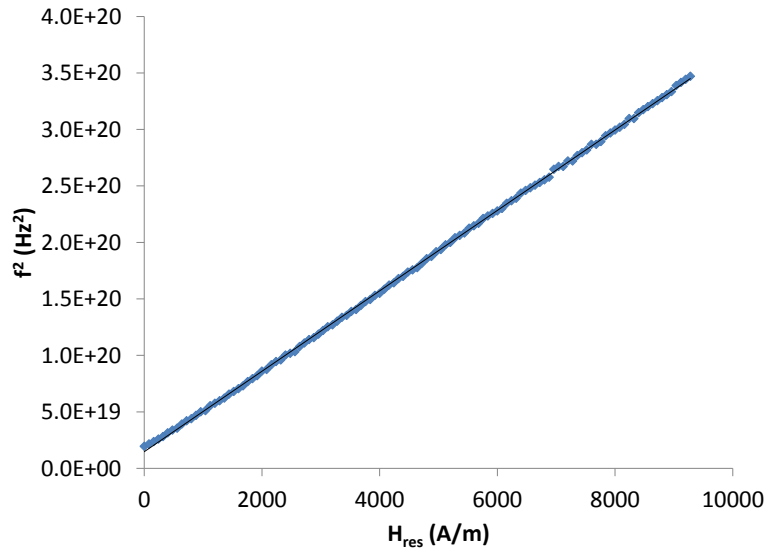

Figure1. Frequency dependence of the resonance field

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HIGH TEMPERATURE ANNEALING OF IRON NANOWIRES SYNTHESIZED BY SIMPLE CHEMICAL REDUCTION

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INTRODUCTION

The aim of this work was to study an influence of high temperature annealing of iron nanowires on their magnetic and structural properties. The samples were synthesized by simple chemical reduction from aqueous solution of $FeCl_3 \cdot 6H_2O$ [1-2]. After that a few amount of obtained nanowires were annealed at five different temperatures (ranging 200°C-800°C) in the argon atmosphere.

METHODS

Physical properties of as-formed and annealed samples were investigated by means of *high-resolution transmission electron microscope*, *X-ray diffraction* and *vibrating sample magnetometer* equipped with the furnace.

RESULTS

Obtained experimental results allowed to determine the morphology and the structure of as-formed and annealed iron nanowires. Moreover, the high temperature magnetic measurements were the sources of knowledge about phase transitions in the iron nanowires and also enabled to estimate the values of Curie temperatures for studied nanostructures.

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STUDY OF THE SHAPE OF THE CORES OF MAGNETIC VORTICES IN NANODOTS

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Magnetic vortex states are characterized by in-plane magnetic moments curling around a core with out-of-plane magnetization, and which in equilibrium has radial symmetry. It has recently been shown [1],[2] that the core diameter can be controlled by introducing a perpendicular anisotropy. In this work we have studied the profile of the core along a hysteresis loop, in circular and elliptical nanodots, with the inclusion of an anisotropy Kz. From the hysteresis loops obtained by numerical simulation, we examined the vortex deformation – the deviation from radial symmetry – for several values of thickness and anisotropy. The deformation starts at zero, for B=0, reaching a maximum of 10-100% just before annihilation (Figure 1, for h=30 nm, D=500 nm), depending on the thickness and anisotropy. For different diameters, the deformation scales with the relative distance from the center. For nanoellipses, the core deformation is dependent on the direction of the applied field. The present work shows that the core deformation is relevant in studies of vortex dynamics, and it may limit the applicability of the rigid core model to vortex studies.

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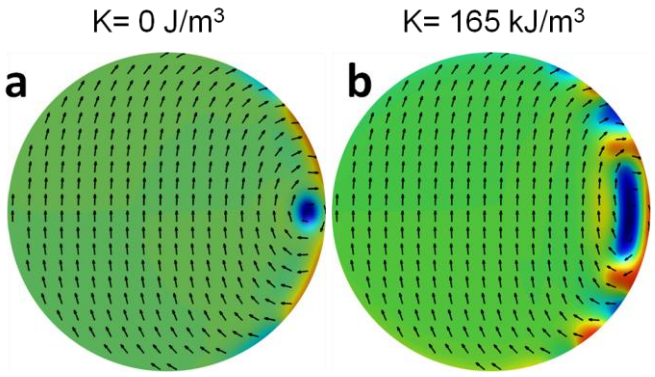

Figure 1.

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ANGLE OF POLARIZATION PLANE IN MAGNETO-OPTICAL DIFFRACTION FOR Pt / Co PERIODIC PATTERNS

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Polarization properties of 1 st order beam diffracted by periodic arrays of Pt/Co patterns were investigated. Line & space and two-dimensional arrays of the patterns with sizes of 10 - 50 μm and periods of 20 - 100 μm were fabricated, and SiO_2 was deposited on the etched areas. Angles of plane of polarization at wavelength of 633 nm were measured to be approximately 0.5 degrees for all samples. On the other hand, angles of plane of polarization for one and two-dimensional arrays of magnetic patterns were calculated by assuming sinusoidal magnetic distributions. It can be expressed by electric fields of lights diffracted by optically, E_x, and magneto-optically, E_y;

$$q = \tan^{-1}\frac{E_y}{E_x} = \tan^{-1}\frac{r_m \Phi_K}{r_m - r_i}, \qquad [1]$$

where r_m and r_i are the reflection coefficients of a magnetic and a non-magnetic material, respectively, and Φ_K is the complex Kerr rotation. It was found that the equation [1] indicates that the angle of plane of polarization does not depend on the size of patterns and the period, but on the difference in the reflection coefficients between the magnetic and the non-magnetic materials, which is consistent with the experimental results.

This work was supported by National Institute of Information and Communications Technology (NICT).

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CORRELATION OF MAGNETIC PROPERTIES, CHEMICAL COMPOSTITION AND ATOMIC STRUCTURE OF Fe/Fe-O NANOCUBES.

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INTRODUCTION

Magnetic Fe/Fe-O nanocubes find numerous applications in spintronics, sensorics, magnetic manipulations, and biomedicine. The knowledge of morphology, composition and atomic structure of the nanoparticles, and the possibility to modify these, enables tuning their magnetic properties for particular applications and studying magnetic phenomena at the nanoscale.

EXPERIMENTAL METHODS

The nanocubes were synthesized using the wet chemistry method described in ref. [1]. The nanocubes were modified using oxygen(O)-plasma and hydrogen(H)-plasma etching. The atomic structure and chemical composition were examined using in-situ Auger electron spectroscopy (AES) and transmission electron microscopy (TEM). Magnetic properties of the nanocubes were studied using ferromagnetic resonance without exposing the nanoparticles to air after plasma treatment.

RESULTS

Post O-plasma AES spectra shows that the carbon peak vanishes due to etching of organic ligands, and post H-plasma AES confirms at least partial reduction of iron oxide at the surface. TEM micrographs (fig. 1) show that the nanocubes can recrystallize after H-plasma etching. This can explain the decrease in coercive field compared to the size of the coercive field obtained in simulations [2]. Further magnetic characterizations will be presented.

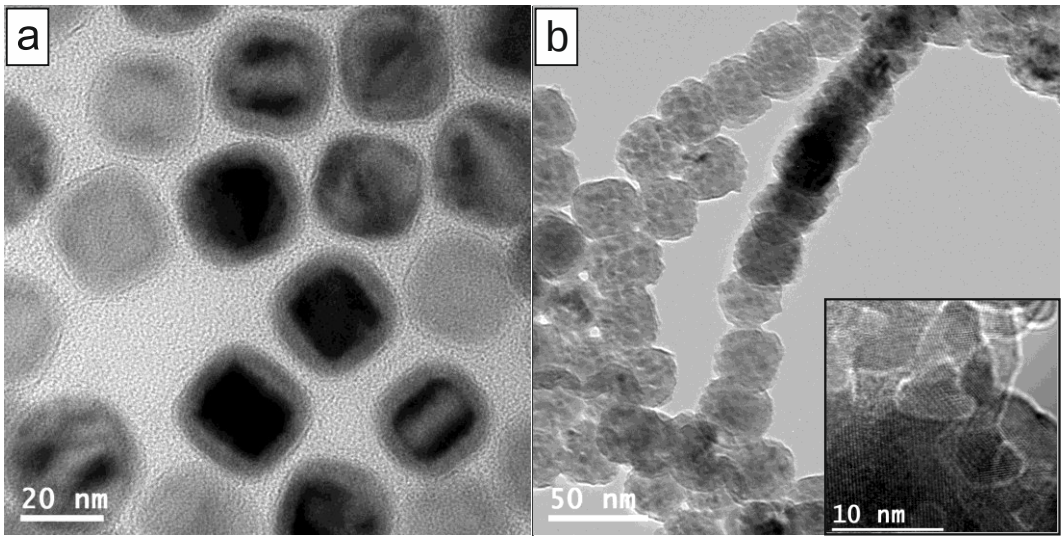

Figure 1. (a) TEM micrograph of as grown core/shell Fe/Fe-O nanocubes. (b) The nanocubes after O- and H-plasma. Inset shows high resolution TEM micrograph.

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DETERIORATION OF EXCHANGE BIAS IN CoO-Co BILAYERS BY THE ROUGHNESS OF THE ZnO SUBSTRATES

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INTRODUCTION

Exchange bias (EB) coupling, [1] an interface effect of an Antiferromagnet/Ferromagnet (AF/FM) structure, depends on interface roughness (IR). Many studies focused on low IR, below 10nm [1]. Here we investigate IR up to 600nm.

METHODS

CoO-Co thin films (10nm) were rf-sputtered on ZnO substrates (films and pellets) of variable roughness, S_a (20-600nm). The desired CoO layer was formed through the absorption of O originating from the ZnO substrate. S_a was calculated with Atomic Force Microscopy (AFM) [Solver-Pro, NT-MDT]. Magnetization measurements were obtained using a SQUID [Quantum Design] for both parallel and perpendicular external magnetic field, $\mathbf{H}_{ex}$.

RESULTS

The EB shift field (H_{shift}^{EB}) and coercive field (H_c^{EB}) exhibit a major/minor decrease (70%/30%) with increasing roughness (600nm) for parallel/normal $\mathbf{H}_{ex}$.

CONCLUSIONS

The magnetization, $\mathbf{M}_f$ of our thin Co films (10nm) lies in-layer due to shape anisotropy, since we are well below the critical thickness (40nm). Thus, $\mathbf{M}_f$ is guided by the morphologically rough landscape of the substrate. Ultimately, this induces misalignment between $\mathbf{M}_f$ and $\mathbf{H}_{ex}$ that prohibits $\mathbf{H}_{ex}$ to align $\mathbf{M}_f$. The misalignment is pronounced for parallel $\mathbf{H}_{ex}$, thus weakening the EB mechanism more effectively.

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ACKNOWLEDGEMENTS

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EFFECT OF IRON DOPPING AND THERMAL TREATMENT ON MAGNETIC PROPERTIES OF ANATASE TiO_2 NANOPOWDERS

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The development of dilute magnetic oxides (DMOs) have attracted extensive attention since the theoretical calculations predicted that transition metals doped wide band gap metal oxide semiconductors might support ferromagnetism mediated by valence-band holes to above room temperature. Ferromagnetism observed also in un-doped TiO_2 has been established to have close link with oxygen vacancies [1]. However, the magnetic properties still remain a controversial issue while the observed magnetic behavior appears to be strongly dependent on the preparation methods and its connection to transition metal doping elements or just intrinsic defects/oxygen vacancies is not decided.
In this work we find that room-temperature ferromagnetism (RTFM) in ^{57}Fe-doped (0.1-1 at.%) TiO_2 nanopowders can be achieved by a hydrothermal route method. The experimental results of magnetic, Mössbauer and EPR measurements on samples as-prepared and thermally annealed in different conditions, reveal the complexity of the magnetic interactions due the specific electron configurations related to the multivalence state and different local surroundings of iron.

Magnetic measurements and Mössbauer Spectroscopy suggests two superimposed magnetic regimes: one predominant above 50 K, and the other below 50 K. In the high temperature domain, a sort of long range magnetic order, giving rise to coercive fields lower than 200 Oe has been evidenced. The observed magnetic order with an average magnetic moment of ~ 0.06 μ_B per formula unit of TiO_2, is not directly related to the doping Fe ions. The paramagnetic/superparamagnetic behavior observed at low temperatures is due not to only Fe clusters with a wide size distribution, but also to paramagnetic defects in the TiO2 matrix. Thermal treatments dissolve (by inducing Fe^{2+} ions) the clusters, altering the magnetic properties.

A careful EPR characterization of local magnetic properties, as revealed by the temperature dependence of EPR susceptibility, $\chi_{EPR} \approx I_{DI}$, [2], is consistent with the bound magnetic polaron (BMP) model of RTFM. It is strongly related to the paramagnetic defects formed during the preparation of doped TiO_2 nanoparticles.

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MAGNETIC NITRIDE NANOPARTICLES PRODUCED BY ION IMPLANTATION

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Transition metal nitrides M_xN (M=Co,Fe), x≥3, are ferromagnetic at room temperature, display metallic behavior, and have higher chemical stability than the metal base materials. Those properties make them suitable for applications in electronic devices like magnetic tunnel junctions and memories. For that purpose, it is essential to study their magnetic properties concerning the magnetic anisotropy and the influence of interfacing with oxides.

In this work iron and cobalt were co-implanted with nitrogen in single crystalline MgO, Al_2O_3 and TiO_2, to form magnetic nitride nanoparticles. The structural and magnetic properties of these nanoparticles were studied using XRD, SQUID magnetometry and CEMS. The results show that magnetic nitrides nanoparticles form and their properties correlate with the host matrix.

This work was carried out with support of "Fundação para a Ciência e Tecnologia", through project PTDC/FIS/102270/2008 and grant SFRH/BD/70150/2010.

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LITHOGRAPHY-FREE SYNTHESIS OF NANOSTRUCTURED COBALT ON SI111 SURFACES: STRUCTURAL AND MAGNETIC PROPERTIES

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In this paper, we illustrate the concept of lithography-free synthesis and patterning of magnetic cobalt in the nanometric scale. Our elaboration method allows fabricating 2D architectures of cobalt and cobalt silicide onto silicon 111 surfaces. A continuous cobalt layer of 1, 3 and 10 nm thickness was first deposited by using thermoionic vacuum arc (TVA) technology and then, thermally annealed on vacuum at temperatures from 450°C to 800°C. Surface structure was analyzed by AFM, SEM-FEG, XRD and Raman techniques. Above 750°C, regular triangular shape cobalt nanostructures are formed with pattern dimensions varying between 10 and 200 nm. Magnetic properties were investigated by means of VSM technique. The evolution of the coercive field versus packing density and dimensions of the nanostructures was studied and compared to micromagnetic calculations. The observed nanostructures have been modeled by fractal curves of different orders and excellent control of shape and packing density could be achieved by adjusting the initial thickness and the substrate temperature.

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SELF-ASSEMBLED FORMATION OF NANOPARTICLE MONOLAYERS ON THE WATER SURFACE STUDIED BY X-RAY SCATTERING

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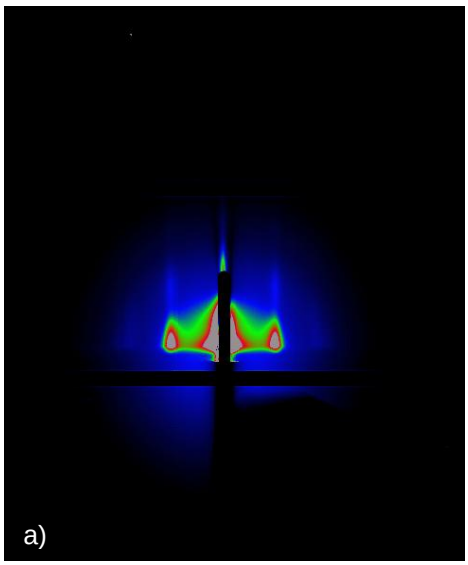
Due to the technological progress of modern society in recent years there is increasing interest in new materials with advanced physical properties, which should lead to further evolution of nanoelectronics, spintronics, photonics, etc. Systems with self-organization and self-assembly are important part of this development. In this context, the monolayers of single-domain magnetic nanoparticles attracting considerable interest both from the point of view of possible applications, and for the fundamental theory of interaction and self-organization of nanoscale objects. In this research we investigated mono and bidisperse ensembles of magnetic nanoparticles on the surface of water in the self-organization process. We performed a unique combination of experimental methods: X-Ray reflectometry (XRR) and Grazing-Incident Small-Angle X-Ray Scattering (GISAXS), which allowed to study spacial distribution of electron density in the monolayer of nanoparticles both in depth and in the plane of the surface. A solution containing magnetic nanoparticles were deposited on the surface of the water in the Langmuir bath, which were followed by isothermal compression, during which there was grow of homogeneous monolayer. The experiment was carried out on the ID10 beamline of the European Synchrotron Radiation Facility (ESRF, Grenoble, France). GISAXS scattering pattern of the 10 nm Fe_3O_4 nanoparticles ensemble were taken at an angle of incidence of synchrotron radiation α_i = 0.2° and pressure in the layer P = 5 mN / m and it shown in Fig. 1a. Figure. 1b shows the corresponding curve of the specular reflection of synchrotron radiation. The theoretical model describing the reflection curve is presented in the inset Fig. 1b. Results of the GISAXS and XRR confirm stable and reproducible formation of a monolayer of particles of hexagonal packing layer at a pressure of about 5-10 mN /m.



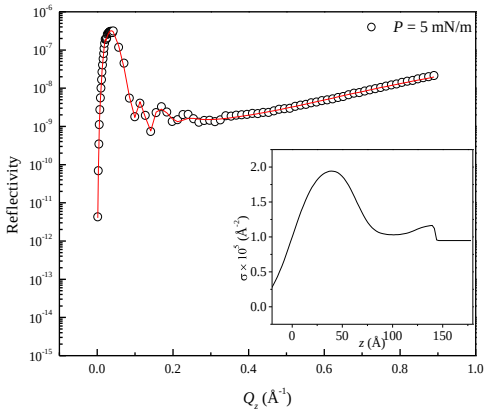


Fig. 1 a) GISAXS scattering map and b) b) XRR from 10 nm Fe_3O_4 nanoparticles. Experimental (symbols) and fitted (line) XRR curves multiplied by Q^4. Corresponding electron density profile is shown in the inset.

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EXCHANGE BIAS PROBLEM IN THE TNIN FERRO/ANTIFERROMAGNET BILAYER

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INTRODUCTION

In the layered structures with alternating layers of ferromagnetic (FM) and antiferromagnetic (AFM) materials an interesting effect called “exchange bias“ is observed. This phenomenon consists in the shift of the field dependence of magnetization on the field: $\vec{M}(\vec{H}) \neq \vec{M}(-\vec{H})$. In addition, the shifted hysteresis loop becomes asymmetric. The phenomenon is used in the read/write heads of modern hard disks drives.

MODEL

For qualitative explanation of the experimental data we propose a simple model [1-3]: the thin FM film of a width L with strong easy-plane anisotropy and additional weak in-plane anisotropy (with parameter β) contacts with rigid AFM half-space. The exchange interaction is characterized by parameter J in the FM layer and by J_0 through the FM/AFM interface. Equation for the angle φ of the deviation for the magnetization vector from the easy-axis has the form $J\varphi'' + \beta \sin\varphi \cos\varphi = 0$ with the boundary conditions $\varphi_x\,|_{x=L} = 0$ and $J\varphi' - J_0 \sin\varphi\,|_{x=0} = 0$.

RESULTS

The total magnetization of the FM layer $M = (1/J)\int dx \cos\varphi(x)$ are obtained in the limits of “thin” $L << J / J_0$ and “thick” $L >> J / J_0$ FM layer (Fig. 1).

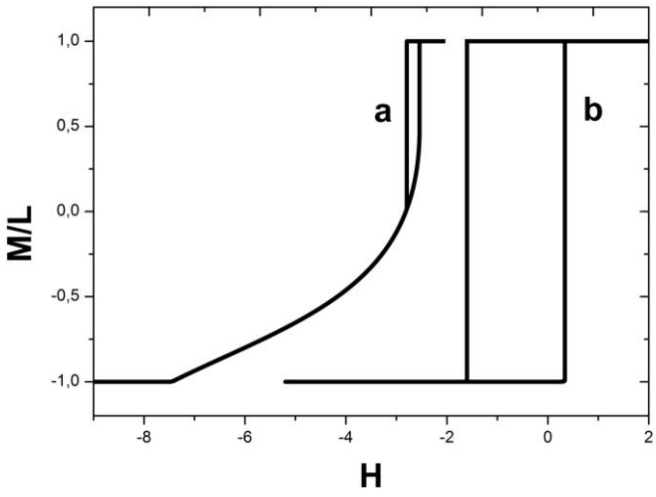

Fig.1 Magnetization curves for «thick» ($J / J_0 = 2, \beta / J = 0.02, L = 7$) (a), and «thin» ($J / J_0 = 12.5, \beta / J = 0.02, L = 7$)(b) FM layer.

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Encapsulated Spin-Crossover Compounds: Synthesis, Magnetic Properties and Functionalization for Deposition on Gold Surfaces

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INTRODUCTION

Molecular bistability is reflected best in the phenomenon of Spin-Crossover (SCO) in iron(II) coordination complexes. This kind of complexes can be switched on the molecular level by the use of temperature, pressure or light. [1] There is a high potential of applications of such SCO compounds in various domains, such as molecular electronics, data storage and display devices. [2]

RESULTS AND DISCUSSION

Weber *et al.* have investigated the properties of diverse SCO compounds with N_2O_4 coordination sphere. [3] The anchoring of SCO complexes on a substrate and the investigation of the magnetic properties is an important step towards molecular spintronics.

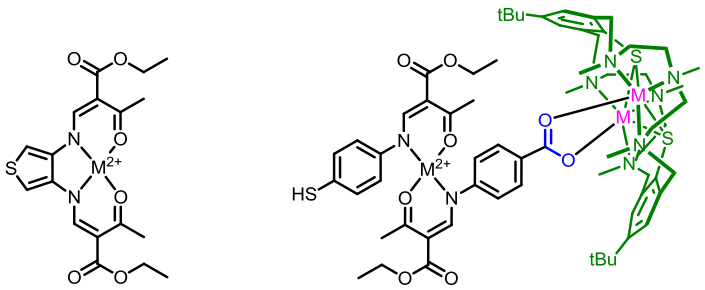

Fig.1: Functionalized ligand backbone and encapsulated complex.

Herein we present the encapsulation of iron(II) complexes as a model compound to examine the magnetic behaviour. We investigated the multinuclear complexes by mass spectrometry and IR spectroscopy and their magnetic properties by SQUID magnetometry.

We also present the first steps in the functionalization of the chelating ligand with N_4O_2 donor function. Therefore we choose to modify the backbone with thiol anchoring groups for the possible formation of self-assembled monolayers on gold surfaces.

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ON THE STRUCTURAL AND MAGNETIC PROPERTIES OF Sm-Co/FeCo THIN FILMS

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Rare earth permanent magnets are critical materials from the point of view of fundamental research in magnetism as well as for advanced technologies. An intense activity of research of soft/hard nanocomposites exchange-enhanced magnets is developed due to their exquisite future technological aplications. The idea behind soft/hard nanocomposite magnets consists of achieving coupling through the exchange interaction between a hard magnetic phase and a soft magnetic phase. In this sense Sm-Co films are attractive as they allow thermal stability even in nanometer ordered grains. Furthermore, by alloying Fe with Co one can achieve an increase in saturation magnetization as well as an increase in Curie temperature.

In this study we aim at the exchange coupling between SmCo hard phase and FeCo soft phases in thin films obtained by DC magnetron sputtering, presenting a systematic study of the influence of the film thickness on the structural and magnetic properties. To understand and to improve the exchange coupling behaviour the intrinsic parameters of both SmCo and FeCo magnetic phases involved are considered.

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EXCHANGE INTERACTIONS AT THE INTERFACE FM/AFM OF NANOCOMPOSITE OBTAINED BY MECHANOCHEMICAL SYNTHESIS

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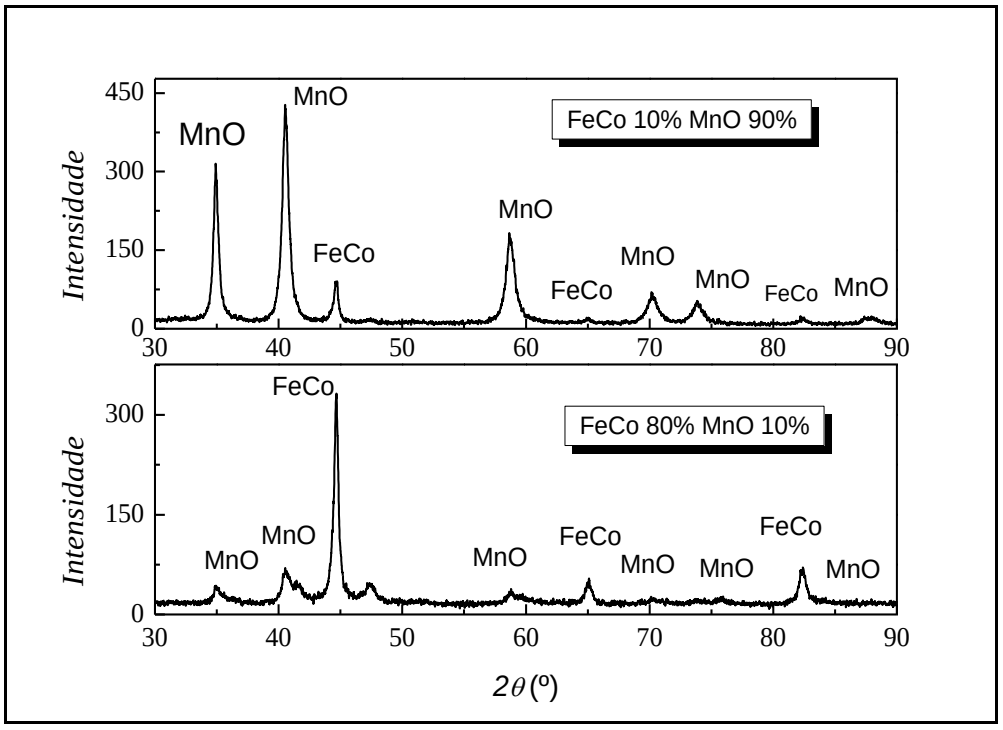
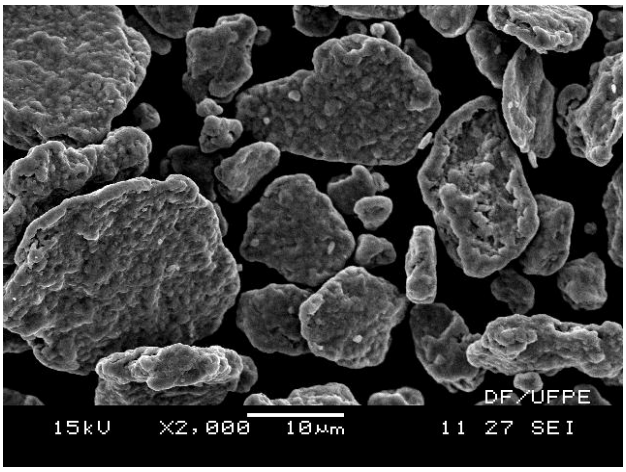
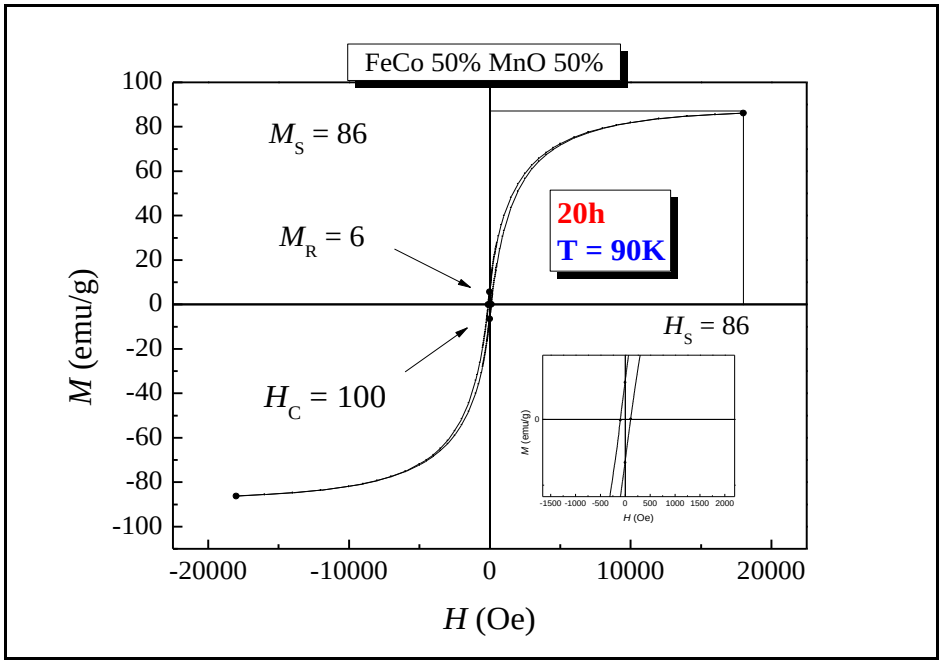
INTRODUCTION

This work presents a study of the relationship between the magnetic properties and microstructures in nanocomposite Ni/MnO, Ni/CoO, Co/MnO, Co/CoO and $(Fe_{50}/Co_{50})x/(MnO)_{x-1}$. The main goal is to understand how the coupling in interphase FM/AFM is manifested in the magnetic response of these materials. Sample preparation was performed using mechanochemical synthesis using a ball mill, high energy planetary type. During manufacture all the variables were fixed to the grinding process and have only changed the processing time and the relative proportion between the phases precursor. The characterization was done primarily by X-ray diffraction (XRD), scanning electron microscopy (SEM) and vibrating sample magnetometry (VSM). Analyzing the XRD peaks of the samples studied, we have seen a decrease in the average particle diameter with increasing milling time. This was seen in broadening of the peaks and using Scherrer's formula to calculate the crystallite diameter. The analysis by SEM shows agglomerates of particles of micrometric size manifold. Joining the results obtained by XRD and SEM, then we can conclude that we are in presence of micrometric agglomerates of nanocrystals phases corresponding to each sample. The magnetic measurements show a strong coupling between the phases present in the nanocomposite obtained, showing again that the mechanical alloying (MA) is a powerful technique for this kind of purpose. In one group of samples $(Fe_{50}Co_{50})x/(MnO)_{1-x}$ crystallite size of FeCo phase remains constant with variation of the relative percentage, x, between phases. On the other hand crystals MnO, decrease the average size increases when the proportion of FeCo.





VEM - $(Fe_{50}Co_{50})_x/(MnO)_{1-x}$ *com x = 0,8.*



Histerese $(FeCo)_x/(MnO)_{1-x}$ 20 h a 90 K. x = 0,5.

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EFFECT OF LAYER THICKNESS RATIO ON MAGNETIZATION REVERSAL PROCESS IN STACKED MEDIA WITH HIGH COERCIVITY

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INTRODUCTION

Stacked media with high coercivity are ones of candidates for next-generation hard disks. It is important to elucidate magnetization reversal process in soft and hard layers of the stacked media at recording. We investigated effect of layer thickness ratio and interlayer exchange coupling between the layers $A_{interlayer}$ on the time-evolutional magnetization change utilizing micromagnetic simulation.

METHODS

Dot pattern with track width and bit length of 30 nm was recorded with magnetic printing [1]. Total thickness of the soft and hard layers was set to 16 nm, and each layer thickness was varied.

RESULTS AND DISCUSSION

Figure 1 shows $A_{interlayer}$ dependence of delay time of hard layer's magnetization reversal from soft layer's one for layer thickness ratio soft:hard of 1:3, 1:1, 3:1. The infinite of the delay time means only the soft layer's magnetization reverses. This corresponds to spin-flop rotation [2]. The region where the delay time is almost constant minimum value corresponds to coherent rotation. Magnetization reversal process between the spin-flop and coherent rotation is incoherent rotation which is suitable for stacked media. Figure 1 shows $A_{interlayer}$ to get the incoherent rotation depends on the layer thickness ratio, and has to be set to larger value for the ratio near 1:1.

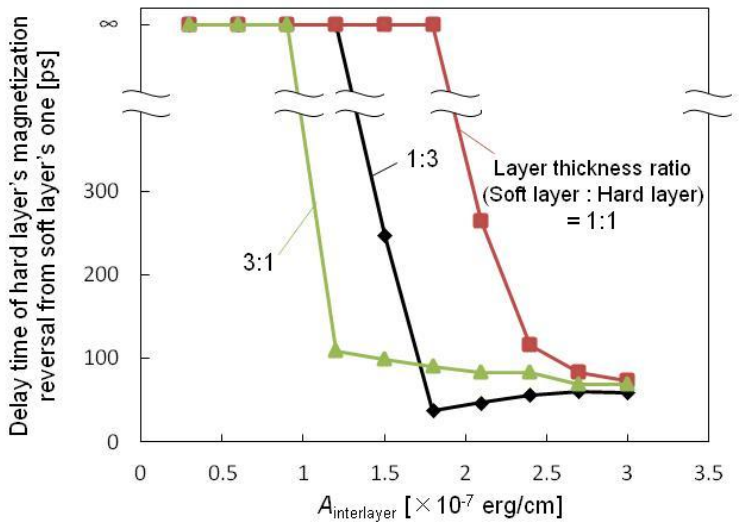

Figure 1 $A_{interlayer}$ dependence of delay time of magnetization reversal process.

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MAGNETOMECHANICAL RESONANCE BASED DETERMINATION OF MATERIAL CONSTANTS OF MAGNETO-OPTICAL CRYSTALS

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In a magnetomechanical vibrations model of ferrimagnetic thin rod under a polarizing magnetic field $\mathbf{H_0}$ calculated values of magnetomechanical resonance frequencies differ from those experimental values [1].

We have proposed a magnetomechanical vibrations model for stress-strain vibrations of the ferrimagnetic with the form of a rectangular parallelepiped under the polarizing longitudinal magnetic field $\mathbf{H_0}$.

It is builted the equation which determines the resonance vibration frequencies at different relations between linear dimensions of the ferrimagnetic and different magnetic field $\mathbf{H_0}$. On the example of yttrium ferrite garnet (YIG) crystals we have carried out comparison of calculated and experimental results.

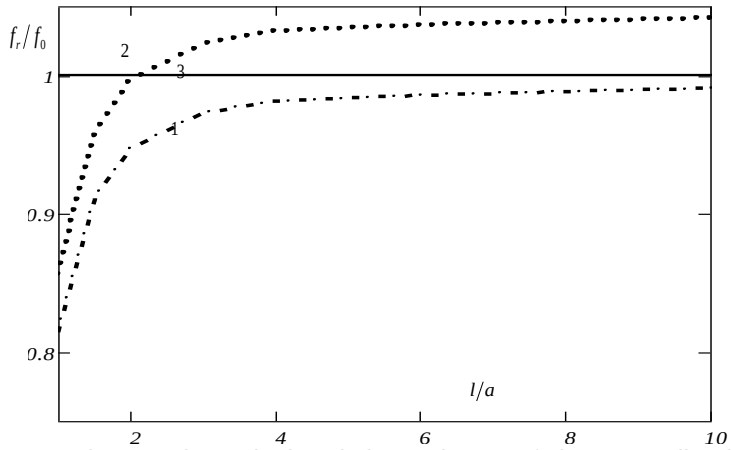

Figure. The calculated dependence of the normalized resonant vibration frequency of the YIG sample with square section on the ratio of its length l to square side a, l/a with and without magnetic field: 1 – $H_0 = 0$, 2 – $H_0 = 500\text{A/m}$, 3 – $H_0 = 0$, $l/a \to \infty$.

The experimental value of the elasticity tensor component $c_{11} = 300.6\text{GPa}$ in the magnetic field $H_0 = 500\text{A/m}$. Without the magnetic field: $c_{11} = 271.9\text{GPa}$. The tabular value is $c_{11} = 269\text{GPa}$.

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COMBINING HIGH MAGNETIZATION OF FECO AND MAGNETIC ANISOTROPY OF FEPT IN AN EPITAXIAL FEPT/FECO FILM

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The Fe_xCo_{1-x} alloy system has been studied extensively because of the highest saturation magnetization up to $\mu_0 M_s \geq 2.45$ T in the composition range of $0.3 \leq x \leq 0.5$. The $L1_0$ FePt ordered alloy has a large uniaxial magnetocrystalline anisotropy ($Ku \sim 7x10^7$ erg/cm^3). The combination of high Ms and high Ku of these materials is quite attractive to develop innovative permanent magnets and recording media. In this research, the magnetic property of the epitaxial FePt/FeCo films was studied to create new materials possessing both the high magnetization and magnetic anisotropy.

$Fe_{60}Pt_{40}$ films were prepared by co-sputtering Fe and Pt targets directly onto single crystalline MgO (001) substrates and by annealing at 640 ^oC for 1 h. Then, the $Fe_{50}Co_{50}$ films were sputtered at 200^oC with the thicknesses from 0 to 3 nm.

Figure 1 shows the typical magneto-optical Kerr hysteresis curves of MgO\FePt (10 nm)\FeCo (t nm) epitaxial films measured perpendicular to the film plane. The easy magnetization axes of films are perpendicular to the film plane. Figure 2 shows the FeCo thickness dependence of (a) Kerr rotation angle at saturation and remanent states and (b) coercivity. It can be seen in Fig. 2 (a), the signals of Kerr rotation angle at saturation and remanent states are rising with increasing the FeCo thickness, and the values are almost the same at each point. These results indicate that FeCo have the perpendicular magnetic anisotropy in the epitaxial MgO\FePt\FeCo films. It is concluded that high magnetization and high magnetocrystalline anisotropy are realized in the epitaxial MgO\FePt\FeCo films.

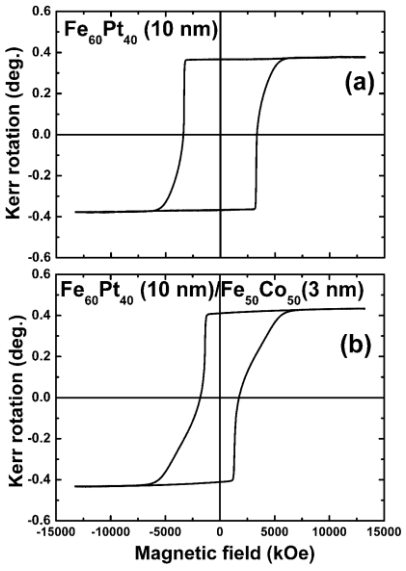

Fig. 1 Magneto-optical Kerr hysteresis curves of MgO\FePt\FeCo epitaxial films measured perpendicular to the film plane

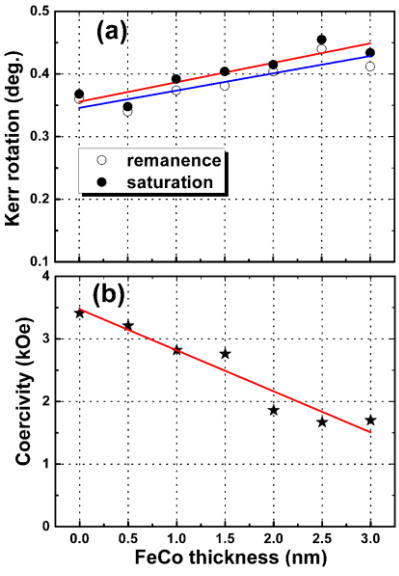

Fig. 2 FeCo thickness dependence of (a) Kerr rotation angle at saturation and remanent states, and (b) coercivity in MgO\FePt\FeCo (t nm) epitaxial films

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RARE-EARTH-DOPED PHOSPHATE GLASSES WITH INTERESTING MAGNETO-OPTICAL PROPERTIES

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Newly processed aluminophosphate glasses from the Li_2O-BaO-Al_2O_3-La_2O_3-P_2O_5-Re_2O_3 system (Re = Eu, Tb) have been investigated with respect to their magnetic and magneto-optical properties and compared to an un-doped sample. The glasses have been prepared by a conventional melting-quenching method providing a continuous mechanical stirring of the melt in order to improve the chemical and optical homogeneity of the final material. The magnetic state of the doped glasses was investigated by SQUID magnetometry performed over a large range of temperature and applied field. A paramagnetic behavior was evidenced at room temperature for the Tb doped samples whereas the magnetic signal of the Eu doped sample was negligible and comparable to the un-doped sample. The effective magnetic moments per rare earth atom are close to the theoretical values proving the nominal stoichiometry and the presence of the Re^{3+} ions. A new methodology has been proposed for the estimation of the magneto-optical effect, by using a sensitive device based on a Faraday rod coupled to a look-in amplifier in the detection chain. According to the performed magneto-optical measurements, the Eu doped sample introduces a positive rotation of the polarization direction of the incident light (Eu^{3+} has no magnetic moment and just a diamagnetic contribution of the glass is taken into account). By contrary, the presence of a Re doping component with permanent moment (Tb^{3+}), introduces a much enhanced negative rotation, the effect being dependent on the rotation of the sample around the wave vector. Such a magneto-optical anisotropy of the vitreous matrix, related to internal stress (induced by preparation conditions) might be used for adjusting the Faraday rotation according to application requirements.

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IN-SITU X-RAY DIFFRACTION MEASUREMENTS OF REMOTE PLASMA SPUTTERED $L1_0$ FEPT THIN FILMS

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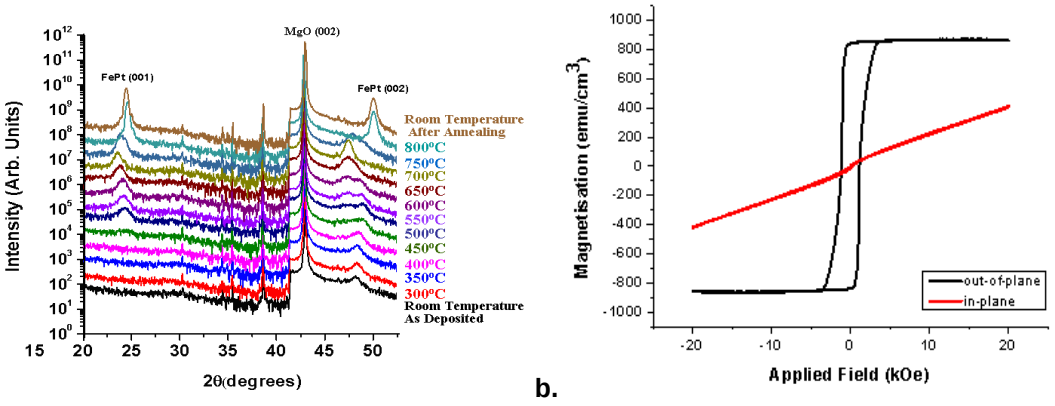
$L1_0$ ordered FePt is currently the leading candidate material for the next-generation high-density magnetic data storage media due to its high perpendicular magnetocrystalline anisotropy (PMA) K_1 [1]. However, the practical application of $L1_0$ FePt is challenging due to the requirements of low fabrication temperatures, good (001) texture, and small grain size with a narrow size distribution [2].

In this work, equatomic FePt thin films are fabricated using a remote plasma sputtering system, which offers good control of the film growth and grain size [3]. The thin films are sputtered at three substrate temperatures 200, 250, 300^{0}C following which in-situ x-ray diffraction (XRD) measurements were taking during post-deposition annealing.

Results for FePt thin films sputtered at 200^{0}C and then annealed up to 800^{o}C show that the (001) and (002) texture was successfully achieved for temperatures >450^{0}C (Fig.1.a). With this texture the films exhibited high PMA (Fig.1b), which we estimate is not less than K_1=2.2 x10^7 erg/cm^3 based on the in-plane hard axis loop.



a. **b.**

Figure 1 a. In-situ XRD measurements of FePt annealed at temperatures 300-800^{0}C,

b. The in-plane and out-of-plane hysteresis loops of FePt after annealing.

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MAGNETOELASTIC EFFECT APPLIED IN BIOSENSORS

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Abstract: The authors introduce some sensors based on magnetoelastic effect to measure glucose, acid phosphatase , tannin and Pseudomonas aeruginosa and so on. First we explain the basic principle of the sensor in detail., Wireless magnetoelastic sensing is a new type of sensing technology, wireless magnetoelastie sensor is based on elements of magnetostrctive, signal in the sensor is activated and transmitted by magnetic field, No physical connections between the sensor and the detection system are required, nor is any internal power required. The wireless nature of the magnetoelastic sensor makes it a powerful candidate for in situ and in vivo analysis.

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$Fe_{50}(Pt_{1-x}Pd_x)_{50}$ ALLOY THIN FILMS WITH $L1_0$ STRUCTURE EPITAXIALLY GROWN ON MgO(001) SUBSTRATES

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$L1_0$ ordered FePt and FePd alloys show K_u greater than 10^7 erg/cm^3 and the films have been investigated for magnetic device applications. The *c*-axis needs to be perpendicular to the film surface. However, an $L1_0$ film tends to include (100) crystal with the *c*-axis lying in the film plane in addition to (001) crystal with the *c*-axis normal, when formed on a (001)-oriented nonmagnetic substrate [1]. In the present study, $Fe_{50}(Pt_{1-x}Pd_x)_{50}$ (x=0, x=0.25, x=0.5, x=0.75, x=1) epitaxial films are prepared on MgO(001) substrates at 600°C. The *c*-axis distribution is investigated by out-of-plane and in-plane XRDs [Fig.1(a)]. The $Fe_{50}Pt_{50}$ film involves $L1_0$(001) and $L1_0$(100) crystals, whereas the $Fe_{50}Pd_{50}$ film consists of only $L1_0$(001) crystal. The volume ratio of two types of $L1_0$ crystal varies depending on the Pt/Pd composition. The highest order degree of 0.7 is observed for the $Fe_{50}Pd_{50}$ film. The $Fe_{50}Pt_{50}$ and the $Fe_{50}Pd_{50}$ films respectively show in-plane and perpendicular magnetic anisotropies, as shown in Fig.1(b). The magnetic properties of $Fe_{50}(Pt_{1-x}Pd_x)_{50}$ alloy system will be discussed in relation to the *c*-axis distribution and the order degree.

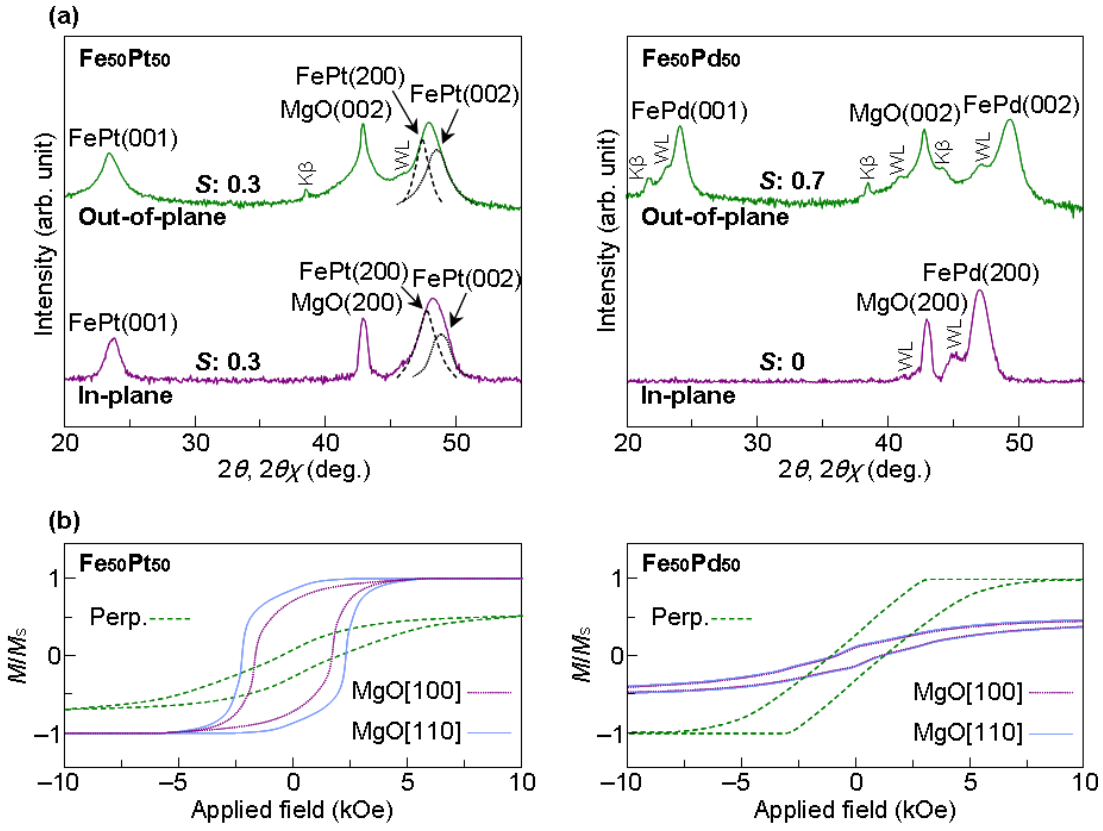

Fig. 1 (a) XRD spectra. (b) *M-H* curves.

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SWITCHING FIELDS OF HIGH-RESOLUTION MFM TIPS COATED WITH Co, $Co_{75}Pt_{10}Cr_{15}$, $Co_{75}Pt_{25}$, AND $Co_{50}Pt_{50}$ FILMS

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Magnetic force microscope (MFM) tip with high switching field (H_{sw}) is required for magnetic domain observations of permanent magnets and future high-K_u recording media. In the last JEMS conference, we reported that H_{sw} of 0.9 kOe was realized by employing $L1_0$ ordered FePd film as a tip coating material [1]. In the present study, MFM tips were prepared by coating sharp Ru-coated Si tips with 20-nm-thick magnetic films of Co, $Co_{75}Pt_{10}Cr_{15}$, $Co_{75}Pt_{25}$, and $Co_{50}Pt_{50}$. The resolution and the H_{sw} are estimated by performing MFM observations of recording media, as shown in Fig. 1. The evaluation details are reported in [1]. Resolutions of 7.5, 12.7, 7.9, and 7.9 nm and H_{sw} values of 0.4, 0.5, 1.1, and 1.7 kOe were observed for Co-, $Co_{75}Pt_{10}Cr_{15}$-, $Co_{75}Pt_{25}$-, $Co_{50}Pt_{50}$-coated tips, respectively. The resolution was influenced by the detection sensitivity, whereas the H_{sw} varied depending on the magnetic anisotropy of coated material. Formation of $L1_1$ ordered phase was recognized in $Co_{50}Pt_{50}$ film by X-ray diffraction. The present study shows that high-resolution MFM tip with high H_{sw} is realizable by using ordered $Co_{50}Pt_{50}$-alloy as a coating material.

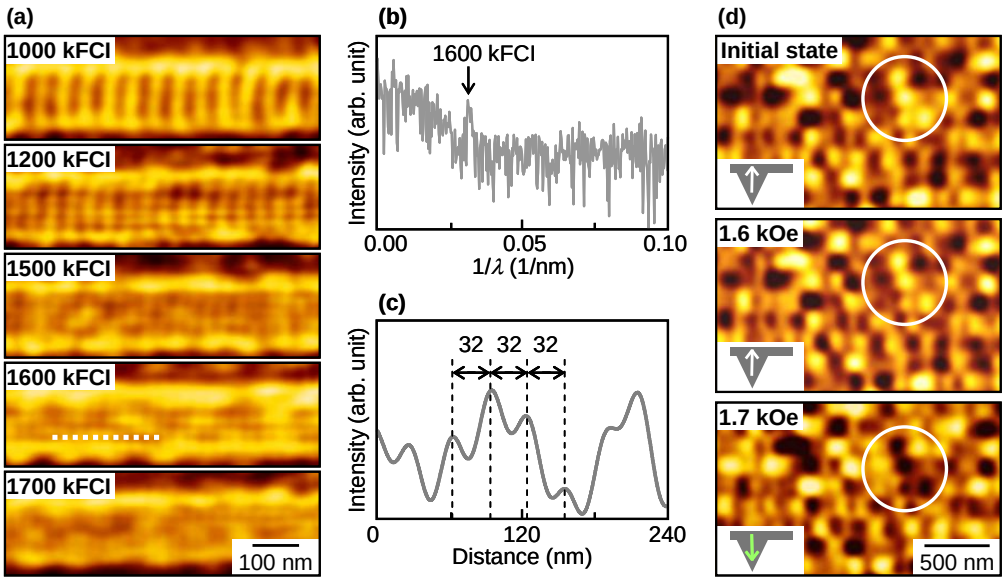

Fig. 1 (a, d) MFM images observed by using $Co_{50}Pt_{50}$-coated tip. (b) Power spectra. (c) MFM single profile along the dotted line in (a).

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SUBSTITUTIONAL EFFECTS ON $CeIn_2$: A FERROMAGNETIC COMPOUND WITH A FIRST ORDER MAGNETIC TRANSITION

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The binary $CeIn_2$ alloy was found to be ferromagnetic below 22 K, one of the highest ferromagnetic ordering temperatures found on this kind of compounds. In addition, the analysis of the magnetic, thermal, and transport properties provided evidence for the first-order character of this magnetic transition on this alloy [1]. More recently, muon spin rotation results have clarified the origin of this first-order transition in CeIn2, finding an intermediate magnetic phase between the paramagnetic and ferromagnetic states [2].

We present the evolution of the magnetic and thermal properties on the $Ce(In_{1-x}Ni_x)_2$ (x = 0.025 and 0.05) series of alloys. The orthorhombic structure of the $CeIn_2$ alloy changes to hexagonal AlB_2-type for the Ni-diluted samples. The dc (ac) magnetic susceptibility and specific heat measurements show a change from first-order ferromagnetism in the $CeIn_2$ alloy (x= 0) to second order ferromagnetism upon chemical substitution of Ni, with an abrupt decrease of the transition temperature from 22 K to 6.3 K (x = 0.025). The results indicate a preeminent role of volume and disorder effects on the magnetic behaviour along the series, and a close relationship between the crystallographic type of structure and the crystalline field effects on the first-order nature of the magnetic transition of the master $CeIn_2$ binary alloy.

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STRUCTURAL AND MAGNETIC PROPERTIES OF Sr_2FeMoO_6 POWDERS, BULK AND THIN FILMS

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Double perovskite Sr_2FeMoO_6 (SFMO) is very interesting material for spintronic and magnetoresistive applications. It has exceptionally high Curie temperature T_C, strong intrinsic magnetoresistivity effect and high spin polarization. However, these features are degraded when going from bulk to thin films. The change in onset T_C between bulks and films is up to 30-50 K, even though the shape of ferro-paramagnetic transitions in bulk and thin film samples are quite similar and clearly wider than in powder samples. In order to fabricate high quality SFMO thin films for room temperature applications, it is necessary to clarify the reasons for reduced magnetic properties. Therefore, we have systematically investigated the differences in structural and magnetic properties of powder, bulk and thin film SFMO samples. Comparison of these results will take the optimization of SFMO thin films further towards spintronic and magnetoresistive applications.

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STUDY OF MAGNETIC DYNAMICS IN LOW BANDWIDTH MANGANITE Pr(1-X)CaXMnO3 (X=0.3-0.5) BY AC SUSCEPTIBILITY MEASUREMENTS

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Among the perovskite manganites, low bandwidth compound Pr(1-x)CaxMnO3 (PCMO) at the doping range x = 0.3 - 0.5 has been under research in recent years because of its stable charge order (CO) state, which has great potential in wide range of applications. Within these x = 0.3 - 0.5 Ca consentrations, the colossal magnetoresistive (CMR) phenomenom is extremely strong in PCMO when compared to the wider bandwidth manganites. Also low temperature antiferromagnetic (AFM) phase, irreversible ferromagnetic (FM) phase, metamagnetic transition upon application of high magnetic fields and thermomagnetic irreversibility have been reported for this material in this doping range [1]. Ac magnetic susceptibility measurements have been widely used for characterization of frustrated magnetic systems such as spin-glass, cluster-glass and superparamagnets and also to reveal domain wall (DW) dynamics in different type of magnetic materials [2]. However, how this dynamic magnetic response evolves over this hole doping concentration x = 0.3 - 0.5 for this low bandwidth manganite, has not been published earlier. In this work, the dynamics of the complex magnetic phases with co-existing AFM-CO-FM ordering, where AFM, CO and FM clusters are competing, has been systematically studied by ac susceptibility in polycrystalline PCMO (x = 0.3, 0.4, 0.5) samples with wide range of ac frequencies and under different dc fields.

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COEXISTENCE OF MAGNETISM AND SUPERCONDUCTIVITY IN Pt DOPED $BaFe_2As_2$ COMPOUND

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We synthesized the samples $BaFe_{2-x}Pt_xAs_2$ (x=0, 0.1, 0.2, 0.3, 0.4, 0.5) with $ThCr_2Si_2$-type structure. We investigated in detail the superconducting state with magnetization measurements in the temperature range 5-400 K up to the field of 9T. By substitution of Pt atoms for Fe atoms , superconductivity is induced and observed over the range $0.1 < x < 0.4$. However, the superconducting critical temperature (*Tc*) in these compounds decrease with Pt and disapears completely at x=0.5 , with a maximum transition temperature T_c of 23.5 K at x = 0.1. Shielding volume fraction (obtained ~100 % at *x* = 0.1) decreases with Pt in a similar manner with T_c versus x. We also focus on the remanent moment which is the difference of the field-cooled and zero-field cooled moments in the low field at lowest temperature, 5K. Suprisingly, in contrast to the earlier works [1.2] we observe a small peaks in the magnetic susceptibility data at about 125 K for the samples used, indicating a similar but weaker spin-density-wave (SDW) and structural transition compared with that manifested at 139 K in the parent compound $BaFe_2As_2$. We discuss the role of Pt impurities on the superconducting states of the samples based on the results obtained from the magnetic analysis.

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EFFECT OF THE MAGNETIC ORDER ON THE BAND-GAP OF MANGANESE-DOPED ZINC OXIDE THIN FILMS

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INTRODUCTION

The wide band-gap semiconductor zinc oxide (ZnO) is commonly used in optics applications. The optical behavior of ZnO can be tuned by doping with transition metals. In particular, doping with Mn is expected [1] to widen the band gap and produce a blue-shift in the near band edge emission peak. Interestingly, a red-shift has been reported in weakly doped Mn-ZnO nanorods [2] and crystallites [3] showing ferromagnetism at room temperature. It has been therefore suggested that the red-shift is due to the same long-range exchange interaction which is at the origin of the magnetic order, *i.e.* a correlation exists between optical and magnetic properties.

We observe a red-shift at room temperature in the near-band-edge emission peak in films with 2% Mn doping. Films with different concentration of Mn were grown on Al_2O_3 <0001> crystal substrates. In order to increase the concentration of charge carriers we grew the films in high vacuum, which results in an increase of double-donor oxygen vacancies [4]. Increasing the magnetic moment by increasing the carrier concentration leads to an increase of the red-shift. Instead, increasing the Mn concentration widens the band gap and the expected blue-shift is recovered. The red-shift is due to *sp-d* interaction between free charge carriers in the band of the semiconductor and the localized magnetic moments [5].

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VORTEX CORE PROPERTIES IN IRON PNICTIDES

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The discovery of Fe-based superconductors generated intensive debate on the superconducting (SC) mechanism. Motivated by T_c-values up to 56 K, the possibility of unconventional superconductivity has been intensively discussed. A plausible candidate is the SC pairing mediated by antiferromagnetic (AFM) interactions. There are two different approaches predicting the $s^{\pm}$ pairing state, in which the SC gap shows an *s*-wave symmetry that changes sign between different FS sheets. The first one is based on the itinerant spin fluctuations promoted by Fermi-surface (FS) nesting, and the second based on the local AFM exchange couplings.

We apply quasiclassical Eilenberger approach to the vortex state to calculate the cutoff parameter, ξ_h, at different levels of impurity scattering rates and to compare results with experimental data for iron pnictides. The $s^{\pm}$-wave pairing symmetry is considered as a presumable state for these materials.

Magnetic field dependence of ξ_h/ξ_{c2} is found to be nonuniversal for $s^{\pm}$ pairing: depending on the chosen parameter set it can reside both below and above analytical Ginzburg-Landau (AGL) curve. It is also found that normalized $\xi_2/\xi_{c2}(B/B_{c2})$ dependence is increasing with pair-breaking impurity scattering (interband scattering in $s^{\pm}$-wave case). Here, ξ_2 is the vortex core size and ξ_{c2} is the Ginzburg-Landau coherence length determined from the upper critical field. Two types of $\xi_2/\xi_{c2}(B/B_{c2})$ dependences are obtained for $s^{\pm}$ superconductors. First, it has a minimum at low temperatures and small scattering evolving into monotonously decreasing function at strong scattering and high temperatures. Second, the intraband scattering results in decreasing of ξ_2/ξ_{c2} value. Such behavior is quite different from that in s_{++} pairing symmetry, where intraband and interband scattering rates act in similar way.

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CUTOFF PARAMETER AND VORTEX CORE SIZE IN d-WAVE SUPERCONDUCTORS

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There is some evidence that the electron-phonon mechanism is not strong enough to produce observed high critical temperatures in unconventional superconductors; this is the case in both the cuprates and Fe-based superconductors. Among many candidates for electronic pairing, Berk-Schrieffer type spin fluctuation theories are popular because they are relatively simple to express and they give some qualitatively correct results.

The *d*-wave pairing in strongly correlated systems is consistent with the observation of nodal quasiparticles in the heavily hole doped superconductor KFe_2As_2 with T_c = 3 K and high-*Tc* cuprates.

In this work the Eilenberger equations are solved for anisotropic d_{x2-y2}-wave superconductors. The cutoff parameter ξ_h and vortex core size ξ_2 (the distance from the vortex center to the radius where the current density reaches its maximum value) in the mixed state are investigated numerically. The cutoff parameter determines the field distribution in the generalized London equation obtained as a projection of the quasiclassical theory. It is used for the fitting of the μSR and small-angle neutron scattering (SANS) experimental data.

Field and temperature dependences of ξ_h/ξ_{c2} in d_{x2-y2}-wave superconductors are similar to those in *s*-wave superconductors: $\xi_h/\xi_{c2}(B/B_{c2})$ dependence has minimum at high temperatures and shows monotonously increasing behavior at low temperatures. Here, ξ_{c2} is determined by the relation $B_{c2} = \Phi_0/2\pi\xi_{c2}^2$. The $\xi_2/\xi_{c2}(B/B_{c2})$ dependence is monotonously decreasing function at intermediate and high temperatures.

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CONTROL OF COMPOSITION AND MAGNETIC PROPERTIES OF $LaMnO_{3+\delta}$ THIN FILMS PREPARED BY PULSED LASER DEPOSITION

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Perovskite-type ferromagnetic materials have a variety of applications in industry as well as in the field of materials research. Many of these materials are derivatives of $LaMnO_3$, which is doped on the *A*-site with lower valent cations like Ca^{2+} or Sr^{2+}. By changing the amount of the dopant, this allows one to tune the magnetic and electronic properties of the material. The parent compound $LaMnO_{3+\delta}$ also reveals a strong dependence of the magnetic and electronic properties on the Mn/La ratio and the excess oxygen content, δ. This is well studied for the $LaMnO_{3+\delta}$ ceramics, but has not yet been systematically explored in the thin films. Here we present such a systematic study of $LaMnO_{3+\delta}$ thin films that have been grown by pulsed laser deposition. The Mn/La ratio in the films can be tailored by fine tuning the deposition conditions, whereas the oxygen content can be changed by post-deposition annealing of the films. This allows one to obtain $LaMn_{\varepsilon}O_{3+\delta}$ thin films with a Mn/La ratio ε of 0.87 – 1.09 and an oxygen excess δ of 0 – 0.15. Depending on the composition the magnetic and transport properties of the films change from paramagnetic insulating (low ε and δ) to ferromagnetic metallic (higher ε and δ).

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EFFECTS OF PSEUDOGAP AND SUPERCONDUCTIVITY ON THE SPECIFIC HEAT OF THE HUBBARD MODEL

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INTRODUCTION

In this work the specific heat C(T) of the Hubbard model (including hopping to second nearest neighbors (t_2)) has been investigated in the pseudogap and also the superconducting region. Experimental results for C(T) of high temperature superconductors, for instance, the YBCO and LSCO shows a close relation between the pseudogap and the specific heat [1].

METHOD

The equations of motion of the Green's functions of the present model have been treated within the two-pole approximation [2]. An analytical expression for the C(T) has been obtained in terms of the Green's functions.

RESULTS AND DISCUSSION

The numerical results show that for C(T) as a function of the total occupation n_T decreases when $n_T \geq 0.85$. The analysis of C(T) in terms of the renormalized quasi-particle bands, shows that the suppression of C(T) is closely related with the opening of the pseudogap on the quasi-particle bands. Superconductivity with d-wave pairing is considered and the effects of such superconductivity on the specific heat are also investigated.

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REALIZATION AND PRELIMINARY EVALUATION OF A MULTIPURPOSE MAGNETIC FILTER FOR BIOMEDICAL APPLICATIONS

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INTRODUCTION

In the near future, many clinical/laboratory processes will be based on magnetic isolation/filtering mechanisms; Magnetically Assisted Haemodialysis [1-2] and cell isolation processes could be based on conjugates (Cs) of magnetic nanoparticles with biomolecules that bind on specific toxins and cells, respectively. Here we introduce a multipurpose Magnetic Filter (MF) for such purposes.

METHODS

The MF was designed under three main requirements: (a) high efficiency on the removal of Cs, (b) absolute safety and (c) isolation/rejection of captured Cs during continuous operation. Software packages (FEMMs and Origin®) were used for theoretical simulations before practical realization.

RESULTS and CONCLUSIONS

The dynamic MF consists of a disc with cylindrical permanent magnets (NdFeB, grade=N42) embedded uniformly along its periphery wherein a track exists to host the rigid tube wherein the biological medium flows. The disc rotates around its axis by electronically-controlled means. This ensures the trapping of Cs and subsequent rejection at an isolation port. The MF was successfully tested under *in vitro* conditions.

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BOMBESIN-FUNCTIONALIZED & GALLIUM-68 RADIOLABELED IRON OXIDE NANOPARTICLES FOR DUAL-MODALITY IMAGING

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INTRODUCTION

Iron oxide nanoparticles possess unique characteristics that make them well-suited as probes for molecular imaging [1]. A single nanoparticle (NP) can be conjugated with a large number of targeting ligands, increasing the affinity of the nanoparticle to its biological target through a phenomenon known as multivalency. Subsequently, the NP can be linked to a large number of reporter molecules (e.g.radionuclides) either via the attached targeting ligand or via an adequate chelating molecule conjugated onto the NP surface, thus increasing the signal-to-noise in imaging applications.

METHODS

In this study, the Bombesin peptide BN1.1 was bound to the surface of DMSA-modified iron oxide NPs. Radiolabeling with the positron-emitter Ga-68 was then accomplished via the NODAGA chelator, also conjugated onto the NP surface. Spectroscopy techniques showed that the NPs were successfully functionalized with BN1.1.

RESULTS AND DISCUSSION

Radiochemical purity was >98%. *In vitro* cell binding assays showed receptor-mediated uptake of NPs-BN1.1-NODAGA-^{68}Ga, the specificity of which was confirmed with the receptor blocking study. The preliminary results of this study warrant the need for further *in vivo* investigation into the targeting properties of this nanoconjugate.

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Co-Zn FERRITE CORES FOR MAGNETIC RESONANCE IMAGING PREPARED BY COPRECIPITATION

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In the search of efficient contrast agents for magnetic resonance imaging our group has investigated the nanoparticles of cobalt-zinc ferrites. In particular, $Co_{0.5}Zn_{0.5}Fe_2O_{4+\gamma}$ phase has been selected with respect to its high magnetization.

The ferrite cores were prepared by coprecipitation from the solution at 90 °C followed by annealing at 500 – 600 °C to gain variability of mean sizes from the range 10 – 40 nm. The particles were encapsulated by amorphous silica to ensure colloidal stability. TEM revealed the mean width of the silica shell around 20 nm. The colloidal stability of aqueous suspensions was confirmed by DLS and mean values of the hydrodynamic size 90 – 150 nm were indicated.

The relaxometric studies included the field dependence of T_2 relaxivity (measurements at 0.5, 1.5, 3 and 4.7 T) as well as its temperature dependence. The aqueous suspension of the silica-coated ferrite cluster of cores with the mean size of 12 nm and specific magnetization, $\sigma_{0.5T}(300K)$ = 42.8 $A.m^2.kg^{-1}_{CoZn\text{-}ferrite}$ exhibited transverse relaxivity r_2 = 460 $s^{-1}mM^{-1}_{CoZn\text{-}ferrite}$ at 0.5 T. The sample containing 15 nm cores possessing specific magnetization, $\sigma_{0.5T}(300K)$ = 48.0 $A.m^2.kg^{-1}_{CoZn\text{-}ferrite}$, showed r_2 = 810 $s^{-1}mM^{-1}_{CoZn\text{-}ferrite}$.

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COBALT ZINC FERRITE NANOPARTICLES PREPARED BY THERMAL DECOMPOSITION AS CONTRAST AGENT FOR MRI

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In the search of a suitable contrast agent for magnetic resonance imaging cobalt zinc ferrites $Co_{1-x}Zn_xFe_2O_4$ have been intensively studied because their physical properties can be easily adjusted and their nanoparticles exhibit high magnetization values.

The $Co_{1-x-y}Zn_xFe_{2+y}O_4$ nanoparticles were prepared by thermal decomposition of the metal acetylacetonates in a high boiling solvent with surfactants. Subsequent silica coating was carried out by the reverse microemulsion method and the final product was obtained by size fractionation. The magnetic cores were characterized by XRF, XRD, magnetic measurements and TEM while the silica coated particles were studied also by IR spectroscopy and DLS. Cell viability tests employed HeLa cells and T_2 relaxivity was measured at 0.5 T.

The prepared cores exhibited narrow size distribution with mean size of crystallites 7 - 21 nm. Their chemical composition was different to the starting metal ratio but can be varied. The saturation magnetization at 300 K typically exceeded 50 Am^2kg^{-1}. Silica coating led to colloidal stability in water and enabled basic biological studies. The T_2 relaxivity showed interesting dependence on aggregation state.

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NEW APPROACHES IN THE DESIGN OF THE MAGNETIC TWEEZERS

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Currently, there are many systems to handle nano-objects used in various fields of science: optical tweezers (for transparent particles), mechanical tweezers (for large particles), magnetic tweezers (the particles must be ferromagnetic) [1]. In magnetic tweezers the non-uniform magnetic field of magnetized ferromagnetic cores is used to control the magnetic particles movement [2].

The main advantages of magnetic tweezers are the low price and simplicity of their use. But there are also essential shortcomings. For example, the remanent magnetic field and interaction between ferromagnetic cores reduce the efficiency of such tweezers [2].

We suggest to move the particles by magnetic field of the electric current. In Figure 1 the idea of such tweezers is presented. The wire arrangement as "a triangle" allows moving a particle in any direction in plane. Current flows through the wire; the gradient magnetic field is created which affects a particle thereby. The attractive force operating on a particle changes at the change of the current strength.

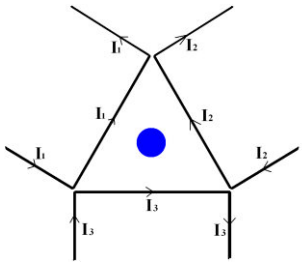

Figure 1

Scheme of current magnetic tweezers

It is shown that for magnetic particles with a diameter of 1-5 μm the operating force reaches 10-100 pN at current up to 1 A. The algorithm of a movement control of a magnetic particle is developed.

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MŐSSBAUER STUDIES OF IRON OXIDES PRODUCED BY ALKALIPHILIC BACTERIES

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Employment of biological systems is one of the possible ways to remove metal contamination from the environment. Some strains of bacteries are able to reduce ferric cations of amorphous ferrihydride and to form more stable iron oxide nanoparticles in appropriate conditions [1]. With reference to contemporary knowledge [2,3], the phase produced by Geoalkalibacter ferrihydriticus bacteries [4] is assumed to be a mixture of magnetite and maghemite, the exact phase composition not being fully explained yet.

The samples of magnetically ordered iron oxide nanoparticles were produced by these bacteries at various quinone concentrations in the cultivating solution. The in-field Mőssbauer spectra at liquid helium temperatures of these samples were used to determine their chemical and phase composition. The spectra are fitted by sextets ascribed to stoichiometric magnetite, whose hyperfine parameters of the nonequivalent iron cation positions were obtained from Mőssbauer and NMR spectra of the powdered sample of pure magnetite [5]. Two additional sextets with hyperfine field distributions correspond to iron cations in tetrahedral and octahedral sites without Fe^{2+} nearest neighbours (see Figure 1). The dependence of the ratios Fe^{2+}/Fe^{3+} on the quinone concentration was derived from the spectra.

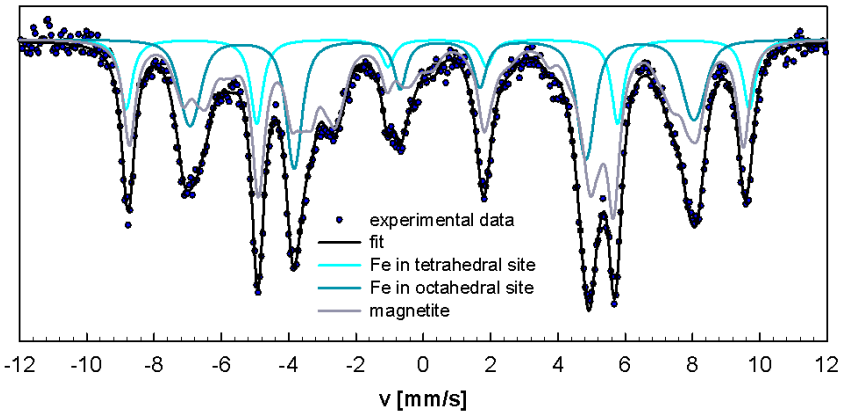

Figure 1: Mőssbauer spectrum (4,2 K, 6 T) of the sample with quinone concentration 0,4 g/l

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COMPARATIVE EVALUATION OF HEATING ABILITY OF DIFFERENT FERRITE-BASED MAGNETIC FLUIDS IN VARIOUS MEDIUMS

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INTRODUCTION

In this study, manganese and cobalt ferrite nanoparticles were synthesized by a facile, low-cost, environmentally friendly and high yield methodology based on the aqueous coprecipitation of proper salts. Firstly, structural, morphological and magnetic characterization were performed to determine crucial factors for optimizing their heating potential (such as size, polydispersity, saturation magnetization, coercivity). In order to study the thermal heating effects resulting from Brownian motion and hysteresis losses and medium viscosity impacts in hyperthermia, nanoparticles at various concentrations were dispersed in different solvents, water and Agar [1]. It was demonstrated that SLP decreased with increase in viscosity [figure1]. During the in-vitro application, ferrites were directly injected in three different cell lines. The comparative results of the AC hyperthermia efficiency of ferrites in different solvents and the in-vitro study explain the specific properties of magnetic fluids with respect to a possible use in hyperthermia.

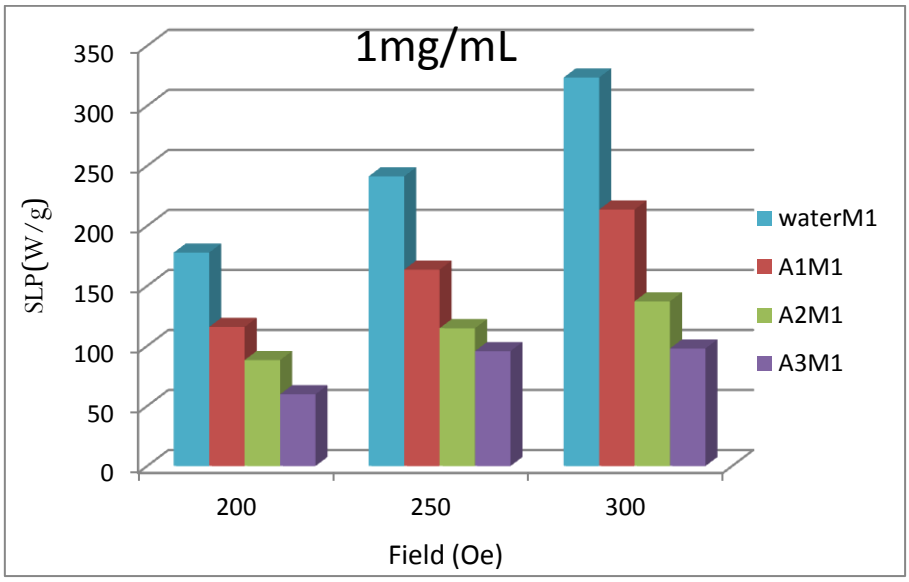

Figure 1: SLP at various concentrations of Agar (A1:1,25%, A2:5%, A3:10%) and at water under AC magnetic field frequency (765 kHz) and three field intensities (16, 20, 24 kA/m).

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DIAMAGNETIC LEVITATION AT THE MICRO SCALE

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Diamagnetic levitation of water-based objects (e.g. frogs, mice, strawberries, liquids…, with $\chi \approx -9 \times 10^{-6}$, has been demonstrated at the macro scale, using superconducting magnets (B = 10-20 T). For the case of highly diamagnetic pyrolytic graphite ($\chi = -450 \times 10^{-6}$), the moderate fields produced by bulk NdFeB magnets (0.5-1 T) are sufficient within the cm-scale. Permanent magnet arrays are particularly well suited to the production of static persistent fields, having no need for power nor cooling nor the application of an external magnetic field. Since the levitation force depends on both the field and field gradient, scaling down the size of both the magnet and the levitating object (and their relative distance) results in an increase of the levitation volumic force. Milli-sized magnets produced by machining of bulk magnets have been used for the levitation of 30 µm glycerine/water droplets and 20 µm NaCl crystals [1]. More recently, micro-patterned thick films of NdFeB have been used for the levitation of Bi particles in air [2], and both polystyrene beads and cells immersed in a paramagnetic buffer [3].

In this paper we will report on diamagnetic levitation of micro-fabricated objects, involving both diamagnet-above-magnet and magnet-above-diamagnet configurations. The design and micro-fabrication of [HOPG / NdFeB] structures will be presented. Finally, prospects for the development of applications (trapping, positioning, manipulation…) will be discussed.

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MAGNETIC PROPERTIES OF $TbMn_{1-x}Fe_xO_3$ (0<x<1) PEROVSKITE

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Perovskite oxides display a large number of novel, non-well understood physical properties such as ferromagnetism in oxides, metal-insulator transition, canted magnetic structures, charge and orbital ordered structures, spin and charge density waves. The rich physics observed, is related with the degeneracy of the d-electron states and the close interplay of charge, orbital, spin and lattice degrees of freedom.

The aim of this study is to elucidate the role of the degenerate and non degenerate electronic state of the transition metal on the physical properties in perovskite mixed oxides. For our purpose the mixed $TbMn_{1-x}Fe_xO_3$ (0<x<1) perovskite compound is selected for a detailed study by using neutron diffraction data, magnetization measurements, Moessbauer spectra and specific heat measurements. For small iron concentration up to x=0.25, neutron diffraction data show a short range magnetic order. For x>0.3 the samples display long range magnetic order of (Mn, Fe) ions magnetic moment. Tb sublattice exhibits short range order up to 10 K. ($Mn_{1-x}Fe_x$) sublattice displays ferrimagnetic ground state with T_N increasing with the iron content. Moreover, two novel spin orientation transitions are observed at temperatures depend on iron content. The first spin orientation transition is observed at low temperature 2-35 K with $T_{SR1}(x)$ decreasing with x, while for the second T_{SR2} (x) curve displays a non-monotonic behavior.

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EuTiO3 MAGNETOELECTRIC PROPERTIES INVESTIGATED BY NEUTRONS AND X-RAYS SCATTERING

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Magnetoelectric materials (MEs) are compounds showing multifunctional properties, suitable for exploitation in futuristic compact applications. For the moment, they represent a hard challenge to unravel their complexity, a necessary battle to be fought in the advancement of our understanding and in the rush for room temperature devices, still far to come.

A natural battlefield for good candidate materials is the subset of multiferroic materials (MFs) characterized by both electric and magnetic order. Unfortunately, two opposite trends seem to exist in nature: either high transition temperatures (type-I) with practically no ME effect or sizable ME properties but confined at very low temperatures (type-II) are allowed. Useless to say, the two would be ideally needed for mass applications based on easily achievable phases.

In particular, type-I MF perovskites of general formula ABO_3 (like $BiFeO_3$), have limited ME effects due to the intrinsic way in which the long range orders are achieved: one of the cations brings in the magnetism (for example Fe^{3+}, $3d^5$) while the other is the source of the electric properties (for example Bi^{3+}, via the $6s^2$ lone pair).

By exchanging the role of the two cations in the structure, sometimes funny and unpredictable effects are found: this is the case of the magnetoelectric compound $EuTiO_3$, where the magnetic ions (Eu^{2+}, S=7/2) order below TN = 5.5K. The electric response never diverges, on the contrary the dielectric constant saturates at the magnetic transition, where the ME effect is maximum [1].

We present an X-rays and neutrons scattering investigation of this peculiar material, reporting its crystallographic and magnetic structures fully refined at low temperature for the first time.

Moreover, we show the interplay between the two in the ME phase, highlighting the role of structural transition [2, 3] and commenting on the presence of intrinsic nanoscopic scales in the compound.

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EQUILIBRIUM PHASES IN THE MULTIFERROIC $BiFeO_3$-$PbTiO_3$ SYSTEM - A REVISIT

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ABSTRACT

The (1-x) $BiFeO_3$-(x) $PbTiO_3$ solid solution exhibiting a Morphotropic Phase Boundary (MPB) has attracted considerable attention recently because of its unique features such as multiferroic, high Curie point (T_C ~ 700°C) and giant tetragonality (c/a -1 ~ 0.19). Different research groups have reported different composition range of MPB for this system. In this work we have conclusively proved that the wide composition range of MPB reported in the literature is due to kinetic arrest of the metastable rhombohedral phase and that if sufficient temperature and time is allowed the metastable phase disappears. The genuine MPB was found to be x=0.27 for which the tetragonal and the rhombohedral phases are in thermodynamic equilibrium. *In-situ* high temperature structural study revealed the sluggish kinetics associated with the temperature induced transformation from one ferroelectric phase to the other. Neutron diffraction study revealed that it is the rhombohedral phase which exhibit magnetic ordering at room temperature (T_N 95°C). The magnetic structure was found to be commensurate G-type antiferromagnetic with magnetic moments parallel to the c-direction (of the hexagonal cell). The present study suggests that the equilibrium properties (e.g the magnetoelectric coupling) in this solid solution series should be sought for x=0.27, the genuine MPB composition.

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PHYSICS OF NANOCRYSTALLINE MULTIFERROIC MATERIALS

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In addition, few rare earth transition metal oxides (with general formula: ABO_3 where A = rare earth ions and B= (Fe, Cr, Mn) have been studied in our lab along with some other perovskites materials such as $BiFeO_3$ for their effect of crystalline size on the temperature dependent Raman spectroscopy, magnetization and dielectric properties. In our lab, in past few years, various multiferroic materials such as $GdCrO_3$, DyCrO3, $DyMnO_3$, $GdMnO_3$, $LuMnO_3$, $TbMnO_3$,$DyFeO_3$, $BiFeO_3$ etc. have been studied for the effect of reduced particle size on their physical properties by developing new routes for their wet-chemical synthesis methods. In $BiFeO_3$, some interesting size dependent effects are observed in the dielectric, magnetic properties as well as Raman spectra. The origin of the size dependent feature observed by us in the dielectric properties are not well understood but size dependent changes below 60 nm in the magnetic and Raman properties supposed to originate from the breaking of the helical ordering or incomplete rotation of spins along the antiferromagnetic axis. In $LuMnO_3$, we observed the presence of two novel magnetic anomalies. We will discuss their possible origin. The $GdCrO_3$ nanocrystals showed a rich interplay of competing magnetic interactions between Gd^{3+} and Cr^{3+}. Overall, new experimental observations are adding to the current understanding as well as creating new excitement and opportunities for researchers in this more than six decade old field.

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INFLUENCE OF SILVER ON THE MAGNETORESISTANCE AND TEMPERATURE COEFFICIENT OF RESISTANCE IN $Pr_{0.67}Sr_{0.33}MnO_3$

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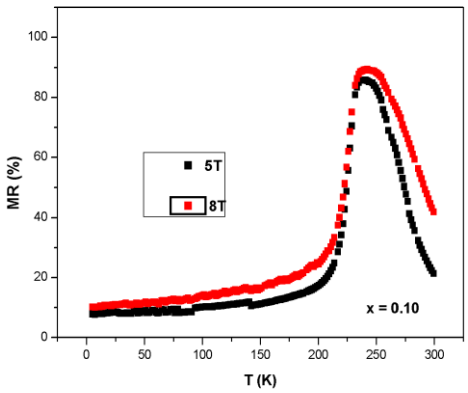
INTRODUCTION

We have synthesized and investigated the effect of Ag doping in $Pr_{0.67}Sr_{1-x}Ag_xMnO_3$ ($0 \leq x \leq 0.3$) via solid state reaction route. The structural, transport and magnetoresistance behaviour of these compounds have been studied. The Rietveld refinement of XRD data shows that these compounds crystallize in an orthorhombic structure with *Pnma* space group with systematic non linear variation in unit cell volume and lattice parameters. The grain morphology shows that silver enhances conducting channels reacts well with the compound only upto a certain doping level. The temperature dependent zero-field and in-field resistivity has been measured between 5 K to 300 K. The samples show a systematic variation in metal to insulator transition temperature (T_{MI}) and a large magnetoresistance (MR%) at x = 0.10 is also observed with maxima at T_{MI}. The highest value of Temperature Coefficient of Resistance (TCR) % has been observed by us for the first time. The results show that Ag takes part in the reaction only when the doping amount is small and at higher doping the system becomes a two phase composite. The higher values of MR% (~ 90%) and TCR% (~ 20%) observed by our group resulted due to silver doping that can be used to tune the intrinsic sensing ability of devices which can benefit the researchers at wide range.

Keywords: Manganites, TCR, Transport properties, orthorhombic structure, Composites

FIGURE



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HIGH PRESSURE NEUTRON DIFFRACTION EXPERIMENT ON TRIANGULAR LATTICE ANTIFERROMAGNET USING HYBRID ANVIL CELL

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Since the introduction of sapphire anvils pressure cells to neutron diffraction, measurements above 3 GPa and at low temperature have been possible.[1] Osakabe has been developing a *hybrid-anvil-type* pressure cell with combination of two different anvils, WC and SiC for JRR3 in Tokai.(Fig. 1)[2] This cell is able to apply pressure up to 10 GPa, and combination with low temperature and magnetic fields are possible.

In order to obtain higher statistic magnetic diffraction data and make use of the wide angle coverage on time of flight neutron instruments, which allows multiple Bragg peaks to be collected simultaneously, we are developing the cell on WISH in ISIS. Recently, we have succeeded in measuring several magnetic reflections of multiferroic $CuFeO_2$ under pressure. The incommensurate and commensurate phase transition, occurring at 11 K at ambient pressure, is clearly shifted to 9 K under 1.4 GPa.(Fig.2) Statistics of these data on WISH were much better than in the previous experiment.[3]

In this presentation, we would like to introduce utilization of the hybrid-anvil-cell for neutron diffraction measurements under high pressure, low temperature and magnetic field conditions.

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Fig. 1 Photograph hybrid-anvil-type high-pressure cell.[2]

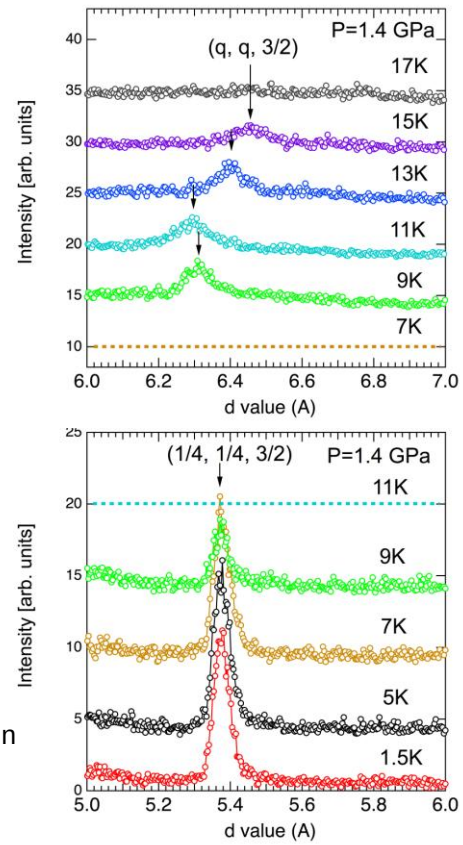

Fig. 2 Temperature dependence of the magnetic diffraction profiles of $CuFeO_2$ in 1.4 GPa, measured

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XAFS STUDIES OF DILUTED MAGNETIC SEMICONDUCTOR Mn-DOPED $ZnSnAs_2$ THIN FILMS ON InP SUBSTRATES

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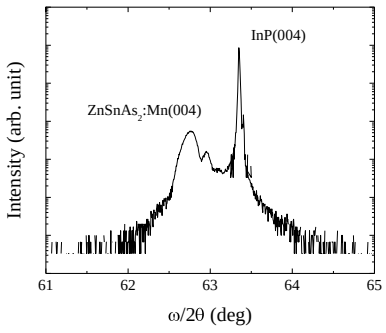
Diluted magnetic semiconductor (DMS) Mn-doped $ZnSnAs_2$ thin films have attracted much attention for application to InP-based spintonic devices, since they show ferromagnetism at room temperature [1]. One attractive property of ZnSnAs2 thin films is that they are almost lattice matched to InP substrates so that the growth of magnetic semiconductor thin films could avoid magnetic secondary phases such as MnAs clusters. However, the state of research and development of II-IV-V_2 DMS thin films is still at very early stage, and basic information is still not available on the parameters needed for spintronic application.

This paper reports the local atomic structure in the Mn-doped $ZnSnAs_2$ thin films which was obtained by the analysis of the spectra of the extended X-ray absorption fine structure (EXAFS) at a Mn K-edge. The $ZnSnAs_2$ layers doped with 5% Mn were epitaxially grown on InP (001) substrates at 300°C, and showed the Curie temperature of 334 K. The XRD pattern of $ZnSnAs_2$:Mn thin film is shown in Fig.1. Extraction of the EXAFS modulation function from the background was performed by the usual subtraction of the extrapolated pre-edge part of the spectrum and the absorption spectrum was fitted with the standard curve fitting procedure. (Fig.2) The phase correction is not carried out in this figure. The coordination number for the $ZnSnAs_2$:Mn from EXAFS fitting was 3.9 with 0.19 % R-factor. The interatomic Mn-As distance was found to be 0.250 nm. The experimental results agree very well with the EXAFS simulation.



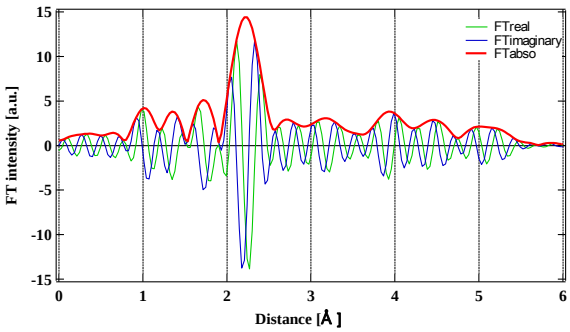


Figure1 (left figure): X-ray diffraction pattern of $ZnSnAs_2$:Mn (Mn: 5%) films.
Figure2 (right figure): Comparison between the EXAFS experimental and simulated results.

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ELECTRIC CONTROL OF THE SUPERPARAMAGNETIC BEHAVIOR IN A COMPOSITE MUTLIFERROIC NANOSTRUCTURE

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We study the superparamagnetic behavior of a composite multiferroic nanostructure consisting of $BaTiO_3$ in contact with Fe, which is known to exhibit a strong magnetoelectric (ME) effect [1] between the surface polarization and magnetization. In our analytical approach we construct a Fokker-Planck equation for the Landau-Lifshitz-Gilbert equation of the magnetization motion, which enables the calculation of the mean first passage time (MFPT) for the total magnetization in Fe induced by thermal excitations in the presence of the ME coupling. Full finite-time numerical calculations support the analytical findings and show the dependence of the ferromagnetic MFPT on an external electric field.

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ACKNOWLEDGEMNTS

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STRUCTURAL AND MAGNETIC PROPERTIES OF $PB_3(MN_{0,84}CU_{0,16})_7O_{15}$

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Structural and magnetic properties of $Pb_3(Mn_{1-x}Cux)_7O_{15}$ single crystal with x=0,16 grown by spontaneous crystallization from solution in melt have been investigated. This compound belongs to the hexagonal space group $P6_3/mcm$. Temperature dependences of magnetization for $Pb_3(Mn_{0,84}Cu_{0,16})_7O_{15}$ under the zero field cooled and (ZFC) and field cooled (FC) conditions are given in figure 1. They are presented for two characteristic directions of magnetic field in the crystal: along the six-fold axis ([001] direction) and in the basal plane. Magnetization measurements show the onset of the magnetic ordered state in $Pb_3(Mn_{0,84}Cu_{0,16})_7O_{15}$ below 67 K. The behavior of magnetization is compatible with a supposition that this state is the canted antiferromagnetic with a weak spontaneous ferromagnetic moment lying in the basal plane of the crystal. At ~20 K one more magnetic transition occurs in the crystals, which can be related to reorientation of a magnetic moment due to magnetic anisotropy variation with temperature. The exchange interactions in $Pb_3(Mn_{0,84}Cu_{0,16})_7O_{15}$ have been analyzed within an indirect coupling model.

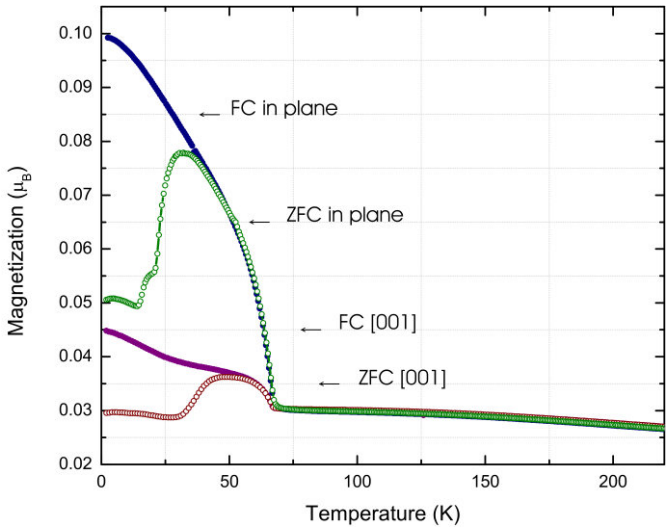

FIGURE 1. Temperatures dependencies magnetization of $Pb_3(Mn_{1-x}Cu_x)_7O_{15}$ with x=0.16 for two characteristic directions of magnetic field in the crystal: along the six-fold axis ([001] direction) and in the basal plane.

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A DIRECT METHOD FOR THE EXPERIMENTAL QUANTIFICATION OF D_{IJ} PIEZOELECTRIC COEFFICIENTS

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INTRODUCTION

The properties of multiferroic and specifically piezoelectric (PE) compounds [1-2] are, nowadays, intensively investigated by means of well established, however relatively complicate methods. In this work we present a direct method for the estimation of coefficients d_{ij}.

METHODS

The method is based on the utilization of optical microscope (OM) [ORTHOLUX (Leitz)] and atomic force microscope (AFM) [Solver-PRO (NT-MDT Co)] for the observation of the deformation, along specific symmetry axes, of a PE specimen upon voltage application. The direct comparison of the OM/AFM images obtained before and after voltage application and simple algebraic calculations enabled us to estimate the d_{ij} coefficients. The method was evaluated in unpoled single crystals ($6x5x0.5mm^3$) of $0.71Pb(Mg_{1/3}Nb_{2/3})O_3–0.29PbTiO_3$ (PMN-PT).

RESULTS

Deformations of the PMN-PT crystal were resolved at the micrometer and nanometer level with OM and AFM, respectively. With algebraic calculations we estimated the d_{ij} coefficients (d_{32}~700-1000pC/N) in the regime of low electric fields (E<1kV/mm). The resulted values agree with that reported in the literature.

CONCLUSIONS

This simple and reliable method could be employed for the investigation of the properties of PE materials in single crystal form.

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Magnetically Frustrated $CoAl_2O_4$ Spinel: Growth, Characterization and Exotic Magnetic Order.

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ABSTRACT

We report the first successful floating-zone growth of high quality $CoAl_2O_4$ single crystals with volume up to 1 cm^3 free from inclusions and sub-grains. The neutron rocking curves of the $CoAl_2O_4$ crystal have the width of about 0.3 degree proving the excellent quality of the as-grown samples. Lattice constant and inversion parameter are defined from the X-ray synchrotron measurements. All crystals have a spinel structure with the lattice constant a_0=8.09853(1) Å. The inversion degree for the single crystal (about 8 %) is among the lowest reported so far for stoichiometric $CoAl_2O_4$. Magnetization measurements give the effective magnetic moment $\mu_{eff}=4.63\mu_B$ per Co^{+2} ion in a good agreement with previous measurements on ceramic samples. The single crystal neutron diffraction experiments reveal the unconventional magnetic order at 1.5 K: atypically broad magnetic peaks, rising from the strong diffuse magnetic background, are connected by weak diffuse scattering streaks (rods) oriented along [111] direction.

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THE BISTABILITY AND SUSCEPTIBILITY DIAMAGNETIC-LIKE ANOMALIES OF ANTIFERROMAGNETIC PHASE OF $Ni_{1.7}Mn_{1.3}BO_5$

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The temperature dependencies of magnetization of the new single crystal $Ni_{1.7}Mn_{1.3}BO_5$ with ludwigite structure were measured at different value and orientation of magnetic field. This sample is characterised as antiferromagnetic material below ordering temperature T_N=90 K. Measurements were performed at heating of sample from the states, induced either FC (field cooling) or ZFC (zero field cooling).

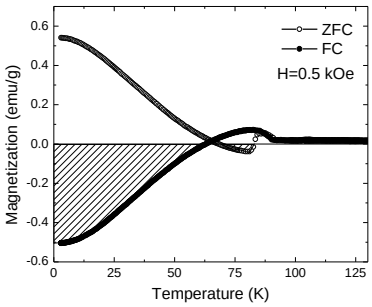

Figure 1 Magnetization of $Ni_{1.7}Mn_{1.3}BO_5$. H=0.5 kOe

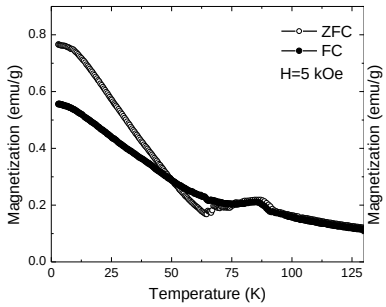

Figure 2 Magnetization of $Ni_{1.7}Mn_{1.3}BO_5$. H=5 kOe

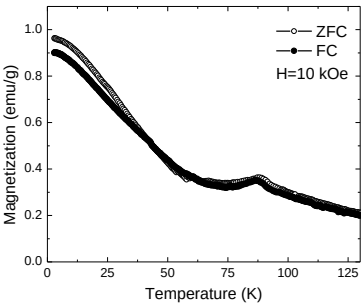

Figure 3 Magnetization of $Ni_{1.7}Mn_{1.3}BO_5$. H=10 kOe

In a low fields ($H \perp c$, H=0.5 kOe) the temperature dependencies FC and ZFC are very different and it demonstrate the bistability and the diamagnetic-like anomalies of susceptibility (Fig.1). Increasing the field (H=5 kOe), the sign-changing behavior of susceptibility disappeared (Fig.2), and then, as shown in Fig.3 (H=10kOe), the bistability disappeared too. This field, H=10 kOe, is quite close to the coercitive field. Such anomalies are not observed in the direction $H \parallel c$.

Earlier, the similar anomalous bistability behavior and diamagnetic-like anomalies of susceptibility was observed in powder sample of another Ni-containing antiferromagnet $Ni(HCOO)_2H_2O$ (T_N=15.5 K) [1].

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SYMMETRY AND MAGNITUDE OF SPIN-ORBIT TORQUES IN FERROMAGNETIC HETEROSTRUCTURES

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Current-induced spin torques are of great interest to manipulate the orientation of nanomagnets without applying external magnetic fields. They find direct application in non-volatile data storage and logic devices, and provide insight into fundamental processes related to the interdependence between charge and spin transport. Recent demonstrations of magnetization switching induced by in-plane current injection in ferromagnetic heterostructures [1] have drawn attention to a class of spin torques based on orbital-to-spin momentum transfer, which is alternative to pure spin transfer torque (STT) between noncollinear magnetic layers and amenable to more diversified device functions [1,2]. Due to the limited number of studies, however, there is still no consensus on the symmetry, magnitude, and origin of spin-orbit torques (SOTs).

Here we will report on the quantitative vector measurement of SOTs in Pt/Co/AlOx trilayers using harmonic analysis of the Hall Voltage as a function of the applied current and magnetization direction. Based on general space and time inversion symmetry arguments, we show that asymmetric heterostructures allow for two different SOTs having odd and even behavior with respect to magnetization reversal. We will present our experimental results, revealing a scenario that goes beyond simple models of the spin Hall and Rashba contributions to SOTs.

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THURSDAY POSTER

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PHOTOMAGNETISM OF $DyScO_3$ AND $NdGaO_3$

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INTRODUCTION

$DyScO_3$ and $NdGaO_3$ are strong paramagnets and order antiferromagnetically with Néel temperatures of 3.8 K and 1 K. In single crystal form, $DyScO_3$ is transparent with a slight yellow tinge, whereas $NdGaO_3$ often has a red color. The spin-orbit interaction is rather large in both compounds leading to a strong magnetic anisotropy in the paramagnetic state.

Magnetization measurements were performed in a Quantum Design MPMS-7 SQUID magnetometer using a fiber optic sample holder coupled to a Xe arc lamp. Using an optical filter system the wavelength could be varied from 360 to 850 nm. Both magnetic field and incident light were along the [110] direction of the $DyScO_3$ and $NdGaO_3$ (110) single crystals.

RESULTS AND DISCUSSION

Both crystals showed a wavelength dependent photomagnetic effect becoming larger at decreasing wavelengths. The photomagnetic effect increased for decreasing temperatures and had a nonlinear magnetic field dependence proportional to the slope of the magnetization hysteresis curve.

This photomagnetic effect might have two origins: (1) electron excitations to or from the rare earth elements might influence the spin-orbit interactions and the magnetocrystalline anisotropy; (2) photons might induce electronic transitions from the ground state to excited states with a smaller magnetic moment.

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ARPES INVESTIGATION OF GIANT RASHBA IN GeTe

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Germanium telluride is a narrow gap ferroelectric semiconductor which has been predicted to show a giant Rashba effect in the bulk [1]. The remanent dielectric polarization vector in GeTe breaks the inversion symmetry, leading to bulk Rashba spin splitting of bands, which can be controlled via external electric field. The hysteretic nature of ferroelectricity provides a unique way to modulate the Rashba effect in novel spintronics devices with non-volatile logic functions associated with the remanent ferroelectric states.

In this work we present the surface band structure of GeTe(111) thin films [2] as determined by Angular Resolved PhotoEmission Spectroscopy (ARPES). A huge Rashba splitting of the valence band has been measured at low temperature, in nice agreement with calculations and thus confirming the potential of this material for applications.

This work paves the way to the realization of FM/insulator/GeTe heterostructures to investigate the spin transport properties of this highly promising Rashba ferroelectric semiconductor.

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CRITICAL EXPONENTS OF DILUTE FERROMAGNETIC SEMICONDUCTORS (Ga,Mn)N AND (Ga,Mn)As

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There are two compounds which arguably demonstrate the highest potential for studying novel spintronics-related phenomena: (Ga,Mn)As, the 'canonical' dilute ferromagnetic semiconductor (DFS) and (Ga,Mn)N, the emerging member of this family [1,2]. Whereas (Ga,Mn)As has become the model material to test semiconductor spintronics concepts, the importance of (Ga,Mn)N stems from a different origin of magnetism and the already dominating role of GaN in photonics and high power electronics. Due to the strong p-d hybridization the $Mn^{2+/3+}$ acceptor level occupies the mid band gap position in GaN, and, interchangeable, either a high p-type doping or high Mn content x is possible. Nevertheless, in uncompensated films, where Mn^{3+} ions prevail, the superexchange interaction becomes ferromagnetic for all Mn-Mn distances resulting in a ferromagnetic order [1] characterized by the Curie temperature T_C = 13 K for x = 0.10 [3].

In this context it becomes of a paramount importance to provide the most comprehensive characterization of the magnetic ground state of this insulating DFS. To this end we investigate the static critical behavior of MBE grown (Ga,Mn)N layers [3] with $0.04 < x < 0.10$ and compensation free, high-T_C (Ga,Mn)As layer, utilizing direct DC field dependent magnetization and temperature dependence of AC susceptibility. From the analysis we establish for each sample its T_C and critical exponents α, β, and γ. In both systems we find $\gamma \cong 2.6$ to exceed about twice its typical value for most common (Stoner) ferromagnets, a value indicative of the profound role of disorder [positional of Mn in (Ga,Mn)N and electrical in (Ga,Mn)As] in the setting of the ferromagnetic state in these two system. We further find that, the Widom relation, $\delta = 1 + \gamma/\delta$, holds precisely only in (Ga,Mn)As. Such calculated δ in (Ga,Mn)N considerably overshoots its experimental value. This interesting discrepancy needs further clarification.

The work has been in part supported by FunDMS Advanced Grant of ERC within the Ideas 7th FP of EC and by (Polish) National Science Centre through project MAESTRO "Quantum phase transitions in magnetic layers driven by an electric field" (Decision 2011/02/A/ST3/00125).

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MAGNETO-ELECTRIC STUDIES OF (Ga,Mn)N BASED SPIN FILTER STRUCTURES

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Spin dependent electron tunneling is attracting much attention as a path to new functional spin dependent devices. The use of ferromagnetic semiconductors as materials of choice for the fabrication of these devices offers the possibility of combining capabilities of ferromagnets and semiconductor quantum structures. A semiconductor-based magnetic resonance tunneling diode structure with ferromagnetic (Ga,Mn)As was reported as working at low temperature [1]. On the other hand, in (Ga,Mn)N a strong short-range ferromagnetic superexchange interaction between Mn ions was found [2,3].

In this work we present experimental results obtained for metalorganic vapor phase epitaxy grown GaN:Si/$Ga_{1-x}Mn_xN$/GaN:Si ($x \approx 3.4\%$) tunneling structures with a ferromagnetic barrier that may act as a spin filter. The high structural quality of the structures has been confirmed previously by transmission electron microscopy, x-ray diffraction, high precision SQUID magnetometry.

We study I-V characteristics and magnetoresistance from room- to milikelvin temperatures. The low temperature measurements revealed the presence of a magnetization-related ~2% negative magnetoresistance and near zero hysteretic in field behavior for the device consisting of 5 nm (Ga,Mn)N, which could be related to the field induced ordering of the Mn spices in the barrier. At higher magnetic fields fine oscillations of the current derivative are observed, hinting that Landau quantization have been resolved. Since the equivalent thick (Ga,Mn)N layers show the existence of the long range ferromagnetic order in the same temperature range [3], we take our results as the strong indications that the spin-dependent transport do take place in these structures, however the full potential of the material still remains to be explored.

The work was supported in part by the European Research Council through the FunDMS Advanced Grant within the "Ideas" 7th Framework Programme of the EC and by the Austrian Science Fund (FWF)

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EPITAXIALLY STRAINED $Fe_{1-x}Co_xSi$ THIN FILMS AND SPIN POLARISATION

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FeSi is a non-magnetic narrow bandgap semiconductor that crystallises in B20 structure. Upon doping FeSi with Co a magnetic n-type semiconductor is obtained [1]. We studied the strained growth and Co-doping dependence of structural, transport and magnetic properties of ε-$Fe_{1-x}Co_xSi$ epilayers grown by molecular beam epitaxy on Si (111) substrates. Studies have confirmed the phase purity of ε-$Fe_{1-x}Co_xSi$ epilayers that are biaxially strained to become rhombohedral. Increased crystal volume induces local anisotropy and engineers other property. Ordinary Hall effect confirms the successful substitution of Fe by Co and addition of one conduction electron per Co dopant. Also observed is increased anomalous Hall effect. Temperature dependence of resistivity falls with increasing Co content, semiconducting for low x and metallic for x>0.4. Whilst the positive linear magnetoresistance is fully reversible, SQUID loops show magnetic hysteresis unlike bulk. Enhanced Curie temp, up to 77K for x=0.4(Fig.1b) is observed. Saturation magnetic moment of epilayers varies with Co doping and calculations indicate contribution of ~1 μB/Co atom for x ≤ 0.25(Fig.1c). In combination with the carrier density, this signifies a very highly spin-polarised electron gas in the low x, semiconducting regime.

This work was supported by the EPSRC and the FP7 ITN Q-NET.

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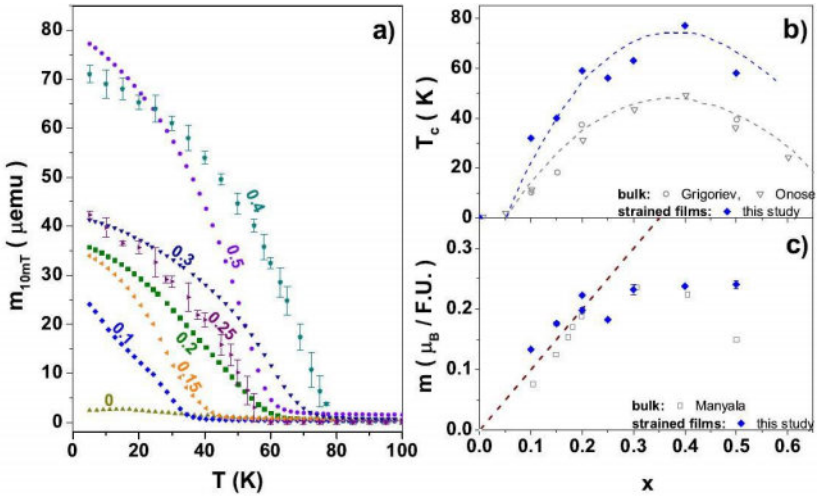

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THE MAGNETIC PROPERTIES OF BC_2N NANORIBBON

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INTRODUCTION

The emerging field of spin electronics (spintronics) has been continuously attracting researchers. Substantial theoretical and experimental efforts have been made in the quest to find the candidates for future spintronics devices. Recently, the search for new spintronics materials has also included graphene-based and other type of materials (e.g. Silicon Carbon [1], Boron Nitride [2], etc.) due to the theoretical prediction that these types of material may show the half-metallic property. Here, we present the results of a density functional theory within a generalized gradient approximation study of Boron Carbon Nitride (BC_2N) NanoRibbon (BC_2NNR)

First-principles total energy calculations of BC_2NNR were performed using the ABINIT code [3, 4]. ABINIT is a plane-wave-based pseudopotential density functional theory (DFT) code. Specifically, the generalized gradient approximation (GGA) of DFT has been used in our calculations. The GGA is a widely used approximation for the exchange correlation functional in DFT and has proven to be very successful in predicting many material properties. The objective of this study is to determine whether this type of material will be ferromagnetic or antiferromagnetic. Our results show that the zigzag shaped BC_2N nanoribbon prefers ferromagnetic state and may show some half-metallicity, depending on the thickness of the ribbon. These results are of the scientific interest in exploring the magnetic properties of BC_2 N-based nanoribbon for future spintronics.

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SPIN-CURRENT OPERATION IN A COPPER NANO-RING

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We have modified a Cu nano-wire into a nano-ring in order to demonstrate spin operation. A lateral spin-valve structure has been fabricated using a JEOL JBX-6300FS in a four stage Lithography process. Two 100 nm wide $Ni_{80}Fe_{20}$ wires spaced by 500nm were fabricated with a series of non-magnetic Cu nano-rings (30 nm thick with outer diameter: $250 \leq d_{out} \leq 400$ nm and inner diameter: $50 \leq d_{in} \leq 200$ nm) between the $Ni_{80}Fe_{20}$ wires. (figure 1) The Cu nano-ring enables the diffusive spin-current path to be split in two. These two paths experiences two different magnitude of perpendicular Ampère fields independently by flowing a dc current along an additional 1micron wide Cu wire close to the ring. A phase shift is hence induced independently onto each spin path of the nano-ring. The additional Cu wire acts as a gate in a three-terminal spin-current operator. We have successfully demonstrated significant modulation in a non-local signal, which is much more effective than that expected from the conventional simple Hanle effect. This is predominantly due to the shorter oscillation period observed as a result of arithmetical operation of the spin currents. We will present results from the device testing including non-local behaviour and will compare with our modelling.

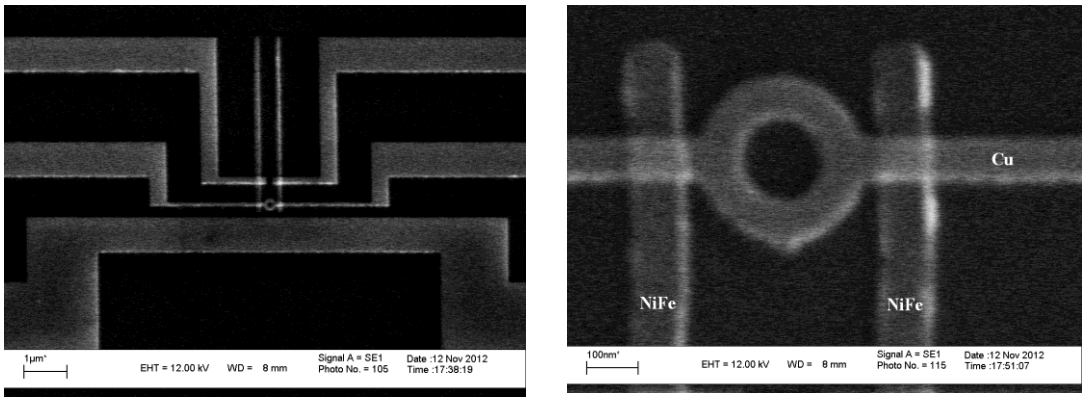

Fig. 1 *SEM images of the nano-ring device*. The vertical wires are $Ni_{80}Fe_{20}$ intersected by the horizontal Cu nano-ring. The left image shows the ring alongside the current bar.

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HALF-DOPED MANGANITE THIN FILMS FOR TUNABLE RESISTANCE IN TUNNEL JUNCTIONS

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Half-doped manganites are attracting renewed attention because their ground state (ferromagnetic(FM)/metallic or antiferromagnetic(AF)/insulator) can be easily modified by engineering the bandwidth and carrier density. This makes these materials ideal when integrated in tunnel junctions with potentially large electroresistance. Indeed, recent reports show record values [1]. Progress in this direction and discrimination between strain and field-effects in these heterostructures require detailed understanding of the strain effects on the properties of half-doped manganite thin films [2].

We report on a systematic study of $La_{0.5}R_{0.5}MnO_3$ (R = Ca and Sr) films, of different thicknesses, grown by pulsed laser deposition on different substrates ($DySrO_3$, $SrTiO_3$, $(La,Sr)(Al,Ta)O_3$, $LaAlO_3$ and $YAlO_3$) to explore different strain states (substrates) for different electronic bandwidth (Sr/Ca) and thus mapping the overall phase diagram. X-ray diffraction, transport and magnetic measurements have been performed to correlate transport and magnetic properties with the lattice deformation. A transition from FM to AF phase is observed when $La_{0.5}Sr_{0.5}MnO_3$ films are strained and a metal-to-insulator transition is observed in case of in-plane compressive strain. More modest changes are observed for $La_{0.5}Ca_{0.5}MnO_3$ which correlates with the distinct bandwidth.

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HIGH-FREQUENCY SWITCHING OF MAGNETIC BISTABILITY IN THE "SMALL DISK ON BIG DISK" NANOSTRUCTURE

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The study of magnetic and magneto-resistive properties of the "small disk on big disk" structure [JAP, 113, 17B527 (2013)] has shown that magnetic vortex (V) formed in big disk, but in the small disk the single-domain configuration (SD) was observed. It was defined experimentally that energetically favorable vortex state can be artificially formed in small disk.

In this study the micromagnetic simulation with OOMMF revealed that successive transition between the magnetic states in small disk can be achieved by an influence of high-frequency magnetic field excitation. In this case, the vortex core in big disk, moving along a circumference, acts as a trigger. An interaction with z-component of magnetization of small disk can lead to one of the three possible magnetic switching processes, Fig.1a. The Fig.1b shows the amplitude-frequency phase diagram with pointed areas of corresponding switching processes. Variation of the field amplitude at fixed frequency can lead to the sequential switching between SD and V configurations. The switching time is about 2.5 ns. Herein, in accordance with the JAP paper, the magnetoresistance of the structure changes on 0.2%.

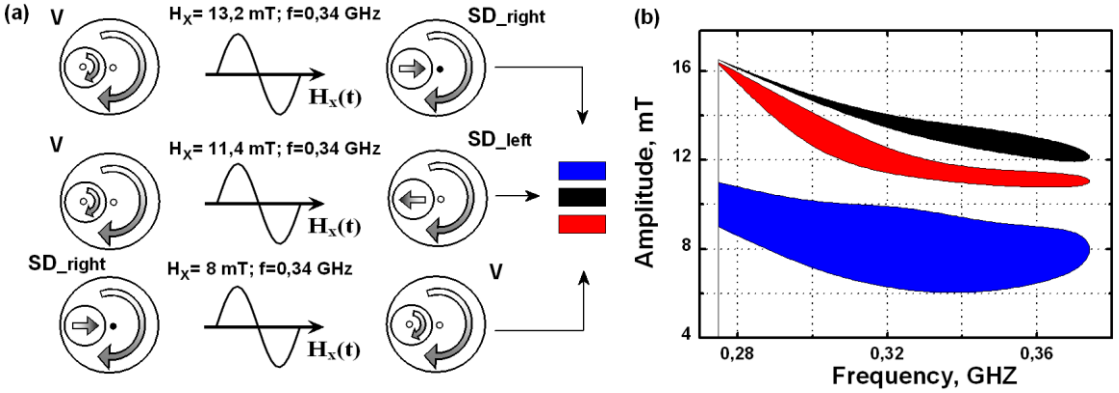

Fig.1. (a) Magnetization switching processes in small disk; (b) The phase diagram.

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ANGLE DEPENDENCE STUDY OF PHASE NOISE IN A MAGNETIC TUNNEL JUNCTION BASED SPIN TORQUE OSCILLATOR

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Spin torque oscillators (STO) are nano-sized devices capable of generating microwave signals at GHz frequencies due to spin momentum transfer [1, 2]. Understanding the phase noise of STOs is important for their practical uses as e.g. communication devices. In this work, we will discuss STO phase noise as a function of relative angle between the free and the reference layer in a magnetic tunnel junction (MTJ) based STO. Similar to previous reports, we find a frequency noise spectrum that is white at high frequency and varies as 1/f at low frequency [3, 4]. However 1/f frequency noise was found only at angles away from the antiparallel alignment of the free and reference layers, indicating a possible correlation with mode-hopping [5].

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DOMAIN WALL DEPINNING IN NOTCHED $Co_{50}Fe_{50}$ NANOWIRES BY IN-SITU LORENTZ MICROSCOPY

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The control of domain walls (DW) in magnetic nanostructures by applying magnetic fields attracts great interest due to their promising spintronics application [1]. In this work, a quantitative study of the depinning processes in notched $Co_{50}Fe_{50}$ nanowires was carried out by in-situ Lorentz Microscopy experiments applying magnetic fields. A series of notched L-shape $Co_{50}Fe_{50}$ nanowires 30-nm-thick and 300-nm-wide were fabricated by optical lithography, where the type and shape of the notches were varied in each. Lorentz microscopy experiments allowed following the evolution of a DW from its nucleation in the corner (see Fig 1) until its propagation through the notches, observing transformation from transverse walls (TW) into single or multiple vortex walls (VW). We have determined the parameters determining the magnetic-field manipulation of DW such as nucleation, depinning and transmission fields to determine the most efficient notch geometry [2].

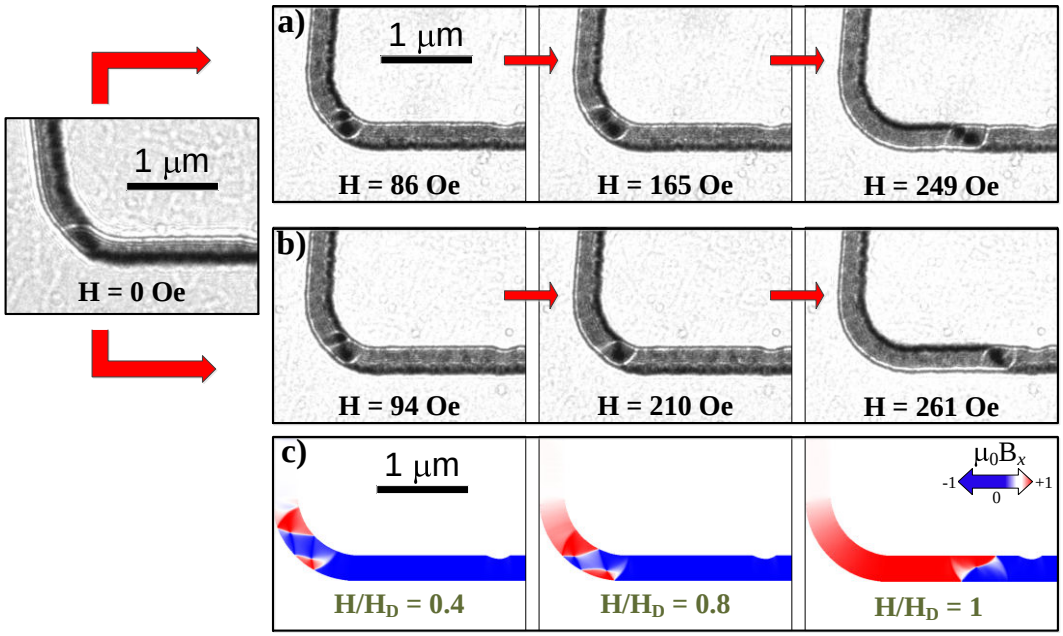

Figure 1. The nucleated TW transforms into a double VW and propagates a) unaltered, or b) changing into a single VW. c) Micromagnetic simulation.

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INCLUSION OF SURFACE ANISOTROPY IN THE MICROMAGNETIC ANALYSIS OF EXCHANGE-COUPLED HARD/SOFT BILAYERS

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A previously developed micromagnetic continuum model [1,2,3] for the study of demagnetization processes in exchange-coupled bi- and multi-layers of hard/soft type, with planar and perpendicular anisotropy, has been extended to take into account the effects of surface anisotropy in the soft layer, for fields applied along the easy direction.
In particular, we have studied in details the case of positive surface anisotropy and strong interface ferromagnetic coupling. The theoretical results have been applied to a bi-layer with perpendicular anisotropy in the hard layer, while the soft layer has been assumed to be ideal.
We have deduced the nucleation field equation and obtained plots of the nucleation field as a function of the soft layer thickness and of the soft surface anisotropy. Demagnetization curves have been also calculated. The nucleation process can be reversible (exchange-spring, ES regime) or irreversible (Rigid magnet, RM regime) depending on magnetic and geometrical parameters. The critical equation, which allows determining the boundary between RM and ES regions, has been deduced. Corresponding phase diagrams in the plane of soft and hard layer thickness have been obtained as a function of soft surface anisotropy.

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DOMAIN WALL PROPAGATION IN NANOCRYSTALLINE NANOWIRES

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$Fe_{73.5}Cu_1Nb_3Si_{13.5}B_9$ glass-coated nanowires and submicron wires with metallic nucleus diameters (Φ_m) between 100 and 500 nm and the glass coating thickness (t_g) of 5 μm were prepared using a modified Taylor technique. All samples were annealed in vacuum at 500, 550, 600 and 650^{0}C, respectively, for different durations up to 60 min.

The domain wall velocity along the wire length was studied by using a modified Sixtus-Tonks (S-T) method specially designed in our lab for very thin samples. Domain wall shape has been studied using a recently developed simultaneous S-T and magneto-optical Kerr effect method (MOKE).

The domain wall velocity increases significantly following the annealing performed to induce the nanocrystalline state, reaching values as high as 2,500 m/s. Annealing at larger temperatures and for longer times leads to a decrease of the domain wall velocity due to the crystallization of the samples.

The investigation of the domain wall shape with respect to the propagation direction shows that the wall propagates with a different velocity in the middle of the wire as compared to the surface, displaying a curvature which indicates a delay in the surface velocity. The curvature decreases following the annealing for nanocrystallization. UHR-TEM studies are in agreement with the observed magnetic behavior of the investigated samples.

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MODELLING OF OPTICAL RESPONSES FROM LAYERS WITH HARMONIC MODULATION OF DIELECTRIC FUNCTION USING RCWA

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INTRODUCTION

Spin and acoustic waves in solids are an important phenomena for many applications. Nowadays, an important effects are studies, such as coupling between spin and acoustic waves or magnonic crystals, where spin waves are modified by lateral periodic structures. Those effects are often studied by optical methods, such as Brillouin light scattering or pump probe techniques. However, up to now, there are no theoretical models of optical response from structures containing simultaneously spin-wave, acoustic wave and/or lateral variation of materials.

Here, we are presenting a formalism, which can describe one-dimensional harmonic modulation of optical properties, which can be simultaneously caused by above mentioned effects. The formalism is based on Rigorous Coupled Wave Analysis (RCWA), generalized for permittivity tensor where any element can be subjected to harmonic modulation.

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SURFACE MAGNETIC DOMAINS DYNAMIC IN HARD TURNED STEEL

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INTRODUCTION

Magnetic domain wall dynamics is extremely sensitive to the microstructure of material. This paper deals with an observation of magnetic domains evolution with magnetic field in different states of the surface of bearing steel.

The surface anisotropy after hard turning operation occurs due to the significant plastic deformation and a temperature exposure exceeding the Currie temperature in the cutting zone followed by rapid cooling.

EXPERIMENTAL METHODS

The domains dynamic on the studied surfaces are analyzed by Barkhausen noise emission (BN) as well as magnetooptical Kerr effect (MOKE) with focused laser beam and MOKE microscopy. While the BN is sensitive to the domain wall motion only, the magnetooptical methods are sensitive to the magnetization direction of each domain.

RESULTS

The transformed microstructure of the material in a conjunction with the residual stresses near the surface causes strong anisotropy in Barkhausen noise up to the ratio 7:1 observed after hard turning operation. The MOKE microscopy reveals finer domain structure with reconfigured domain arrangement.

Grinding operations do not induce significant domain alteration and domains arrangement of the ground surface corresponds with raw untouched state.

Abstract

MICROMAGNETIC STUDIES OF COUPLING BETWEEN COBALT NANOELECTRODES

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INTRODUCTION

The work present the micromagnetic studies of coupling between two cobalt electrodes of different geometrical shapes: 4μm x 4μm square pad and a 8μm x 1μm rectangular wire, which are joined together by a constriction. The structures of such a shape, fabricated by electron-beam-induced deposition (FEBID) - a novel single step lithography technique, have been previously experimentally investigated in the ref [1]. Based on the theory of anisotropic (AMR) in the diffusive electrical transport regime, they found a very good correlation between the experimentally observed magnetoresistance (MR) and the AMR values, which are derived from the y-component of the magnetization. The complementary results of micromagnetic simulations, presented in this contribution give an insight into the to the reversal process and the magnetic coupling of those electrodes. The magnetization maps, which are in a good agreement with the experimental data, allow to estimate the simulated AMR values.

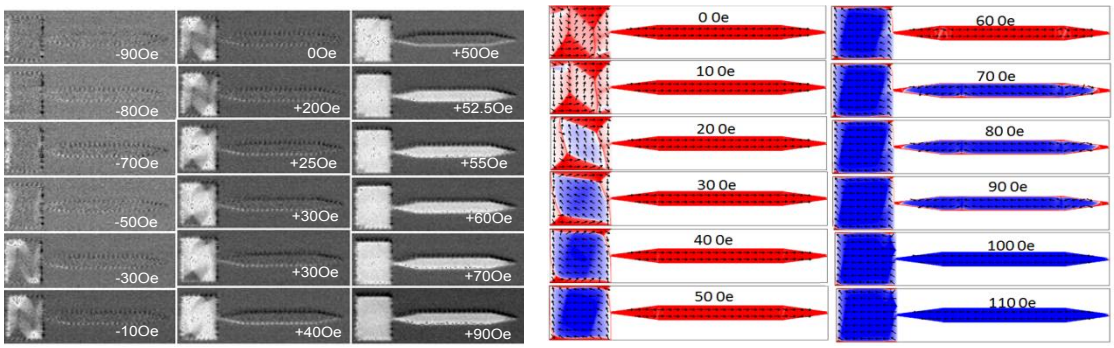

Figure. 1. Magnetization maps, derived experimentally by XMCD at room temperature and the correlated results of micromagnetic simulations. The images show the x-component of the field.

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MAGNETIZATION DYNAMICS OF IRON GARNETS IN THE COMPENSATION RANGE

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Magnetization dynamics of iron garnet $(TbErGd)_3(FeAl)_5O_{12}$ crystal 50mkm thick (111)-plates were studied in 77-300 K temperature range, including magnetic compensation temperature T_k. Magnetic field $H = H_o\sin(2\pi ft)$ was oriented perpendicular to sample plate, field frequency was changed from 30 to 1200 Hz with amplitudes up to 500 Oe. Domain structure (DS) was registered by high speed digital camera at 2000 fps.

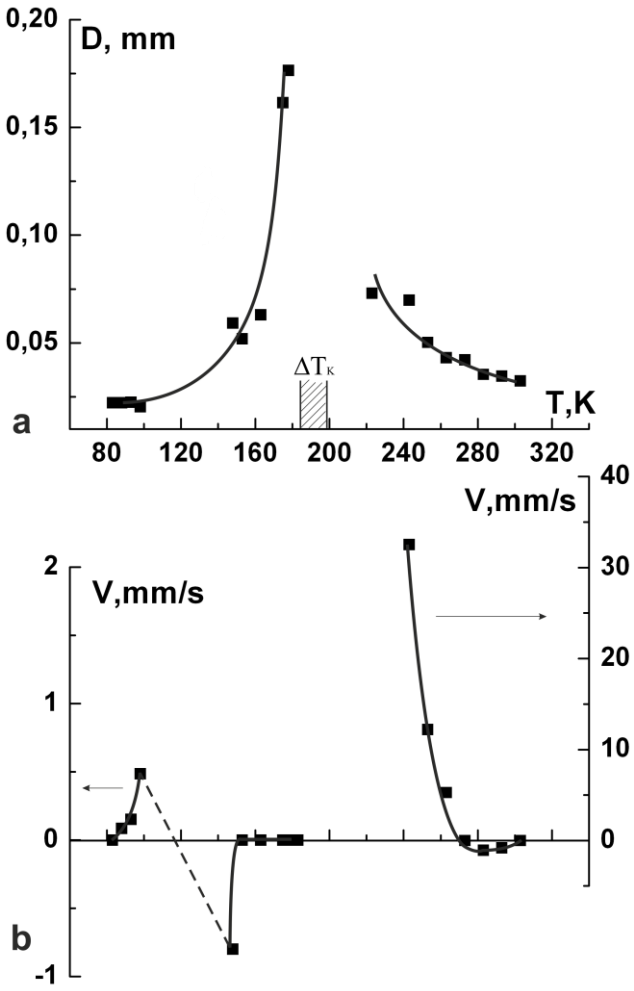

Figure 1. Dependence of a) dynamic period D of DS, b) DW drift speed V from temperature. Frequency f = 200 Hz.

In this work by direct observations of DS at different temperatures it is established that magnetization of the crystal for wide range of oscillating field amplitudes occurs via translational motion of domain walls (DW) (drift of DW) [1]. Dynamic period D of DS (Figure 1a) and DW drift speed V (Figure 1b) were measured on both sides of compensation range ΔTk. Dependencies of DW motion speed from temperature on different sides of ΔTk are qualitatively different. At $T>\Delta Tk$ drift speed increases with temperture till 35 mm/sec, at $T<\Delta Tk$ drift speed doesn't exceed 1 mm/sec. On both sides of ΔTk the change of DW drift direction with the temperature change was detected.

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HYBRID MODELS OF HYSTERESIS FOR MIXED HYSTERETIC LOOPS IN HETEROGENEOUS MAGNETIC MATERIALS

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We have recently shown that mixed hysteresis loops, such as the ones found in some systems of randomly distributed cobalt nanoparticles [1] or magnetic superlattices and heterostructures [2], can be modeled by a superposition of the clockwise and counter-clockwise Jiles-Atherton model [3, 4]. Here we extend this result to Preisach-type models as well as to the superposition of different types of clockwise and counter-clockwise hysteresis models. We will also prove that the (counter-clockwise) Bouc-Wen model [5] that was traditionally used in the applied mechanics community can describe inverted hysteresis loops in magnetic materials. A pertinent comparison of the these models will be presented at the conference.

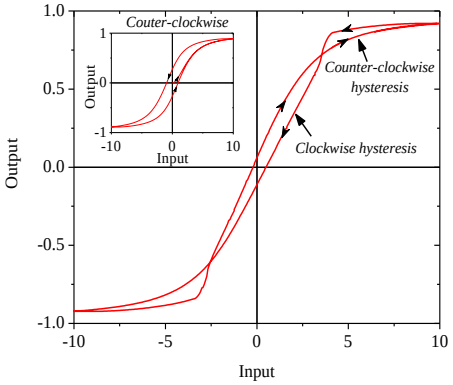

Fig. 1 Example of an mixed hysteresis loop obtained using the superposition of clockwise and counter-clockwise Jiles-Atherton models.

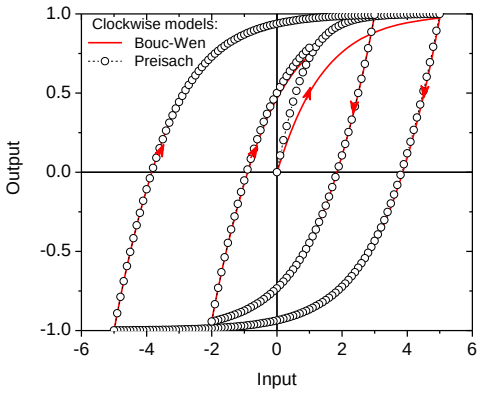

Fig. 2 Comparison of hysteresis curves obtained using the counter-clockwise Preisach and Bouc-Wen models.

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A FIRST-ORDER REVERSAL-CURVE ANALYSIS OF THE BOUC-WEN MODEL OF HYSTERESIS

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Counter-clockwise hysteresis has recently attracted the attention of the magnetics community, due to several experimental findings in inhomogeneous and hetero-structure magnetic systems [1,2]. In this presentation we perform a first-order reversal-curve analysis of the Bouc-Wen model of hysteresis [3] and compare this model with the recently developed counter-clockwise Jiles-Atherton [4] and Preisach [5] models of hysteresis. The Bouc-Wen model has often been used by the applied mathematical community in structural control and applied to a variety of mechanical systems. As far as we know this is the first attempt to apply the model to magnetic hysteresis. Sample simulation results are presented in Figs. 1 and 2. We will show that this model can be approximated accurately by a superposition of stop-and-play operators and, consequently, by the counter-clockwise Preisach model.

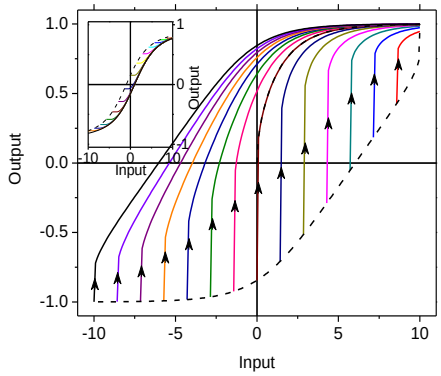

Fig. 1 A set of FORCs obtained using the Bouc-Wen model.

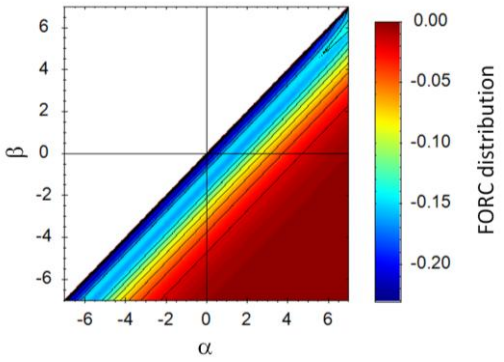

Fig. 2 A FORC diagram associated to the Bouc-Wen model.

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MAGNETIC RESONANCE FREQUENCY OF A STACK OF CHIRAL MAGNETIC PLAQUETTES

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The lateral dimensions of integrated electronic devices are constantly shrinking and, in the case of magnetic memories, rapidly reaching the threshold for data stability, since a smaller memory cell volume is associated with lower thermal stability of the information. The goal of this work is to present a new type of non-volatile magnetic memory based on stacks of CHIral Magnetic Plaquettes (CHIMPs). These plaquettes consist of a thin layer of magnetic material, shaped into regular polygons with an odd number of sides. For Py layers with dimensions between 100-800 nm, the spontaneous magnetic configuration is that of an in-plane vortex state with an out-of-plane core. Hence, it is characterized by two parameters: chirality (the vortex sense of rotation) and polarity (the direction of the vortex core). Stacking *n* CHIMPs in a multiple MTJ configuration (Figure 1), it should be possible to exploit these two degrees of freedom to store up to 4^n bits.

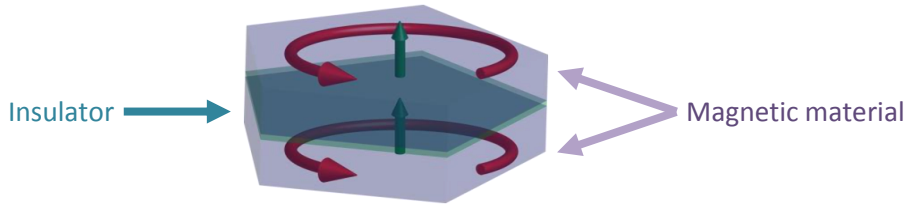

Figure 1: A two-CHIMP stack

The dynamics of the core can be excited by an external magnetic field or by a spin transfer torque and it typically shows a resonant behavior [1]. Both a single CHIMP and a two-CHIMP stack have been investigated using the OOMMF micromagnetic simulator [2], in order to determine the resonance frequency of the core precession as a function of the different vortex configurations.

States with different polarities can be distinguished by their characteristic resonance frequencies, since they are different for parallel and anti-parallel polarity configurations (Figure 2). The numerical implementation of the MTJ structure allows having a very thin insulating layer between CHIMPs, enhancing the influence of the stray fields on the magnetizations. This feature provides a fast (in the order of tens of nanoseconds) and reliable mechanism for the readout of the stored data.

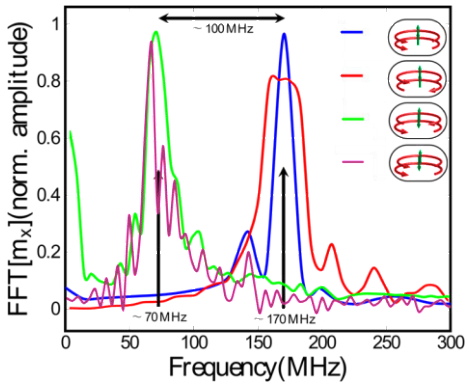

Figure 2: Resonance frequencies for different configurations of the stack

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MAGNETIC ANISOTROPY OF $Fe_5Si_{1-x}P_xB_2$: A DFT STUDY

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We present the results of density-functional theory calculations on the magnetic anisotropy of the $Fe_5Si_{1-x}P_xB_2$ systems. Pure Fe_5SiB_2 and Fe_5PB_2 are two promising materials with potential industrial application as the rare earths free permanent magnets. They crystallize in the tetragonal I4/mcm space group (see Figure 1b) and have Curie temperatures 784(1) and 628(11) K, respectively [1]. Our calculations are simultaneous with the ongoing experimental studies.

We used FP-LAPW method implemented in WIEN2k [2]. Because Si and P are neighbors in periodic table, Virtual Crystal Approximation is a suitable method for studying the full concentration range of $Fe_5Si_{1-x}P_xB_2$ alloys. The volumes and geometries were optimized in spin-polarized mode.

Optimized lattice parameters of Fe_5PB_2 (a=5.5460, c=10.341 Å) well agree with experimental ones (a=5.5498, c=10.332 Å). A similar situation is observed for Fe_5PB_2. Figure 1a presents the calculated Magnetic Anisotropy Energy MAE dependency for full concentration range of $Fe_5Si_{1-x}P_xB_2$ alloys.

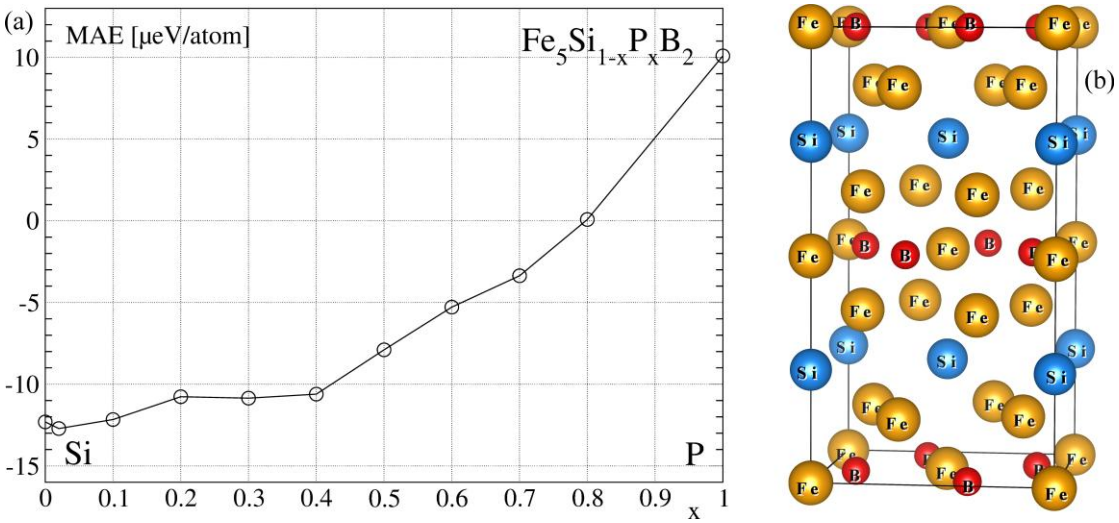

Figure 1: a) Magnetic Anisotropy Energy; b) crystal structure for $Fe_5Si_{1-x}P_xB_2$.

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MAGNETIC PROPERTIES OF SEVERE PLASTIC DEFORMED Nd and Sm RARE-EARTH METALS

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INTRODUCTION

This work reports the magnetic properties of thin Y, Ce, Nd and Sm ribbons obtained with the help of severe plastic deformation (SPD) technique. Severe plastic deformation procedures are very interesting for designing novel functional materials. Depending on the degree of deformation, magnetic, structural or thermodynamic properties could be varied in severely deformed materials, especially in thin ribbons of SPD-treated materials.

The interest in this matter is far from being purely academic. Since the discovery of the “giant” magnetocaloric effect [1], the development of magnetic refrigeration gained increased attention. A review on magnetic refrigerator and heat pump prototypes built before the 2010 shows different constructions of the magnetocaloric devices [2]. And one of the possible ways of engineering magnetoclaoric (MCE) materials is tightly connected with preparing very thin (a few microns) ribbons of high value MCE alloys with good mechanical properties.

A significant depression of magnetic and thermodynamic properties occurs in severely deformed samples of Gd. The reason of such behavior is in a giant magnetic anisotropy induced by SPD. This unexpected phenomena drives to a new thermodynamic and magnetic properties of severely deformed Gd ribbons [3] which are inapplicable for magnetocaloric applications without additional heat treatment procedure. The heat treatment regimes are directly connected with the degree of plastic deformation.

In this work we continue our previous investigations of the SPD on the magnetic properties of 4-*f* elements, with special accent on magnetic anisotropy and magnetocaloric effect.

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NON DESTRUCTIVE EVALUATION OF THE DEGRADATION OF MECHANICAL PROPERTIES OF DUPLEX STAINLESS STEEL

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INTRODUCTION

Aim of this study is the correlation among magnetic properties, tensile deformation and microstructure of the duplex stainless steel 2205 which is achieved by the magnetic ferrite phase of the two phase microstructure.

The amount of Barkhausen noise for a given material is linked with the amount of impurities, crystal dislocations, etc. and can be a good indication of mechanical properties of the material.

METHODS

The Barkhausen noise reveals as a series of jumps in magnetization in a ferromagnetic sample when it is exposed to a varying external magnetic field. These changes induce voltage changes in a surrounding coil and consequently are transformed into acoustic noise.

RESULTS AND DISCUSSION

Specimens of duplex stainless steel 2205 were tested under tensile deformation in different percentages. Two kinds of magnetic measurements of were taken: 1) online, during the tensile deformation and 2) offline, the prestrained specimens were measured again after the deformation. The measurements of the parameters of BHN combined with the percentages of the deformations and their graphic plot showed an exponential relationship. Microstructure was studied with SEM and EBSD techniques. Hardness also measured and its measurements compared with those of Barkhausen noise. The resultant plots showed a linear proportion among them (Fig. 1).

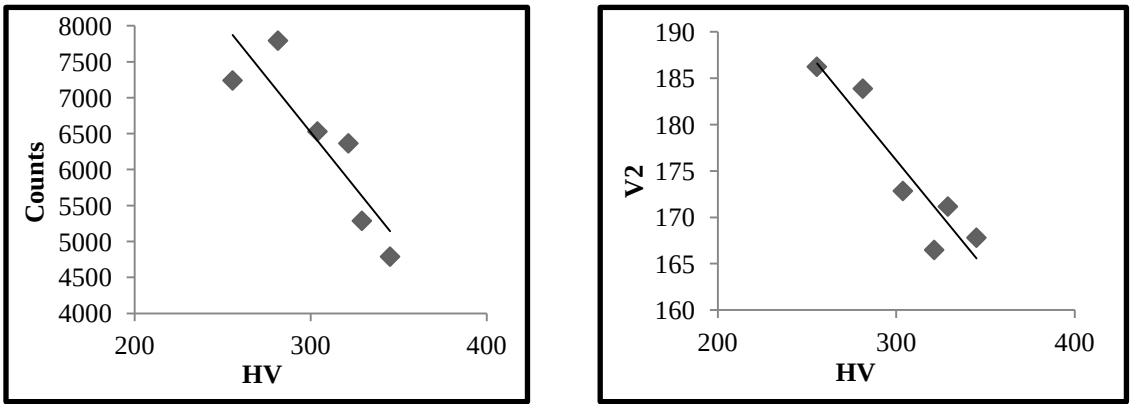

Fig. 1: Barkhausen noise dependence on the Duplex steel hardness.

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CORRELATION BETWEEN PLASTIC DEFORMATION IN TRIP 800 STEEL SPECIMENS AND MAGNETIC BARKHAUSEN NOISE.

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INTRODUCTION

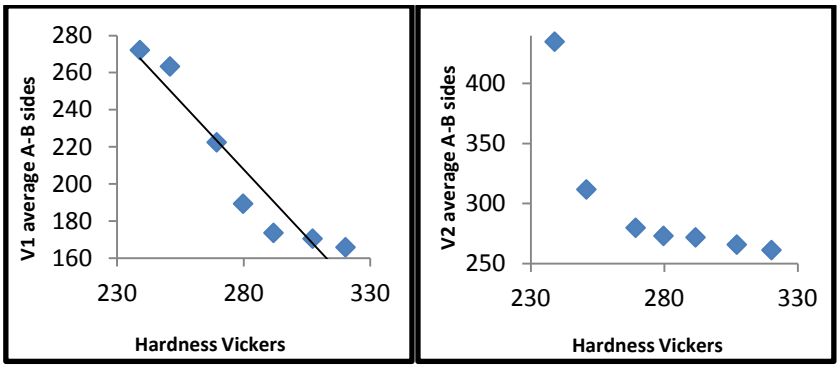
Aim of this study is the contribution to a better understanding of the dependence between Magnetic Barkhausen Noise and the plastic deformation of TRIP 800 steel samples. The dependence between the magnetic properties and the microstructure of ferromagnetic materials has generated the opportunity for methods to be developed in order to evaluate their mechanical properties via Magnetic Non Destructive Testing.

METHODS

The experimental procedure involves two sets of measurements. The first set involves measurements obtained during uniaxial, continuous, tensile loading at different percentages of the stress-strain diagram, while the second set involves measurements after the deformation of the TRIP steel specimens. Micro hardness and macro hardness were determined in terms of Vickers standards. Their results were correlated with the Magnetic Barkhausen Noise measurements. The microstructure of TRIP steel specimens was characterized by means of Scanning Electron Microscopy.

RESULTS AND DISCUSSION

The experimental results indicated that there is a dependence between Magnetic Barkahausen Noise and plastic deformation of TRIP steel specimens. The figures [Fig.1,2] that follow, show that Magnetic Barkhausen Noise is, almost, linearly proportional to hardness, which could be an indirect evaluation of mechanical properties for TRIP steel samples and a non destructive procedure for hardness determination.



Figures 1,2: Correlation between MBN parameters and hardness HV

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SYNTHESIS AND CHARACTERIZATION OF AMORPHOUS, MAGNETIC Fe-Si-B RIBBONS

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INTRODUCTION

The aim of this work is, mainly, the study of the properties, structure and crystallization process of the amorphous Fe-based ribbon with the following chemical compositions: $Fe_{80}Si_xB_{20-x}$ (x=5,6,8) and $Fe_{75}Si_{15}B_{10}$.

METHODS

Thermal analysis, including Differential Scanning Calorimetry and Magnetic-Thermogravimetric Analysis, were used to shed light in the thermal stability and structural changes taking place during the transformation from the amorphous state to the crystalline state. The arising microstructure was observed via X-ray diffraction. Finally, the results of the kinetic analysis and crystallization process are demonstrated.

RESULTS AND DISCUSSION

Two exothermic peaks corresponding to two crystallization events could be observed in all DSC thermograms. The plots of the Thermomagnetic Gravimetry showed a weight change that corresponds to the variation of the magnetic moment that occured at several temperatures, indicating the phase transformation of the specimens. The phases that arised and the crystallization kinetics [Figure 1] are dependent to the chemical composition and the annealing procedure.

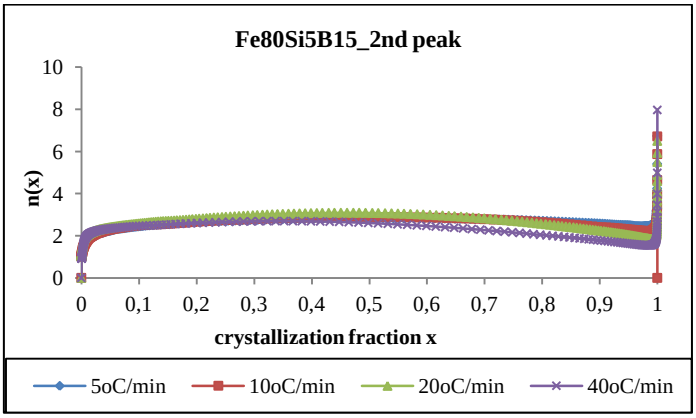

Figure 1: The relationship between Avrami exponent values and the crystallization fraction x for different heating rates of the $Fe_{80}Si_5B_{15}$ sample.

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MAGNETIC PROPERTIES OF SINGLE-CRYSTALLINE $Dy_3Ru_4Al_{12}$

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A magnetic study of single-crystalline $Dy_3Ru_4Al_{12}$ (hexagonal crystal structure of $Gd_3Ru_4Al_{12}$-type) was performed in static and pulsed magnetic fields. The system is an antiferromagnet with T_N = 7.5 K (Fig. 1). The magnetic moments are probably mainly oriented along the *c* axis, however, a complex magnetic structure can be expected. Below 2 T along the *c* axis $Dy_3Ru_4Al_{12}$ displays two hysteretic transitions (Fig. 1 top). Two magnetization jumps are observed along the *b* axis and one along the *a* axis as well (Fig. 1 bottom). Above the transitions the magnetization is still far from the forced ferromagnetic state ≈ 30 μ_B/f.u. However, there are no more jumps up to 60 T (Fig. 2). The different behavior of the magnetization along the three axes reflects strong magnetic anisotropy of $Dy_3Ru_4Al_{12}$.

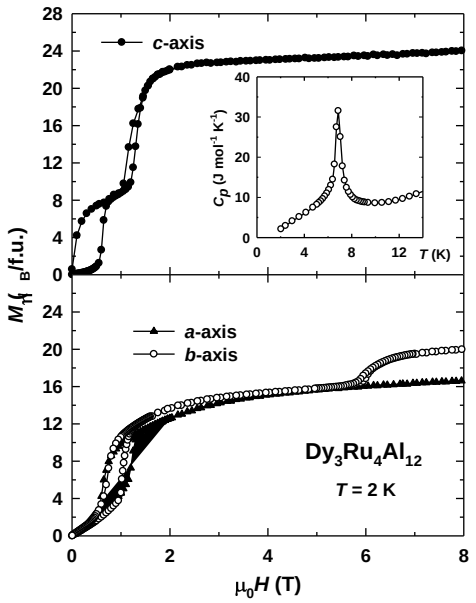

Fig. 1. Magnetization curves along the principal axes of $Dy_3Ru_4Al_{12}$ at T = 2 K in static fields. The inset shows the specific heat near T_N = 7.5 K.

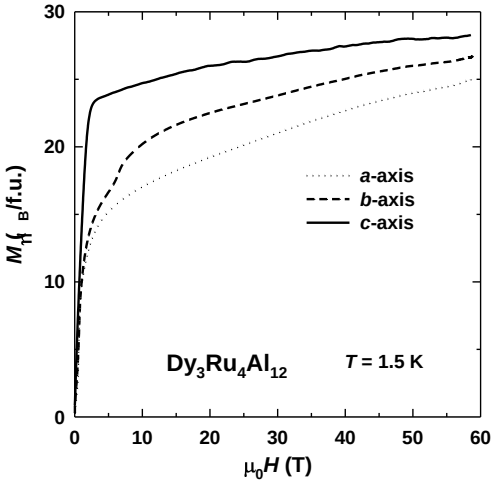

Fig. 2. Magnetization curves along the principal axes of $Dy_3Ru_4Al_{12}$ at T = 1.5 K in pulsed fields.

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THE ROLE OF SN IN MAGNETISM OF NIMNSN HEUSLER ALLOYS

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Ni-Mn based Heusler alloys undergo martensitic transitions leading to properties such as magnetic-shape-memory-effect, magnetic-field-induced-strain and magneto-caloric-effects. The occurrence of such effects is closely related to the nature of the magnetic interactions across the transition. In NiMnSn-alloys these interactions are strongly dependent on the Sn-concentration[1]. A minor change in Sn-concentration leads to lattice-distortions and surprisingly to a dramatic change in magnetic parameters. However up to now the role of Sn-atoms remains unknown and has been unexplored in element-specific investigations [2].

We have used X-ray Magnetic Circular Dichroism (XMCD) to investigate the influence of the martensitic transformation on the electronic structure and magnetic properties of the individual constituents in $Ni_XMn_YSn_Z$ alloys. XMCD at the Ni and Mn K-edges and the Sn $L_{1,2,3}$-edges have been recorded for the martensite and the austenite phases. The strong XMCD-signal at the L-edges of Sn reveal its magnetic polarization, while its temperature dependence can be correlated to the SQUID data in contrast to recent XMCD measurements at the L-edges of Ni and Mn [2]. Thus indicating a crucial role of Sn in the divers magnetic interactions in Ni-Mn based Heusler alloys.

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ELECTROMAGNETIC PROPERTIES OF Ni-Mn-Ga THIN FILMS DEPOSITED ON Si SUBSTRATES

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INTRODUCTION

Ni-Mn-Ga is a ferromagnetic memory shape alloy whose properties show great potential for applications, especially in thin film form [1]. Following previous research [2], Ni_2MnGa thin films were successfully deposited by r.f. sputtering at low temperature (400^0 C). A study of structural, magnetic and electrical properties of the prepared films is presented.

EXPERIMENTAL DETAILS

Ni-Mn-Ga thin films were deposited using co-deposition from two targets of $Ni_{50}Ga_{50}$ and $Ni_{50}Mn_{50}$ by r.f. sputtering with magnetron powers of 12W and 14W, respectively, at 400 ^{0} C on Si(100) substrates. Thicknesses ranging from 20 to 80 nm were obtained.

RESULTS AND DISCUSSION

The structural properties of the films were studied by XRD, TEM and SEM. XRD measurements (Cu-Kα radiation) (fig. 1) show some crystallinity in a mainly amorphous structure. Cubic and tetragonal phases coexist and the preponderance of the cubic over the tetragonal phase increases with decreasing thickness. The peaks are broad in omega, confirming low crystallinity. Magnetization studies (SQUID, VSM) show that the films have low coercivity (~100 Oe) and high saturation magnetization (350 emu/cm^3) (fig. 2). Temperature dependent magnetic studies show T_C~350K (similar to bulk of the same composition [2]). Resistivity vs temperature measurements using the four probe technique revealed the structural transformation more pronouncedly than magnetization versus temperature measurements. Additionally, those measurements make way to the stud y of avalanche and return-point memory effects.

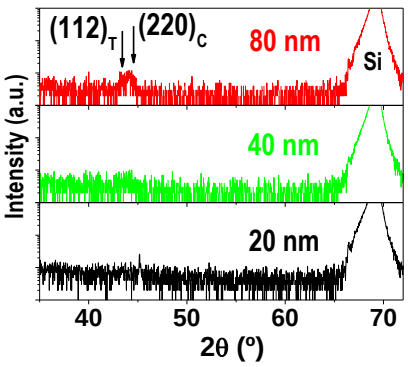

Fig. 1 *XRD diffractograms for films deposited on Si/SiO_2 substrates*

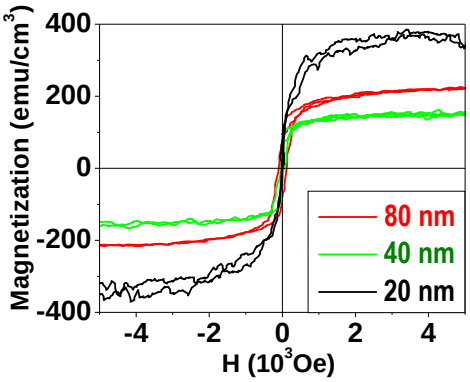

Fig. 2 *Magnetization hysteresis curves for films deposited on Si/SiO_2 substrates*

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NEW GREEN CHEMICAL STRATEGY FOR DIRECT SYNTHESIS OF $L1_0$ FEPT ALLOY FROM LAYERED PRECURSOR

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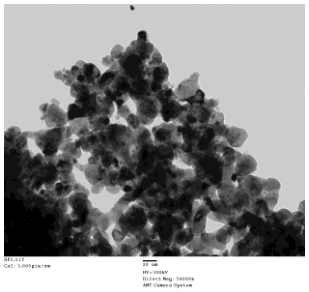
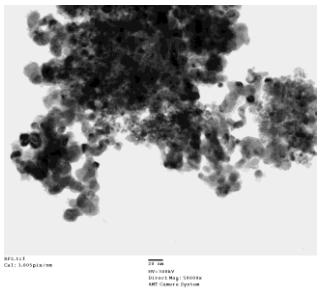
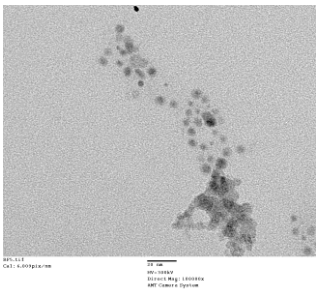
INTRODUCTION

In this work, a new green chemical strategy for the direct synthesis of $L1_0$ FePt alloy nanoparticles is reported. The starting material is a polycrystalline molecular complex ($Fe(H_2O)_6PtCl_6$) [1-3], in which Fe and Pt atoms are arranged on alternating planes, like in the $L1_0$ structure. The starting compound was milled with crystalline NaCl to get nanocrystals. The reduction of such composite, in the nanocrystalline form, under 5 % H_2 and 95 % Ar at 400 °C with a heating rate of 5 °C/min, led directly to a highly ordered $L1_0$ phase without using metals additives. After the reduction the mixture was washed with water to remove the NaCl and $L1_0$ FePt nanoparticles were obtained without using organic solvents. Our investigations demonstrate that the method is able to produce $L1_0$ nanoparticles with average size dependent on the fraction of ($Fe(H_2O)_6PtCl_6$) (see Figure, bar 20nm) with respect to NaCl, as shown by TEM and HRTM measurements. The XRD pattern shows the presence of characteristic peaks of the fct phases. The hysteresis loop, measured at room temperature, shows a high coercivity, as expected for the high anisotropy $L1_0$ phase. The method has the following advantages with respect to others wet chemical synthesis to prepare $L1_0$ FePt nanoparticles: it works at temperatures much lower than those reported in the literature and without metal additives; it does not use organic solvent and it is one pot; it leads to a highly ordered $L1_0$ phase.







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OPTICAL AND MAGNETO-OPTICAL SPECTROSCOPY OF $Mn_2Rh_xCo_{1-x}Sn$ HEUSLER COMPOUNDS

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Heusler compounds are well-known as exceptionally tunable materials. They have received considerable attention due to their high Curie temperature and high spin polarization [1], which makes them good candidates for applications in novel spintronic devices. Furthermore, their predictable electronic and magnetic structures allow for appropriate tuning of their properties by suitable element substitution. In addition to the well-known cubic Heusler compounds, tetragonally distorted Heusler compounds are receiving increased interest due to spin transfer torque applications.

In this work, we present a systematic study of magneto-optical (MO) properties of $Mn_2Rh_xCo_{1-x}Sn$ Heusler compounds by means of Kerr MO spectroscopy. The samples with x varying from 0.3 to 1 were prepared by repeated arc melting of stoichiometric amounts of high-purity elements in argon atmosphere. MO Kerr spectroscopy was carried out in polar and longitudinal configurations using azimuth modulation technique. Experimental data were confronted with ab-initio calculations based on density functional theory employing the full-potential linearized augmented plane wave method.

This work was supported by Grant Agency of Czech Republic (grant no. 13-30397S).

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ANISOTROPIC MAGNETOCALORIC EFFECT IN $DYAL_2$ MEASURED BY SAMPLE ROTATION

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ABSTRACT

The anisotropic magnetocaloric effect (AMCE) has recently attracted more attention because it can be an alternative method to the usual MCE[1][2]. In this work we describe a system that allows direct measurements of the heat flow variation as a function of the angle between the external magnetic field and the crystallographic axis of a single crystalline sample. We realized experiments on single crystals of $DyAl_2$, carefully prepared by the Czochralski method, and the results were compared to the literature theoretical calculations[3][4] and analyzed in terms of the released magnetic anisotropy.

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HIGH PRECISION GENERALIZED MAGNETO-OPTICAL ELLIPSOMETRY

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INTRODUCTION

Generalized magneto-optical ellipsometry (GME) [1] has emerged as a powerful tool to obtain optical and magneto-optical constants of magnetic materials with a very high degree of precision. This non-invasive characterization method has been also successfully applied to the study of magneto-optical coupling in ferromagnetic films [2] the study of spin-polarized electronic states in multiferroic materials [3] or to determine the field dependent magnetization orientation via 3-dimensional [4] vector magnetometry.

METHODS

In this work we studied theoretical and experimentally (Figure 1) the error propagation due to the angle of the light incidence angle on the refractive index N and the magneto-optical coupling constant Q.

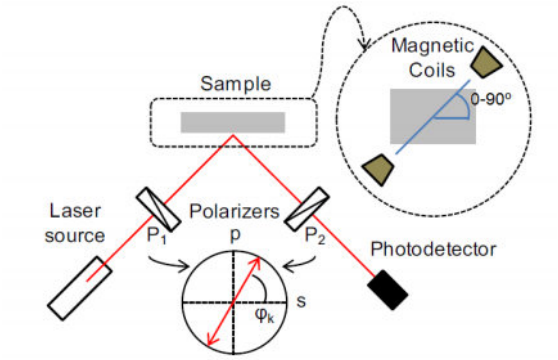

Figure 1: Scheme of the GME experimental setup

RESULTS AND DISCUSSION

In order to optimize the accuracy of the constants N and Q is better to use a light incidence angle above 40 degrees. Under 25 degrees GME is impracticable.

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AKNOWNLEDGEMENTS

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SPECTRA OF SECOND ORDER PERMITTIVITY COEFFICIENTS IN CUBIC Fe, Co AND Ni EMERGING FROM SYMMETRY ARGUMENTS

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Using ab-initio calculations, we determine spectra of the second-order magneto-optical permittivity coefficients (G_{44} , ΔG) for ferromagnetic bcc Fe, fcc Ni and fcc Co. Those second-order magneto-optical permittivity coefficients provide phenomenological description of all second-order magneto-transport effect (and its anisotropy), such as anisotropy magnetoresistance, quadratic magneto-optical Kerr effect, X-ray magnetic linear dichroism, magneto-reflectivity, etc. depending on the investigation technique and the energy of the probing photon (zero photon energy means dc). The calculations of the conductivity/permittivity tensor elements are done within the framework of Density functional theory using general magnetic orientation with respect to the crystal axis. Then, dependence of the ab-initio permittivity elements on general magnetization orientation is compared with expected dependences from phenomenological model including coefficients G_{44} , ΔG based on symmetry arguments.

Financial support of the EU project Nanotechnology– the basis for international cooperation project (CZ.1.07/2.3.00/20.0074) is greatly acknowledged.

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SPINODAL DECOMPOSITION IN BULK Fe_2NiAl ALLOY DURING COOLING AT A CRITICAL RATE

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Fe_2NiAl-based alloys are known as hard magnetic materials whose coercive force is $H_c \approx 700$ Oe. Upon cooling below the solubility curve, a solid solution decomposes to a mixture of two isomorphic cubic phases $\beta \rightarrow \beta+\beta_2$. The maximum coercive force H_c achieved upon intermediate decomposition stage is related to the nonequilibrium microstructure, which is formed upon cooling of solid solution at a critical rate (heat treatment HT1), or during aging of homogeneous solid solution (HT2). The H_c value reached after HT1 is higher than that reached after HT2 by a factor of 1.5.

In this study, the spinodal decomposition $\beta \rightarrow \beta+\beta_2$ has been investigated for bulk Fe_2NiAl samples, which were cooled at the critical rate V = 4°/s from 1200°C to an intermediate temperature T_q and subsequently water-quenching to RT. The coercive force was found to exhibit a nonmonotonic dependence on the temperature T_q; the minimum H_c was found at $T_q = 850$°C.

X-ray studies reveal no changes in the profile and positions of diffraction lines in X-ray patterns for samples prepared by quenching from1200°C or cooling at a critical rate. TEM showed a decrease in the size of elongated β-precipitates with decreasing T_q temperature. After cooling to $T_q = 850$°C, isotropic spherical β-phase particles are formed. The contact of these particles with each other leads to the loss of single-domain size and simplification of magnetization reversal.

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NANO PARTICLE SIZE OR THE CHEMICAL PRESSURE IS THE CAUSE OF SPIN FLUCTUATION

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INTRODUCTION

Since the only parameters which determine the magnetic behavior of iso structure of Gd_3T (T=Ni , Rh, Pd) are the density and the nature of conduction electron where the exchange correlation energy and the fluctuation range of s-d are considered. The lattice constant, AC susceptibility and electrical resistivity measurement as well as the approximation calculation of GGA and LSDA by the Wien2k package program in which the fallowing character can be suggested; 1- strong spin fluctuation witch could be the cause of some changes in volume. 2- performance of additional polarization of conduction electron and modification of band structure on which the mechanical deformation leads to distortion of the lattice .3- the Ac susceptibility manifest abroad shouldering order where the phase transition is found to be as a mixture of transitions at low magnetic field. The mixture of two ordering transition can be due to the strength of band width which is the cause of chemical pressure of spin fluctuation in temperature dependence of ρ(t).

A large difference in the values of ordering temperature for Gd_3Pd in the iso structure crystal of Gd_3T is still a puzzle.

EQUATIONS

If you want to include equations, use the “equation” style for that paragraph and use the “math profile”. Use the MS-word equation editor, with defaults to “times new roman” and symbol “fonts.

$$F=mx\alpha \qquad [1]$$

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HOW THE ATOMIC DISPLACEMENT CAN BE DUE TO THE INDUCED SPIN POLARIZATION

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INTRODUCTION

Since the heat formation of the binary intermetallic compound of Gd_xBi_y is strongly functional the percentage of Gd magnetic ion, the character of nature of conduction electron as well as the band function should be considered. The decreasing of the heat formation by increasing of the magnetic ion is expected to be due to the induced spin polarization of the conduction band by magnetic ion defined by . Where the heat formation and the magnetic character are considerable through the

1) The energy difference of where the character of conduction electron could b s or d-like.
2) The population of the fluctuation of the electrons in the valance and conduction band named inter band mixing which can stabilize the structure or a closely related structure.

But the variety of magnetic properties and its effect on crystal structure, among Gd-Bi (where the Bi is a non-metal magnet) seems to be related to electronic structure close to the Fermi level rather than simply the number of conduction electrons which is the basic parameter in the RKKY indirect exchange model. Consequently because of the strength of exchange interaction, the nature of conduction electron could be d-like or even of the 5d-state. The 5d-state is believed to be band-like which takes part in chemical bonding and thus could be the main source of; the excess (or even reduction) of effective magnetic moment in some Gd-compounds.

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MECHANOCHEMICAL SYNTHESIS OF MnBi NANOPARTICLES FOR RARE-EARTH-FREE NANOCOMPOSITE PERMANENT MAGNETS

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Recent research on magnets is focused on the development of rare-earth-free permanent magnets (REFPM) due to rare-earth metal crisis and high cost. However, single phase REFPMs offer lower energy product as compared to the rare-earth magnets [1]. The energy product of REFPMs can be further enhanced based on exchange coupled hard/soft nanocomposites [2]. In our lab, the latest efforts are focused on the bottom-up fabrication of these nanocomposites which requires hard magnetic nanoparticles with high coercivity. In this work, we report, for the first time, the synthesis of MnBi nanoparticles by mechanochemical process with a size in the range of 100-300 nm having high coercivity in the range of 12-18 kOe. The effect of excess CaO dispersant and heat treatment on the phase formation, particle size and magnetic properties are currently being investigated and will be reported.

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SPIN GLASS STATE AND ITS MAGNETIC PROPERTIES: STRUCTURE, SYMMETRY GROUP AND THE TEMPERATURE DEPENDENCE OF SUSCEPTIBILITY

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Abstract

The fibre bundle approach has been applied to the unified description of all the magnetic structures and their symmetry groups [1-3]. On this basis the explicit formulas describing both the variety of magnetic structures and their symmetry groups have been derived. In the particular case of the spin glass state the global magnetic coupling constant has been interpreted as a section of the corresponding fibre bundle [4]. The fibre of this bundle makes the space of the Gaussian distribution. Thus one can say that the randomness of the distribution of the magnetization vectors in the spin glass state is of the Gaussian-like character. An observation was made that another kind of the fibre bundle sections make the magnetic moments situated on the separate atoms multiplied by a certain Gaussian factor defined in R^3, the last factor making the problem continuous and more physical. The magnetic symmetry group of spin glass state turned out to be *SO(2).* The constant behavior of susceptibility of spin glass state as a function of temperature at the regime of heating at a nonzero external magnetic field corresponds to the gradual degeneration (to the Dirac delta function) of the Gaussian distribution of the magnetization vector. On the other hand the identical behavior of susceptibility at the regime of cooling at the same magnetic field happens with the gradual recovery of this Gaussian distribution with no hysteresis. In the case of a zero magnetic field the susceptibility increases with the increase of temperature up to a certain maximum value, which makes a kind of a peak, and then it decreases in a normal way. In both cases, i.e. for nonzero and zero external magnetic fields an internal spontaneous magnetic field indispensable for stability of the spin glass state in a sample plays an essential role [5]. The latter effect will be discussed in the paper.

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YTTRIUM SUBSTITUTION IN La-Ba MANGANITES

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We examine the effect of average cation radius at the A site of the perovskite structure on the structural, magnetic and magnetocaloric properties of barium doped lanthanum manganites. The A site cation radius is varied by partially replacing La^{+3} ions by smaller Y^{+3} ions in the parent compound, for x up to 50%, in a nominal formula $(La_{1-x}Y_x)_{0.7}Ba_{0.3}MnO_3$. The barium doping level and thus the ratio $Mn^{+4}/(Mn^{+3}+Mn^{+4})$ was kept constant at 30%. When the level of substitution is low, samples are single phase with a distorted perovskite structure. At higher levels a second hexagonal phase is observed.

All samples exhibit a ferromagnetic to paramagnetic transition. Transition temperature decreases with the percentage x of substitution. Arrott – Belov plots show that all samples follow the behavior expected for a conventional second order transition. The magnetic entropy change has been determined using isothermal magnetization curves in the vicinity of Curie temperature. The Landau theory of second order phase transition was applied to all samples in order to explain the observed temperature dependence of ΔS_M. For sample with x=25%, $La_{0.525}Y_{0.175}$ $Ba_{0.3}MnO_3$, T_c =271K and = 1.66 $Jkg^{-1}K^{-1}$ in a field change of 2 T, compared to unsubstituted $La_{0.7}Ba_{0.3}MnO_3$ with T_c =319K and = 2.61 $Jkg^{-1}K^{-1}$.

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PREPARATION AND MAGNETIC PROPERTIES OF THE COMPOSITE MATERIAL BASED ON FeCuNbSiB/RESIN

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Soft magnetic composites is well known group of materials for applications as cores (in transformers, electromotors and electromagnetic circuits, sensors and induction field coils) with three dimensional isotropic ferromagnetic behaviour with an ambition to replace electrical steel sheets or ferrites.

The composite material was based on soft magnetic powder and hybrid phenol-formaldehyde resin chemically modified by SiO_2 nanoparticles. Coated powder was compacted at 800 MPa into a ring shape. Complex permeability spectra were measured with an impedance analyzer. The DC magnetic properties were obtained by a fluxmeter based DC loop tracer. The AC hysteresis loops (1 kHz – 100 kHz) were measured at the maximum flux density of 0.1 T. The specific electrical resistivity was measured by the 4 point technique.

The aim of this work was to investigate the magnetic properties of $Fe_{73.5}Cu_1Nb_3Si_{15.5}B_7$ /resin composite to extend possibilities for application of this kind of material in the form of the ring at higher frequency. Permeability and core loss are structure sensitive and depend on factors such as powder size and shape, porosity, and specific electrical resistivity.

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MICROSTRUCTURE AND MAGNETIC PROPERTIES OF $Pr_3(CoFeCu)_{28.5}Ti_{0.5}B_5$/ $Pr_3(CoFeCu)_{27.5}Ti_{1.5}$ NANOCOMPOSITES MAGNETS

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Introduction. Nanocomposite RE-Fe-B permanent magnets have attracted extensive attention in the last years due to their enhanced magnetic performances and potential applications [1]. In this work, we present our results on the microstructure and magnetic properties of nanocomposite magnets prepared from ball-milled powders of RE-based melt-spun ribbons.

Experimental. $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{27.5}Ti_{1.5}$ and $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{28.5}Ti_{0.5}B_5$ alloys have been produced by melt-spinning followed by heat treatment. Powders prepared from these ribbons have been mixed in different weight ratios of 9:1, 8.:2 and 7:3 and pressed at RT making small discs, which were isothermally annealed in the temperature range 650–950^0 C.

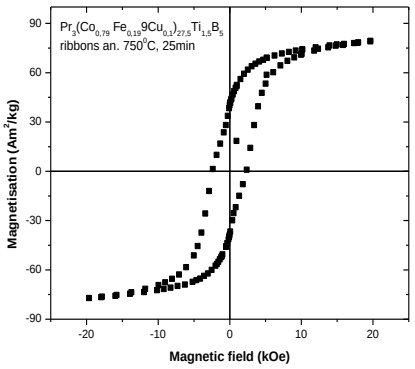

Figure 1. Hysteresis loop of $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{28.5}Ti_{0.5}B_5$

Results and discussions. XRD patterns of $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{27.5}Ti_{1.5}$ melt-spun ribbons indicate that the main phase is that of $TbCu_7$ type and a amorphous phase. XRD pattern of $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{28.5}Ti_{0.5}B_5$ as-spun ribbons shows broad peaks which are characteristic of an amorphous material and the main phase is that of $Nd_2Fe_{14}B$ type of structure. Increasing the annealing temperature or time leads to smaller coercivity values (Fig.1). In addition, the melt spun ribbons were separately mechanically milled for a period of time ranging from 10 min to 4 h. Detailed results on the microstructure of $Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{27.5}Ti_{1.5}$ /$Pr_3(Co_{0.71}Fe_{0.19}Cu_{0.1})_{28.5}Ti_{0.5}B_5$ nanocomposite magnets and the correlation between the magnetic properties and the grains size will be presented.

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PRODUCTION OF CRACK-FREE HOT–DEFORMED NANOCRYSTALLINE NdFeB-type MAGNETS

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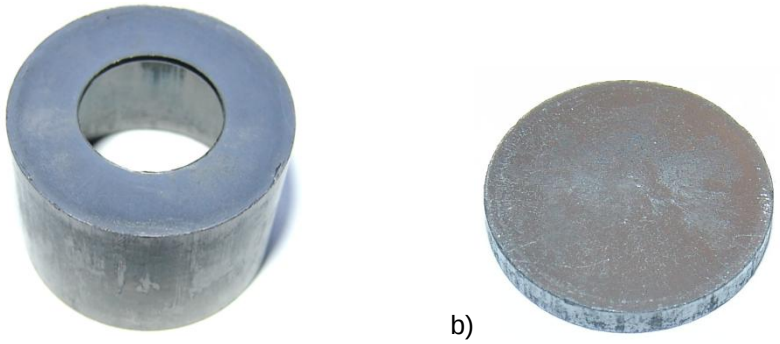
INTRODUCTION

Radially oriented ring magnets with excellent magnetic properties can be prepared by backward-extrusion [1]. However the first extruded portion shows mechanical cracking and needs to be removed what leads to material waste [2]. Our pressing equipment has been modified in order to exert a back pressure during backward extrusion, leading to the crack-free production of radially oriented ring magnets (see figure 1a), without detrimental influence on magnetic properties. Micrographs on polished cross-sections demonstrate overall good alignment of elongated platelet shaped grains with radially oriented c-axis in most parts of the ring which coincide with a remanence B_r=1.3 T and coercivity $\mu_0 H_c$=1.6 T. Further, die upsetting has been optimized for different deformation degrees in such a way, that material flow reaches the wall of the die cavity at the end of the process. Thus, crack–free, mechanically and magnetically homogenous, axially oriented tablet-shaped magnets could be prepared as shown in figure 1b. Magnetic properties are comparable to the extruded ring magnets and to those reported previously [3].

FIGURES AND TABLES



a) b)

Fig. 1. The presented technique leads to smooth, crack-free: a) backward – extruded b) die – upset Nd – Fe – B magnets.

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GIANT ANISOTROPIC MAGNETOCALORIC EFFECT IN DYBI SINGLE-CRYSTAL

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ABSTRACT

In this work, we present the results on the anisotropic magnetocaloric properties of the DyBi single-crystals. This system crystallize with the NaCl-type cubic structure and present an antiferromagnetic ordering with a Neel Temperature of 10K[1]. The application of magnetic field induces a metamagnetic transition, and the critical magnetic field (Hc) depends on the crystallographic direction. The Hc occurs in 32kOe (at T = 2K) for the direction <110>, while in the direction <100> the metamagnetic transitions occurs at two levels (with Hc = 46 kOe and 65kOe) and the magnetic moment reaches 9.3μ_B (close to the value of the free ion 10μB), well above the values of 6.7 μ_B for <110> axis. The isothermal entropy change was evaluated by magnetization measurements for magnetic fields applied parallel to the <100> and <110> axis. The results obtained for μ_0H =5, 6 and 7T (figure 1), show that for the both directions there is negative and positive peaks in entropy change, as a consequence of the metamagnetic transitions[2,3]. The anisotropic MCE was calculated by taking the difference of these two curves[4]. The anisotropic EMC is similar than conventional MCE evaluated to the easy axis (<100>) (figure 2). The results show that by exploring anisotropic properties of the materials it is also possible to obtain a significant MCE. From a technological point of view, this can be an interesting alternative because the MCE could be produced just by rotating the magnetic material under a constant magnetic field.

FIGURES

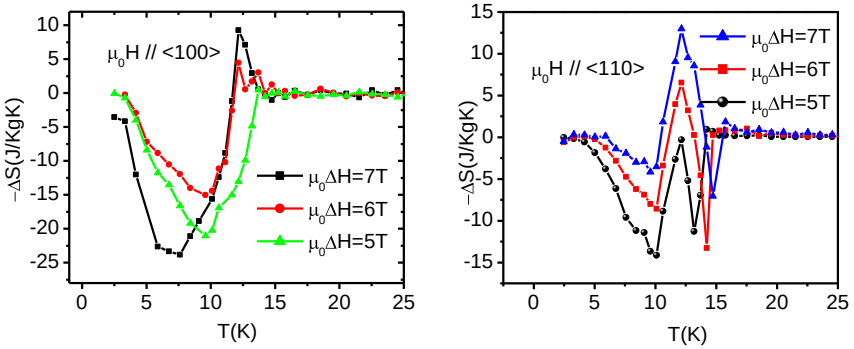

Figure 1- Isothermal magnetic entropy change (-ΔS) as a function of temperature, obtained to DyBi at μ_0ΔH= 5T, 6T and 7T

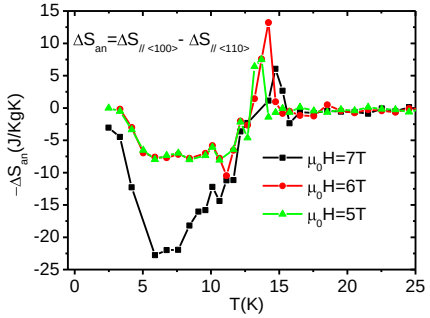

Figure 2- Isothermal anisotropic magnetic entropy change (-ΔS_{an}) as a function of temperature, obtained for DyBi at μ_0ΔH= 5T, 6T and 7T

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SYNTHESIS AND CHARACTERISATION OF $Fe/Mn_{0.5}Ni_{0.5}Fe_2O_4$ PSEUDO CORE-SHELL TYPE COMPOSITE POWDER

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Pseudo core-shell composite powder of $Fe/Mn_{0.5}Ni_{0.5}Fe_2O_4$ type was obtained by milling/mixing and subsequent annealing treatment of elemental iron powder and nanocrystalline/nanosized mixed manganese-nickel ferrite. The nanocrystalline/nanosized mixed manganese-nickel ferrite was synthesized by ceramic route and mechanical milling. The nanocomposite powder is of pseudo core-shell type. The iron particles are covered by a thin layer of nanocrystalline/nanosized ferrite particles. The present study follows the chemical homogeneity, particles size distribution, structural, morphological and magnetic properties of $Fe/Mn_{0.5}Ni_{0.5}Fe_2O_4$ composite. The addition of iron to the manganese-nickel mixed ferrite lead to a significant increase of the material spontaneous magnetization. The influence of each step of the synthesis route on the nanocomposite magnetic properties is evidenced and discussed. The annealing leads to the changes of the magnetization of the nanocomposite powder as a result of cations reordering in the spinel structure and due to the interdiffusion phenomena at the interface. Saturation induction and electrical resistivity show a good compromise between the properties of the composite constituent phases.

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FIELD INDUCED BIREFRINGENCE IN FERROFLUIDS BASED ON NANOPARTICLES OF ZN/MN MIXED FERRITE

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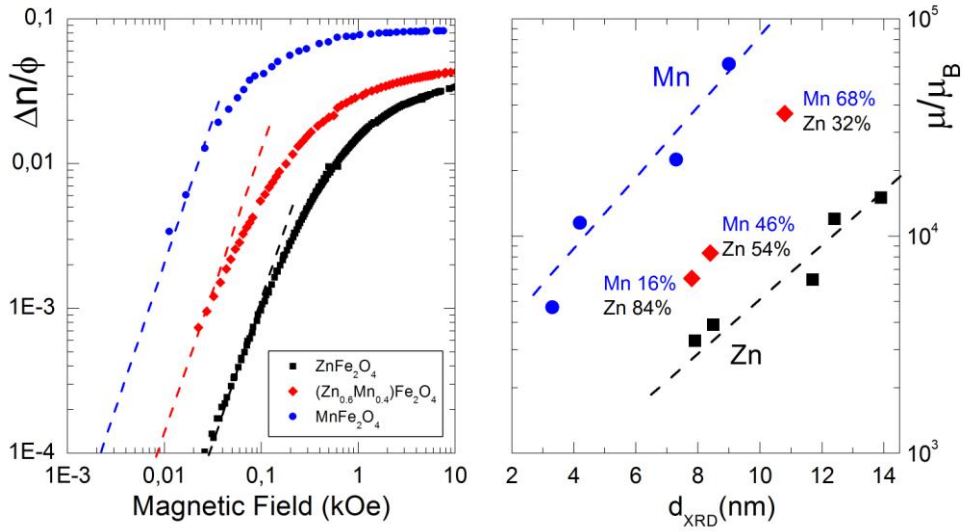
Magnetic fluids based on mixed ferrite $Zn_xMn_{1-x}Fe_2O_4$ are promising materials for heat exchange applications. Such colloidal dispersions are synthesized following a hydrothermal coprecipitation method described in [1]. Core-shell nanoparticles prepared in this way with a core of $Zn_xMn_{1-x}Fe_2O_4$ and a thin maghemite protecting shell are optically anisotropic [2]. Thanks to their rotational degrees of freedom in the fluid carrier, the nanoparticles progressively orient along applied field. It provides the dispersion with a strong magneto-optical birefringence Δn proportional to the nanoparticle concentration Φ. A Langevin formalism well describes it [3]. In figure left, we compare the field-dependent birefringence of three dispersions at x=0, 0.6 and 1 for comparable Debye-Scherrer diameter $d_{XR} \approx 8.5$nm. Figure right shows the obtained progression of the reduced nanoparticle magnetic moment μ/μ_B (μ_B : Bohr magneton) deduced from Langevin adjustment of Δn as a function of d_{RX} for various dispersions based on $MnFe_2O_4$, $ZnFe_2O_4$ and $Zn_xMn_{1-x}Fe_2O_4$ (at x=0.3, 0.6, 0.9).



Left – Field dependence of reduced birefringence $\Delta n/\Phi$ at $d_{XR} \approx 8.5$nm; Right : μ/μ_B versus d_{XR} for dispersions of various materials.

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MAGNETO-STRUCTURAL STUDIES OF THE $MN_{1.15}FE_{0.85}P_{1-X}GE_X$ COMPOUNDS PREPARED BY ARC MELTING

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The series of $Mn_{1.15}Fe_{0.85}P_{1-x}Ge_x$ compounds, with x between 0.23 and 0.32, were prepared by arc melting technique and subsequent homogenization process. Calorimetric and magnetization results show that the temperature values of structural phase transition and Curie temperatures coexist and cover the temperature range from 270 to 355K. The magnetic entropy change reaches the maximum value for the compound with x = 0.28 and equals to 32 J/kgK for the magnetic field change of 5 T. Additionally, the adiabatic temperature change for the same sample was measured using magneto-calorimeter, and it equals to 1.3 K for the magnetic field change of 1.7 T. On the other hand, thermal hysteresis of the M-T and DSC curves around the transition temperature upon heating and cooling is 3-5K for various P/Ge atomic ratios.

Acknowledgements

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GAINT MAGNETOCALORIC EFFECT IN MULTIFERROIC $RMnO_3$ (R=Dy, Tb, Ho and Yb)

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ABSTRACT

We have investigated the magnetic properties and magnetocaloric effect (MCE) in multiferroic $RMnO_3$ (R=Dy, Tb, Ho and Yb) single crystals. Above a critical magnetic field(H_c), $RMnO_3$ undergo a first-order antiferromagnetic (AFM) to ferromagnetic (FM) transition below the ordering temperature (T_R^N) of R^{3+} moment and a second-order FM to paramagnetic (PM) transition above T_R^N. Both H and T dependence of magnetization shows that the system is highly anisotropic in the FM as well as PM states and, as a result, the magnetic entropy change (ΔS_M) is extremely sensitive to the direction of applied field and can be negative (normal MCE) or positive (inverse MCE)[1]. For hexagonal $HoMnO_3$ and $YbMnO_3$ systems, a very small inverse MCE is observed only for H parallel to c axis and it decreases with increasing H and crosses over to normal one above H_c. On the other hand, for orthorhombic $DyMnO_3$ and $TbMnO_3$, though the inverse MCE disappears above H_c along b axis, it increases rapidly with H along a axis for $T<T_R^N$. Except for $YbMnO_3$, ΔS_M, relative cooling power and adiabatic temperature change along easy-axis of magnetization are quite large in the field-induced FM state for a moderate field strength. The large values of these parameters, together with negligible hysteresis, suggest that the multiferroic manganites could be potential materials for magnetic refrigeration in the low-temperature region.

In order to compare and contrast the nature of MCE among multiferroic manganites, the variation of ΔS_M^{max}, ΔT_{ad}^{max} and RCP for H||e have been plotted in Fig.1

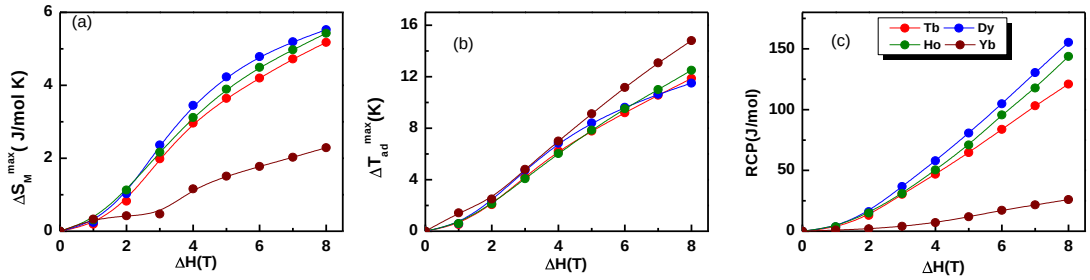

Fig. 1. The maximum of magnetic entropy change (a), maximum adiabatic temperature change (b) and relative cooling power (c) as a function of field for $RMnO_3$ crystals with H parallel to easy axis

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SPONTANEOUS GENERATION OF VOLTAGE IN $PR_{1-X}CA_XMNO_3$ (X = 0.33; 0.4) SINGLE CRYSTALS

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The strong interaction of the electron, spin and lattice subsystems leads to a number of unique properties of manganites of rare earth metals, in particular, colossal magnetoresistance, giant volume magnetostriction, magnetocaloric effect etc. Recently, a new phenomenon – spontaneous generation of voltage (SGV) has been discovered in this type of materials [1]. In this work SGV has been found in $Pr_{1-x}Ca_xMnO_3$ (x = 0.33, 0.4) single crystals. The magnetic and electrical properties of these compounds have been studied and relationship with the structure have been analyzed.

The structure of $Pr_{1-x}Ca_xMnO_3$ (x = 0.33; 0.4) at room temperature has an orthorhombic *Pbnm* space group. It is known that, unlike most of the manganites, in $Pr_{1-x}Ca_xMnO_3$ the ferromagnetic metallic phase is absent. In the concentration range $0.3<x<0.5$ an inhomogeneous magnetic insulating ground state takes place. In this case the ferromagnetic phase coexists with the charge- and orbital-ordered antiferromagnetic phase of the CE-type. The latter has its own characteristics and its structure is described by the $P2_1nm$ space group without inversion center [2, 3].

Analysis of the field and temperature dependences of the magnetization shows that a sharp increase of magnetization occurs upon approaching the critical field H_C. It is associated with the transition of the charge-ordered phase in the ferromagnetic state. Charge and orbital ordering occurs at T_{CO} = 240 and 225 K, the antiferromagnetic ordering at T_N = 174 and 125 K for x = 0.4 and 0.33 respectively. Below T_N the difference between ZFC and FC-magnetizations has been observed, which indicates the presence of ferromagnetic clusters in this temperature range. SGV has been detected in the temperature range 80 (the lowest temperature at which the measurements were performed) – 300 K. In the temperature range 300 K – T_{CO} voltage is low (–10 μV) and practically does not changes with decreasing temperature. Then it begins to increase (in the range of $T_{CO} - T_N$) and changes sign at around 200 K. The voltage increases exponentially starting from temperature slightly lower T_N and at 80 K reaches very high values ~100 mV (in the plane *ab*) and ~10 mV (along the *c*-axis). The magnetic field affects on the magnitude of the spontaneous voltage only within the temperature range of 80 K$<T<T_{CO}$. Voltage decreases when a field is applied in the temperature range $80<T<120$ K and increases in the range 120 K$<T<T_{CO}$.

We consider the possible mechanisms of SGV emergence and their connection with crystal structure properties.

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NUMERICAL ANALYSIS AND SIMULATION DESIGN OF A MAGNETORHEOLOGICAL BRAKE SYSTEM

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INTRODUCTION

Conventional hydraulic brake systems are widely used in commercial vehicles. However, they present some drawbacks such as time delay in pressure build up and poor breaking performance at high speeds [1]. The magnetorheological brake (MRB) is a pure electrically controlled actuator and has the potential to further reduce breaking time, easy implementation of a new controller or existing controllers (e.g. ABS, VSC, EPB, etc.) and lighter overall weight since it does not require the auxiliary components used in CHBs [2].

METHOD

The design process was started with an analytical model of the MRB. Then, the MRB device was designed with a focus on magnetic circuit optimization and material selection. A finite element model of the MRB was created to simulate the steady- state magnetic flux flow within the MRB domain using COMSOL Electromagnetic Module and solve for the magnetic field intensity distribution.

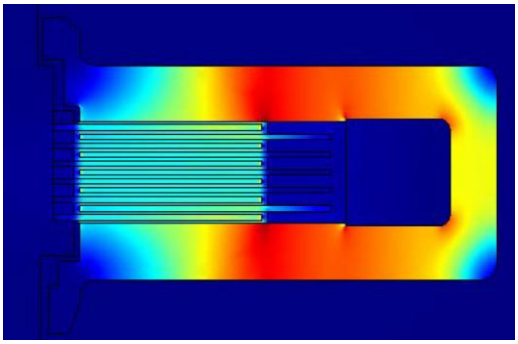

Figure 1. *Magnetic Flux Density Contour*

RESULTS AND DISCUSSION

The results showed that the braking torque increases with applied current, reaching more than 20 Nm at 1.8 A, thus confirming experimental predictions. There were discrepancies with respect to the simulation results due to estimated material properties used in the simulations.

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DIRECT MAGNETOCALORIC CHARACTERIZATION AND SIMULATION OF THERMOMAGNETIC CYCLES

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The development of new promising magnetocaloric materials for applications depends both on a deep knowledge of the system itself and on an experimental characterization able to report its real behavior in operating conditions.[1] For this reason we believe that it is necessary to go even beyond a complete magnetocaloric characterization of the materials made comparing specific heat (c_p), Δs_T and ΔT_{ad} values separately measured.[2,3,4]
Here we present a new step concerning the characterization of the magnetocaloric effect (MCE).

The authors describe an experimental setup for the direct measurement of the MCE capable of simulating high frequency magnetothermal cycles on laboratory-scale samples (10^{-1} – 10^{-2} g).

Time and frequency dependent characterization could provide information concerning the impact of thermal transport-properties and magnetic field induced structural fatigue on the magnetocaloric behavior. Moreover such experimental techniques can report the in-field reversibility of first order magnetic phase transitions as well.

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MAGNETOSTRICTIVE POLYCRYSTALLINE Fe-Ga MELT-SPUN RIBBONS FOR ENERGY HARVESTING DEVICES

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In this work, we studied the effect of the longitudinal (LF=1.2 T) and transversal (TF=0.6 T) magnetic field annealing (T_{an}=500^{0}C; t_{an}=1 h) on magnetic and magnetoelastic properties of polycrystalline $Fe_{100-x}Ga_x$ (x = 19.5; 22.5) melt-spun ribbons (MSRs) prepared by rapid quenching to be used for energy harvesting devices.

The structure of as-quenched (AQ) MSRs consists of a mixture of disordered bcc (A2 phase) and ordered fcc Fe_3Ga (β phase). The anisotropy field decreases from 2.2 T in the AQ state to 1.5 T and 1.2 T for magnetic field annealed $Fe_{80.5}Ga_{19.5}$ and $Fe_{77.5}Ga_{22.5}$ MSRs, respectively. MOKE measurements indicate butterfly-shape hysteresis loops for TF annealing and translated hysteresis loops over y axis with 2 maxima that are approximately equal for LF annealed ribbons due to the presence of A2 and β phases with the easy axis oriented in different directions.

Magnetostriction increases with the increase of the Ga content, but the most significant increase is obtained for the TF annealed ribbons. This behavior is strongly related to the existence of internal stresses, which are the main source of anisotropy via magnetoelastic coupling, in the AQ state, which by magnetic annealing are released.

This work was supported by the MNT-ERA.NET Programme, Contract No. 7-059/2012.

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DIRECT RESEARCH OF MAGNETOCALORIC PROPERTIES OF NI-MN-IN-CO ALLOY IN HIGH MAGNETIC FIELDS

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A promising class of materials for magnetic cooling at room temperatures is that in which a first order magnetostructural phase transition (PT) is induced by the magnetic field. Recently, big interest is attracted to Ni-Mn-In-Co alloys due to large entropy change at PT and as consequence large magnetic-field-induced strains and giant inverse MCE [1,2]. The entropy change of a solid directly characterizes the cooling capacity. The problem of creation the method for measuring the cooling capacity of MCE materials in direct experiment in magnetic fields up to 140 kOe was posed. The vacuum setup with the system for direct measuring the cooling capacity and MCE-value of the sample for placing in Bitter coil was developed. As a sample was created $Ni_{43}Mn_{37.9}In_{12.1}Co_7$ alloy with austenite start temperature is 0° C. The sample was glued to a massive copper plate and the temperature was measured on copper plate when the magnetic field was turned on. As a result of experiments, the cooling capacity of sample equals 2000 J/kg in magnetic field 80 kOe.

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COMBINED MAGNETIC SUSCEPTIBILITY; HF-ESR AND ^{57}FE MÖßBAUER MEASUREMENTS ON A FERROMAGNETIC FELN SINGLE MOLECULE MAGNET

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A new family of ferromagnetically coupled ferric lanthanide clusters is reported. Their electronic and magnetic structures were studied using magnetic susceptibility, HF-EPR and ^{57}Fe Mößbauer measurements. The heteronuclear $[Fe^{III}_4Ln^{III}_2(Htea)_4(piv)_6(N_3)_4]$ (where Ln^{III} = Tb^{III}(1), Dy^{III}(2), Ho^{III}(3) Y^{III}(4), Gd^{III}(5), and Er^{III}(6); H_3tea = triethanolamine and Hpiv = pivalic acid) cyclic coordination cluster (fig. 1) [1] is built up from two azido-bridged $[Fe^{III}_2(N_3)_2(piv)_3]^+$ dimers bridged by two Ln^{III} centres. Magnetic susceptibility measurements indicate overall ferromagnetic interactions with slow relaxation of the magnetization for 1, 2 and 3 indicative of Single Molecule Magnet behaviour. The ferromagnetic interactions as well as the blocking of the inversion of the magnetization were confirmed from Mößbauer studies. HF-EPR measurements show that both the ground and first excited states are populated at variable fields up to 14T for each lanthanide.

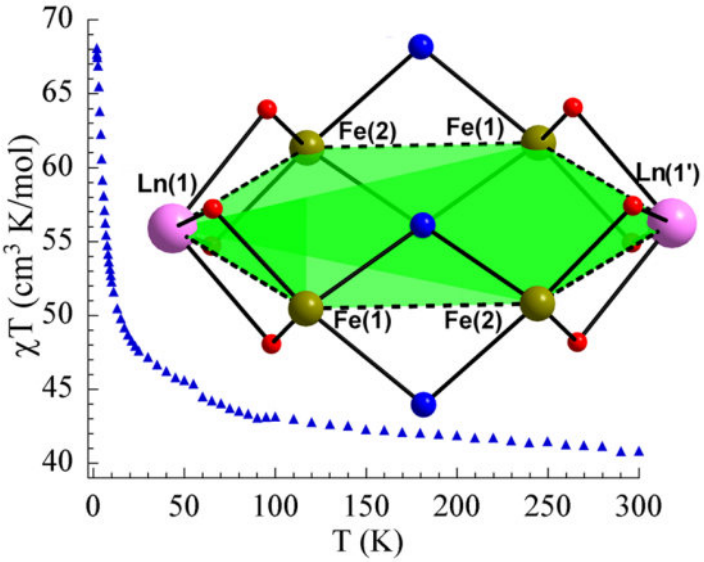

Fig. 1 Plot of χT vs T of 6 (left) and a scheme of the molecule highlighting the planar ring.

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MEASUREMENT OF DOMAIN WALL ASYMMETRY IN MAGNETIC NANOWIRES USING LORENTZ MICROSCOPY

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Thin film nanowires of permalloy are known to support transverse and vortex domain walls [1]. However, at certain dimensions the transverse walls display an asymmetry and in this paper we explore the quantitative measurement of this asymmetry using simulations and experimental Lorentz microscopy studies. Simulations were carried out using the freely available OOMMF software [2] for straight and curved nanowires. Figure 1(a) shows the magnetic structure of a transverse domain wall. The simulated Lorentz microscopy image shows the wall as bright and dark lines (Figure 1(b)). Measurement of the asymmetry is achieved by drawing a line across the wire at the wall vertex and measuring the areas of the two halves using MATLAB code (Figure 1(c)). Typical results are graphed in Figure 1 (d). The simulations show a clear trend in wall asymmetry with increasing width, in good agreement with the trend of experimental results. However, the latter are also affected by pinning sites on the nanowire edges, which can both increase and decrease domain wall asymmetry. These aspects will be described in detail.

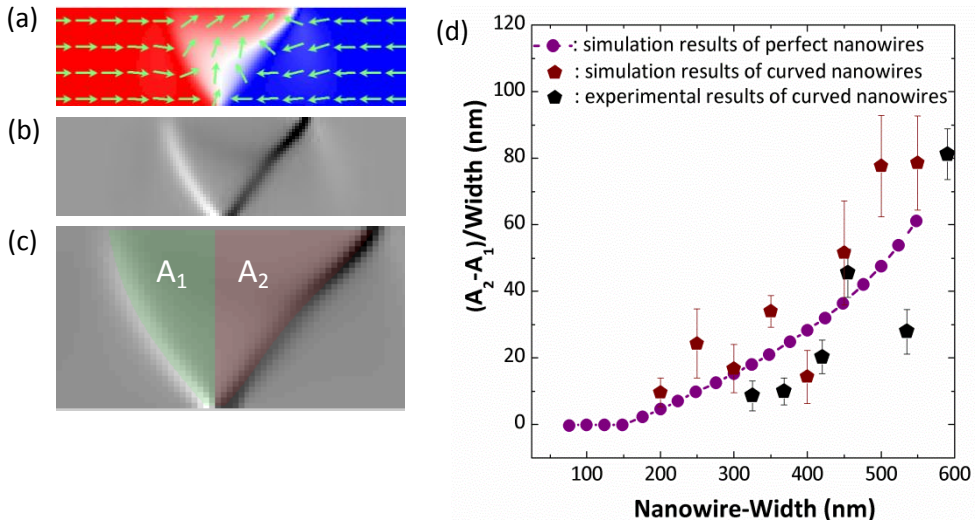

Figure 1. (a) Simulated magnetization configuration of an asymmetric transverse domain wall from a 350 nm wide nanowire. (b) Simulated Lorentz image of wall in (a). (c) Division of wall into two half areas by drawing perpendicular line from wall vertex. (d) Asymmetry measurement of walls in 10.5 nm thick nanowires for head to head domain walls.

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SUPERSPIN GLASS FREEZING IN THE FINE COBALT BASED NANOPARTICLES

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Much attention in the recent years has been focused on understanding of the superspin-glass behavior of single domain nanoparticle systems. This collective magnetic phase is represented by the slow dynamics at low temperatures and is caused by the frustration of superspins due to the interparticle interaction. Based on the analogy with atomic spin-glasses was this state in nanoparticles called as superspin-glass (SSG).

Co-based nanoparticles with different size (4 -12 nm) were prepared using chemical method. The detailed structure was studied using the methods of HRTEM, XRD, XANES and EXAFS. Magnetic measurements were performed on a commercial superconducting quantum interference device (SQUID) magnetometer over a range of temperatures (2-300K) and applied fields up to 5 T in DC and AC magnetic field.

In the presented work we have studied the existence of the superparamagnetic blocking or superspin-glass freezing process in fine cobalt based nanoparticles in dependence on the strength of magnetic interactions. We have analyzed DC and AC susceptibility data and applied on them the analysis using the Neél, Vogel-Fulcher, critical-slowing down laws and Cole-Cole diagrams. We have confirmed that the strong dipolar interactions in the nanoparticles modify the anisotropy energy barrier and yield to the glassy dynamics.

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SHAPE ANISOTROPY AND MAGNETIC DOMAIN STRUCTURE IN Co FILMS: A MAGNETIC FORCE MICROSCOPY STUDY

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INTRODUCTION

The magnetic domain structure (MDS) of Co films has been widely investigated in the last years, both theoretically and experimentally. Here, we study experimentally the MDS of polycrystalline Co monolayers by means of Magnetic Force Microscopy (MFM).

METHODS

The Co monolayers were rf-sputtered on Si [001] substrates. The MFM experiments were conducted in a Solver-Pro [NT-MDT] scanning probe microscope, with Co coated tips. All measurements were performed at room temperature in the as-deposited state of the Co films (zero magnetic field).

RESULTS

The MFM data obtained in a wide Co thickness range (d_{Co}=10-180nm) evidenced a crossover from in-plane to out-of-plane magnetization at around 50nm. Specifically, for d_{Co}<50nm large in-plane magnetic domains are observed, while for d_{Co}>50nm a stripe domain (SD) structure with out-of-plane domains is revealed. The SDs are aligned, possibly influenced by the residual magnetic fields (approximately 10-15Oe) that originate from the magnets of the sputtering gun. The width of the SD increases with d_{Co}, following a $d_{Co}^{1/3}$ law.

CONCLUSIONS

Our results agree with the literature and confirm the great impact that the MDS of Co monolayers has on more complicate hybrid trilayered structures [1].

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AKNOWLEDGMENTS

E. Aristomenopoulou acknowledges Dr D. Stamopoulos for enlightening discussions and the A.G. Leventis Foundation for a scholarship.

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MAGNETIC ORDER AND FINITE SIZE EFFECTS IN NANOSIZED DOPED FERRITE PARTICLES

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Finite-size effects dominate the magnetic properties of nanosized particles and become important as the particle size decreases, due to the increasing surface to volume ratio. We have focused on the size dependence of the magnetic properties and the surface effects of $CoFe_2O_4$ nanoparticles in the size range 2-7nm of diameter with very narrow grain size distributions. Additionally, we compared these results with nickel ferrite nanoparticles.

Ferrite nanoparticles were synthesized by high temperature decomposition of $Fe(acac)_3$ and $Co(acac)_2$ or $Ni(acac)_2$. The nanoparticle size was controlled varying the reaction temperature and the metallic precursor/surfactant ratio[1].

The characterization was performed with TEM, XRD. Magnetic properties were determined from the temperature dependence of magnetization and magnetization isotherms measurements and Mössbauer spectroscopy. The samples exhibit characteristic of a superparamagnetic system showing an increase in the blocking temperatures with the particle size. It is observed a size dependence of the ferrimagnetic order in the magnetization curves and Mössbauer spectra. Larger particles have a bulk-type magnetic ordering while the smaller ones have broken the ferrimagnetic order behaving as paramagnetic and/or superparamagnetic of small clusters, depending on temperature. The nanoparticles of 4.5nm of diameter show a mixed behavior indicating that this particle size is the crossover between the system perfectly ordered and the magnetically disorder one[2].

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MAGNETISM OF SMALL Cr EMBEDDED IN A Cu, Ag AND Au FCC MATRICES: AN AB INITIO STUDY

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We present extensive first principles density functional theory (DFT) calculations dedicated to analyze the magnetic properties of small Cr_n (n=2,3) clusters embedded in Cu fcc, Ag fcc and Au fcc matrices. We consider several dimers and trimers having different interatomic distances. In all cases the Cr atoms have been embedded as substitutional impurities in the metallic network. The cell parameters used for the calculations are Å, Å and Å, for Cu, Ag and Au. For the case of dimers immersed in Cu and Ag matrices, the lowest-energy state corresponds to the ferromagnetic Cr dimer whose interatomic distance is . For Cr dimer immersed in the Au matrix the lowest-energy state corresponds to a ferromagnetic coupling when the interatomic distances is . For the case of Cr trimer immersed in Cu and Ag matrices we have found that the lowest-energy state corresponds to the antiferromagnetic Cr trimer AF(↑,↓,↑) forming an isosceles right angle triangle whose hypotenuse and legs are, respectively, and . The lowest-energy state for the Cr trimer immersed in the Au matrix correspond to the antiferromagnetic Cr trimer AF(↑,↓,↓) forming a right angle triangle whose hypotenuse and legs measure , and .

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FMR LINE WIDTH AND EXCHANGE BIAS IN F/AF STRUCTURES AS CORRELATED WITH AF-FILM THICKNESS AND SURFACE ROUGHNESS

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Magnetic moment relaxation in ferromagnetic resonance (FMR) is well described by Landau-Lifshitz and Gilbert equation where a phenomenological damping term is introduced in addition to the precession motion, originating from intrinsic and extrinsic mechanisms of damping. Besides different types of defects, roughness is assumed to be one of the extrinsic factors which contribution to the damping increases for thin films. A possible complication for damping may come for biased ferromagnetic layers as it happens in some of bilayer ferromagnetic/antiferromagnetic (F/AF) systems.

In the report, we study FMR in NiFe(10nm)/IrMn(t) (TS) and IrMn(t)/NiFe(10nm) (BS) multilayered structures which were deposited in a magnetic field of 420 Oe using DC-magnetron sputtering. The angular dependence of FMR was measured to estimate the exchange bias field and FMR peak width to correlate them with the AF thickness, surface roughness for alternative F/AF deposition order.

It was observed that the exchange bias field and FMR peak width increase with increasing roughness for the TS and decrease for BS samples. For interpretation of these observations which look controversial at first sight, we involve a larger group of effects for mutual correlations, originating from grain size growth, compensated/uncompensated F/AF interfaces, as well as influence of exchange bias field on the damping rates in TS and BS.

This work is supported by Russian Foundation for Basic Research (contract 12-02-31541). The FMR study was performed at User Facilities Center of M.V. Lomonosov Moscow State University.

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MAGNETIC ANISOTROPY IN A SINGLE-ATOM TUNNELING JUNCTION: *AB INITIO* CALCULATIONS

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Recent years have brought significant advances in experimental and theoretical studies of magnetic adatoms on metal surfaces [1-4]. Magnetic adatoms are current focus of intensive research due to both their importance in fundamental low-dimensional physics and the potential applications in nanoscale materials and devices. In the majority of experiments properties of magnetic adatoms are investigated by a microscope and significantly depend on the microscope-adatom distance.

We present the detailed theoretical investigation of the structure, electronic and magnetic properties of a single atom magnetic junction. In particular, we use the Vienna *ab initio* simulation package for calculations [5]. Our focus is on investigation of tip adatoms interaction. We have performed calculations of the magnetic and electronic properties of 3d adatoms in the presence of tip and an external electric field. We demonstrate that magnetic anisotropy energy of the adatom above the surface significantly depend on the tip-substrate distance.

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PROXIMITY INDUCED MAGNETIZATION IN COBALT/FLUORIDE FERROMAGNET/ANTIFERROMAGNET HETEROSTRUCTURES

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Mechanisms underlying by an exchange coupling in ferromagnet-antiferromagnet (FM-AFM) systems remain unclear. In the present work, magnetic proximity effects[1] in Co/MnF_2 and Co/NiF_2 FM-AFM heterostructures (Fig.1), grown by molecular beam epitaxy, have been studied using X-ray magnetic circular dichroism (XMCD).

It was observed (Fig.2) that the magnetized Co induces a net magnetic moment at the interface of AFM at 300 K - well above $T_{Néel}$ for bulk NiF_2 (73 K) and MnF_2 (67 K). Orientation of Mn^{2+} magnetic moments in MnF_2 was found to be antiparallel with respect to Co magnetization. On the other hand Ni^{2+} magnetic moments in NiF_2 showed parallel alignment with Co. It has been demonstrated that the induced magnetization is more pronounced in AFM films with smaller crystallographic domains, as compared to the films with higher crystalline quality. The observed XMCD signal from MnF_2 layer can be accounted by magnetization of its ~0.5 monolayer (1ML=3.1nm) closest to the interface.

The XMCD measurements were carried out at the APE beamline of the ELETTRA synchrotron and BL16A beamline at the Photon Factory synchrotron.

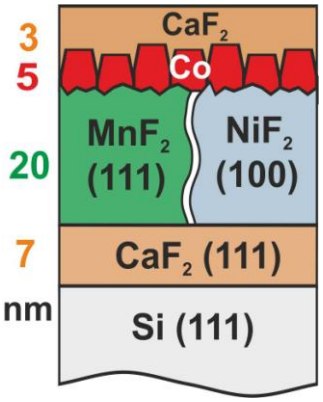

Figure 1. Composition of the FM/AFM heterostructures

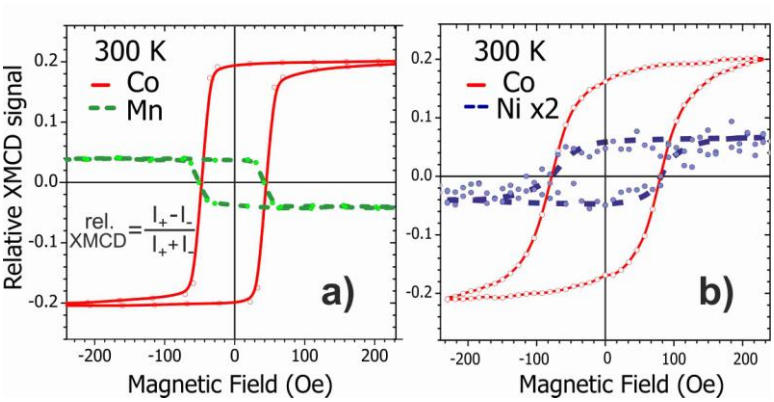

Figure 2. Element specific XMCD hysteresis curves a) Co/MnF_2 b) Co/NiF_2; I_+(I_-) denotes absorption intensity for left(right) circularly polarized light at L_3 edge

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INTERACTING SKYRMIONS AND SKYRMION-CRYSTALS

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INTRODUCTION

Skyrmions[1] were introduced in the two-dimensional Heisenberg model as a topological mapping of the spin-sphere and correspond to a soliton solution in a non-linear field. Only recently they've been experimentally found, specifically in quiral materials[2]. Actually, as a soliton, skyrmions should not interact with one another in a continuous and infinite model[3], but, experimentally, they seem to form lattices (skyrmion crystals) with fixed positions[4].

We have studied skyrmions in two-dimensional, finite and discrete, Heisenberg ferromagnet, by means of spin dynamics. We show that skyrmions and multi-skyrmion solutions are stable, although in a discrete lattice they cease to be static and non interacting solitons[5].

Small lattice sizes can affect the skyrmion energy and rotation motion, rising its natural energy. Also skyrmion-skyrmion interactions arises in this scenario. In discrete lattices skyrmions can interact with each other, differently from the continuous case, and that they have a repulsive interaction regardless their skyrmion charge or lattice size. This repulsive interaction is cylindrically symmetrical and could explain why skyrmion crystals emerges in real materials, instead of a “skyrmion gas”, as would be the non-interacting case .

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STUDY OF MAGNETIC PROPERTIES IN ANTIDOT SYSTEMS WITH DIFFERENT SIZES

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The domain structure of cobalt, permalloy and Co/Cu/Py antidot arrays (Figure 1) in a thin layer is analyzed by micromagnetic simulations. Magnetic properties of cobalt antidots thin films with different sizes have been studies by classical magnetometry techniques, micromagnetic simulations and FORC diagrams. The results show an increase in the coercive field as a function of the increase of the pore diameter. The magnetic reversal mechanism is studied by micromagnetic simulation in the OOMMF. In order to study the magnetic properties of the samples in detail we applied the first order reversal curves (FORC) technique. We can note in the FORC diagrams of the antidot arrays a progressive increase in the distribution of coercivity and interaction. The progressive increasing in the distribution of coercivity and interaction gives rise to more complex magnetic domain structures with the increasing of the diameter of the pores (labyrinth structure), which results in an increasing in the coercivity of the films. On the other hand, the increased distribution of interaction indicates that there is a stronger magnetic interaction owing to the formation of multiples domains produced by the presence of the antidots.

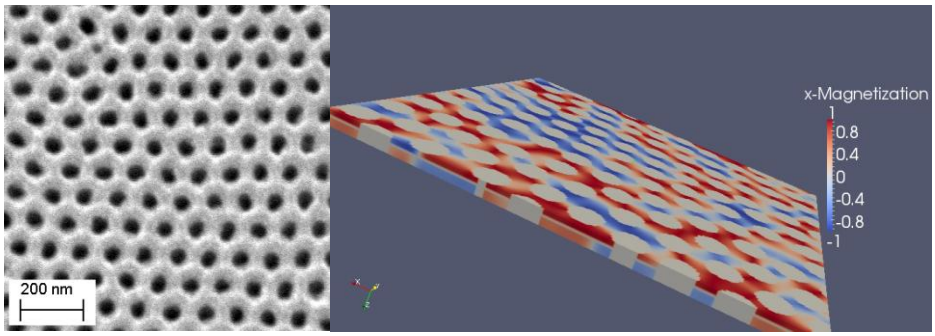

Figure 1. (left) SEM image of antidots array, and (right) micromagnetic simulation of Co/Cu/Py antidots array with a thickness of 10, 5, and 20 respectively, with 60 nm of pore diameter. The image corresponds to the coercivity state of the complete system.

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MAGNETIZATION AND FORC ANALYSIS OF HEXAGONAL COBALT PLATE-LIKE NANOPARTICLES

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Magnetic micro and nanoparticles based on Fe, Co, Ni elements have been used for specific performances in micromechanical sensor, microwave absorber, magnetic recording systems, magnetocaloric devices and others. Here, large scale and high quality of single-crystalline hexagonal cobalt nanoplates have been obtained by a simple chemical reduction method at room conditions without complex apparatus. These particles were incorporated on polyethylene matrix by a solution blending method and the structural and magnetic properties of this material have been studied by hysteresis loops, FORC analysis, and micromagnetic simulations. The results of the simulations confirm that the coercivity distribution is associated to the distribution of nanoparticle sizes and distribution of orientation of the nanoparticles with respect to the external field. After the analysis one can identify different magnetic entities that are present in the system (Figure 1). The magnetic behavior of these individual hexagons cannot be observed by macroscopic measuring techniques as their strong magnetic anisotropy and aspect ratio induce the agglomeration in packets of almost spherical form as the ones observed in the SEM image. The magnetic properties of these spherical packets of Co plates can be inferred by the measurements we performed and by the FORC diagrams.

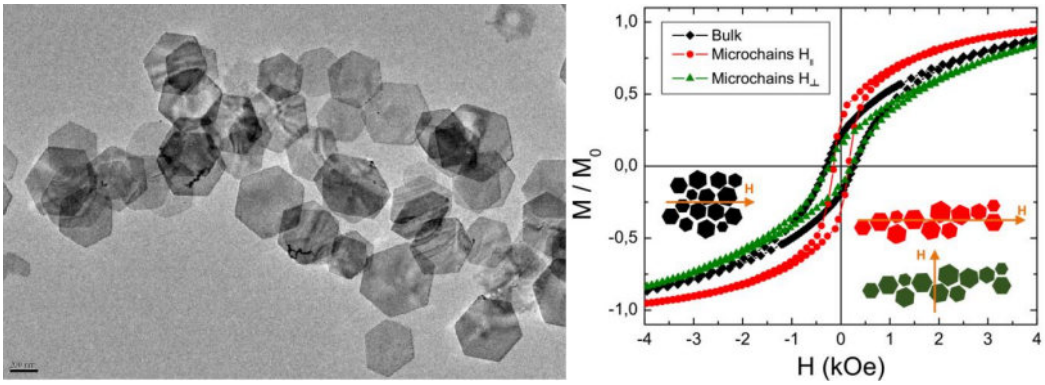

Figure 1. (left) TEM image of cobalt hexagonal nanoplates, and (right) hysteresis loops of a bulk (disordered), and microchains of hexagonal nanoplates with the external field applied parallel and perpendicular to direction of microchains.

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NOVEL THIOPHENOLATE BRIDGED POLYNUCLEAR TRANSITION-METAL COMPLEXES: SYNTHESES AND MAGNETIC PROPERTIES

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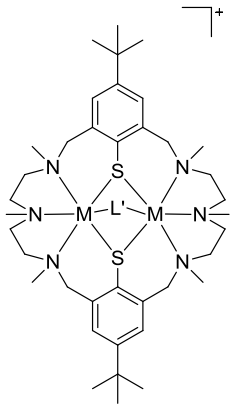
In the last decade much effort has been put in synthesis and characterization of polynuclear transition-metal thiolate complexes, due to their intriguing magnetic and electronic properties.[1] Since the polynuclear complexes of macrocyclic ligands are more stable than their acyclic counterparts and the metal ions in such complexes are fixed in close proximity, which has important implications for metal-metal interactions, we focused extensively on the preparation and characterization of dinuclear transition-metal complexes with the macrocyclic hexaaza-bis(thiophenolate) ligand H_2L^{MeN6S2} (Fig. 1).



$[M^{II}_2(\mu\text{-}L')(L^{MeN6S2})]^+$
M = Mn, Fe, Co, Ni, Zn, Cd

Figure 1: Cationic $[M^{II}_2(\mu\text{-}L')(L^{MeN6S2})]^+$ complexes.

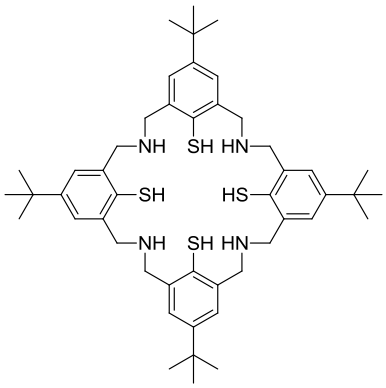


Figure 2: Novel H_4L^{N4S4} ligand.

With the help of a modular synthesis strategy we are able to vary the ring size of the macrocyclic ligand and therefore the size of the binding pocket easily, which dramatically effects on the coordination behavior.[2] A substitution of the triamine side chains of H_2L^{MeN6S2} with additional bridging thiophenolate moieties, leads to the tetraaza-tetrakis(thiophenolate) ligand H_4L^{N4S4} (Fig. 2). The introduction of additional bridging donor atoms enables the complexation of up to four transition-metal centers in close proximity to each other and bridged over a sulfur atom, which opens the door for novel magnetic molecules with high spin ground state. The synthesis and investigation of the magnetic properties of transition-metal complexes with H_4L^{N4S4} will be presented.

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SEGREGATION OF DIVALENT EUROPIUM IN MBE GROWN Eu-Fe FILMS

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The examination of formation of ordered Eu-Fe compounds and the valency of europium in MBE grown Eu-Fe films were the main point of our interest. We considered that such Eu-based materials, in which the control of the valency of Eu (and thus control the magnetic properties) would be possible, may be applied into new classes of spin-based sensors or memory devices.
In our studies [1] we demonstrated that MBE grown Eu-Fe films exhibit numbers of quaint properties: valance transition of europium, superparamagnetic behavior, anomalies in resistivity etc. Now we focused on issues related to the characteristic heterogeneity in Eu-Fe films. Formation of previously observed nano-regions with different Eu-Fe ratios will be discussed on the basis of the XRF, XPEEM and ToFSIMS studies.

This work was supported by the NSF grant DMR0907053 and by the SPINLAB project financed by the EU European Regional Development Fund.

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SIZE DISTRIBUTION OF FeNiB NANOPARTICLES

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Two compounds of FeNiB nanoparticles were prepared by chemical reduction of metallic salts, one without coating and one with a sheath of SiO_2 around the FeNiB grains. The microstructure was investigated by X-ray and TEM and the magnetic behaviour by SQUID and VSM. Due to differences in nanostructure of the powders, somewhat different magnetic behaviour between the two types of powders appears. Whereas superparamagnetic fluctuations are present above 150 K for the coated particles, blocking of magnetic moments is found up to room temperature for the uncoated ones.

In this work we report on the determination of the particle size distribution from the magnetic measurements by two methods: first, from temperature dependence of the ZFC curves, and second by analysis of the time dependence of magnetization. The results are compared to the grain size distributions obtained from the TEM investigations. This comparison allows the determination of the effective anisotropy constants, which appears to be strongly different for the two types of samples.

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INFLUENCE OF TEMPERATURE ON THE INTERLAYER EXCHANGE COUPLING IN Fe-Ni/Tb-Co AND Co/Tb-Co BILAYERS

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Thin magnetic films containing exchange coupled layers of materials with ferromagnetic and antiferromagnetic ordering are of interest due to the possibility of its application in spintronics [1]. Amorphous ferrimagnetic Tb-Co with strong in-plane magnetic anisotropy can be used rather than traditional Fe-Mn antiferromagnetic in order to increase interlayer exchange coupling intensity and potentially improve the temperature stability. In this work we investigated the temperature behavior of the exchange bias field and coercivity of the ferromagnetic layer in Me/Tb-Co (Me=Fe-Ni, Co) bilayers.

Samples Me(50 nm)/Tb-Co(110 nm) were prepared by magnetron sputtering; magnetic anisotropy of the Tb-Co layer was induced by application of the uniform in-plane magnetic field during the deposition. Magnetic measurements were performed at temperatures 5 to 350 K.

Initial study has shown strong dependencies of coercivity and exchange bias field of the Me=$Fe_{20}Ni_{80}$ layer in Me/Tb-Co bilayers [2], whereas in case of Me=Co its changes are relatively weak. We demonstrated that modification of the interlayer interface and altering the composition of the ferromagnetic layer can lead to the improvement of temperature stability of Me/Tb-Co magnetic properties.

This work has been supported by RFBR (grant 11-02-00288-a)

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MAGNETOTRANSPORT OF INDIUM ANTIMONIDE DOPED WITH MANGANESE

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Indium antimonide doped with Mn (or $In_{1-x}Mn_xSb$) belongs to the III-V diluted magnetic semiconductors attracting interest due to development of spintronics [1]. Investigations of structural and magnetic properties of $In_{1-x}Mn_xSb$ have revealed presence of different magnetic systems, including (i) the substitutional Mn ions, (ii) the MnSb nanoprecipitates having the sizes of ~ 100 – 600 nm and (iii) the atomic-size Mn complexes [2].

Here we report investigations of the Hall effect and the magnetoresistance (MR) in $In_{1-x}Mn_xSb$ with x = 0.02 – 0.06, using the same polycrystalline samples as those studied in [2]. The Hall resistivity exhibits a non-linear dependence on B, containing the normal and the anomalous contributions. Conservation of the anomalous Hall effect up to 300 K is attributable to FM MnSb precipitates. MR is positive above T ~ 10 K, suggesting contributions of two types of holes with different concentration and mobility.

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OPTICAL AND MAGNETO-OPTICAL PROPERTIES OF Co DOPED $CeO_{2-\delta}$ FILMS

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Magnetically doped CeO_2 is a promising dilute magnetic semiconductor, which shows high Curie temperature and excellent silicon compatibility [1]. The optimization of its physical properties is therefore crucial for the future application in integrated non-reciprocal photonic devices.

In this work, we have systematically studied optical and magneto-optical (MO) properties of $Ce_{1-x}Co_xO_{2-\delta}$ (x = 0, 0.02, 0.06, 0.15 and 0.25) films by means of spectroscopic ellipsometry and MO spectroscopy. The samples were prepared by pulsed laser deposition on MgO (100) and oxidized Si (100) substrates, and grew as textured polycrystalline films with thickness between 200 and 900 nm. They exhibited room temperature ferromagnetism and an out-of-plane easy axis attributed to magnetoelastic effects from the in-plane compressive strain. The MO spectroscopy was carried out in both Faraday and Kerr configurations using azimuth modulation techniques. The MO Faraday spectrum of $Ce_{0.94}Co_{0.06}O_{2-\delta}$ film is displayed in Fig.1 showing clear MO response in the photon energy range from 0.5 to 4 eV.

This work was supported by Czech Ministry of Education (grant no. LH13115) and the National Science Foundation.

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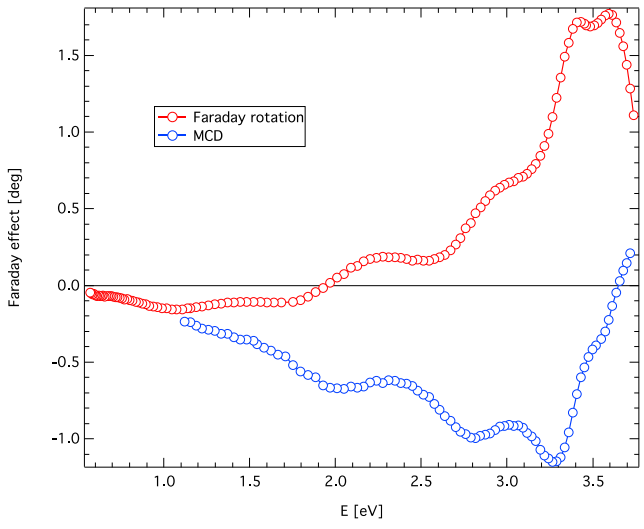

Fig.1 MO Faraday spectrum of $Ce_{0.94}Co_{0.06}O_{2-\delta}$ film.

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MANETOCRYSTALLINE ANISOTROPY AND STRUCTURE OF SRRUO$_3$ FILMS ON SRTIO$_3$ [111]

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The itinerant ferromagnetic oxide $SrRuO_3$ is a promising candidate for a wide range of oxide electronic applications due to its well controllable growth and good transport properties [1]. It is well known, that strain induced structural changes modify drastically the electronic properties of $SrRuO_3$ [2]. The effect of substrate orientation has been studied by Grutter et al. who reported on an enhanced magnetic moment of trigonally distorted thin films grown on $SrTiO_3$ [111] [3]. To further elucidate this effect a series of $SrRuO_3$ thin films in the thickness range of 5 to 60 nm were fabricated by pulsed laser deposition on $SrTiO_3$ [111] substrates. These thin films were characterized by X-ray, magnetization and transport measurements. Angle dependent magnetotransport [4] allows us to study the structure and magnetocrystalline anisotropy and its evolution in the temperature range from 10K to 200K.

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MAGNETOOPTICAL STUDIES OF NiFe/Cu/Co SPIN VALVE MULTILAYERS WITH INDUCED MAGNETIC ANISOTROPY

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Understanding of fundamental micromagnetic effects requires systematic study of exchange interactions between magnetic nanolayers. These interactions may be influenced by an application of external magnetic field during fabrication processes, which gives the possibility to control magnetic properties of nanolayers for applications in magnetoresistive read heads and spin-transfer-torque devices. Since micromagnetic effects manifest themselves as small changes in magnetic properties, MO spectroscopy in polar and longitudinal configurations and vector magnetometry are used as effective probe techniques.

In this work, we present a systematic study of physical properties of multilayered spin valves NiFe/Cu/Co with magnetic anisotropy induced by magnetic field (70 mT) applied during the deposition. Two sets of samples are investigated. First set was prepared by ion beam sputtering using Co, Cu and $Ni_{80}Fe_{20}$ targets at the Ar+ pressure of $1.2x10^{-4}$ mbar. Second set was prepared similarly but Ar+ irradiation was applied after each step of growth to increase the interface quality. The copper spacer thickness was 2,3,4,5 nm. CoO layer acts as a buffer layer providing a better growth of Co overlayer. Polar MO Kerr effect spectra at saturation for both sets of samples are shown in Fig.1 and Fig.2, respectively.

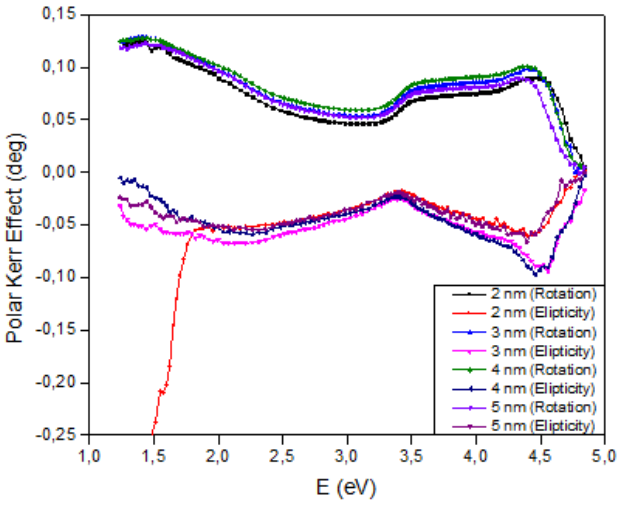

Fig.1 Polar MOKE spectra of non-irradiated samples

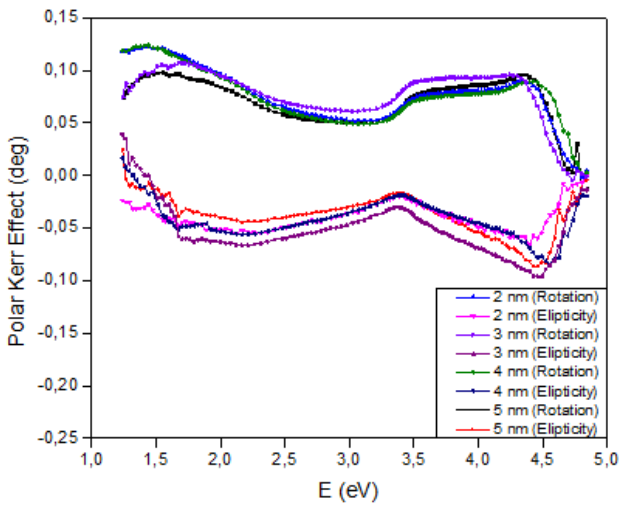

Fig.2 Polar MOKE spectra of irradiated samples

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MAGNETOTRANSPORT PROPERTIES IN $La_{2/3}Ca_{1/3}Cr_{0.06}Mn_{0.94}O_3$ THIN FILMS

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INTRODUCTION

Studies of Colossal Magnetoresistance(CMR) manganites over the last decade were to a large extent focused on the effects of the cation doping in $La_{1-x}Ca_xMnO3$ systems. Mn-sites doping also changes the electrical behavior of the material from semi-insulating to metallic behavior. It is hence worthwhile to investigate the influence of doping by other elements at Mn-site[1,2]. In this work we have investigated the chromium(Cr) effect on the structural and magnetotransport properties in $La_{2/3}Ca_{1/3}Cr_{0.06}Mn_{0.94}O_3$(LCMCrO) thin films.

METHODS

LCMCrO films were grown on (100)-SrTiO3(STO) and (100)-LaAlO3(LAO) single crystalsubstrates, by using a DC-magnetron sputtering at high O_2 pressure(500mTorr). Its properties were investigated by X-Ray Diffraction(XRD), X-ray Photoelectron spectroscopy(XPS), and. VSM option and the DC Resistivity Option in a PPMS.

RESULTS AND DISCUSSIONS

No appreciable structural changes were observed between undoped and LCMCrO doped samples from the XRD and XPS measurements(Fig.1). In Fig.2 we can appreciate the increase of magnetization in LCMCrO, unlike studies in bulk[3]. Curie temperature appears not to be significantly changed by the low Cr doping. Finally we observed the correspondence behavior of magnetoresistance.

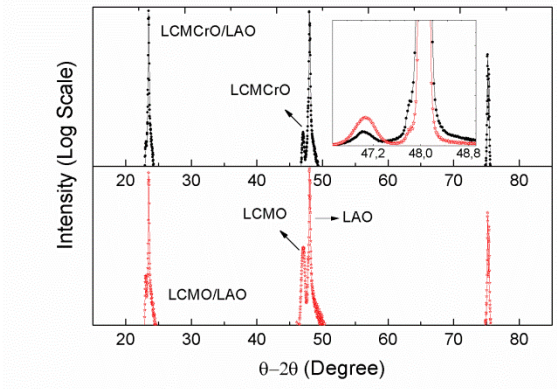

Fig. 1: XRD spectra LCMO/LAO (bottom) and LCMCrO/LAO-6% (Top) thin films. Inset: Central peak amplification for both samples.

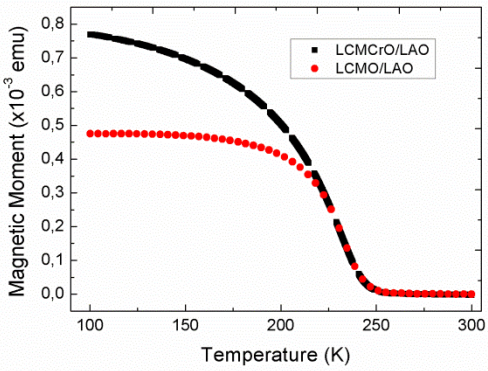

Fig. 2: Temperature dependence of magnetization for LCMO/LAO and LCMCrO/LAO-6% at H=500 Oe.

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INFLUENCE OF THE SURFACE TREATMENT ON THE LOCAL STRUCTURE OF MAGNETIC NANOPARTICLES

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In this work, we explore the modifications of the local nanocrystal structure of manganese ferrite nanoparticle induced by the duration of the hydrothermal treatment. Measurements of neutron diffraction realized at Laboratiore Léon Brillouin, of X-ray absorption spectroscopy and X-ray Diffraction performed at the Brazilian Syncrotron Light Laboratory allow us to follow the structural changes. The oxidation state of the manganese ions deduced from the absorption edge of the XANES spectra is 3+, a result different from bulk ferrite. The cation distribution is accurately determined by Rietveld refinement of neutron diffraction patterns and shows that 60% of manganese ions are located at B-sites. Then, the presence of a shoulder before the main absorption peak may be attributed to Mn^{+3} ions in octahedral environment and the expected Jahn-Teller distortions. As the duration of the surface treatment increases to 120 minutes, the oxidation state of the manganese ions changes to 4+. Simultaneously, the shoulder of the XANES spectrum vanishes and the diffraction peaks of the X-ray diffractograms are shifted towards larger diffraction angles. The latter associated to a reduction of the cell size, from 8,45Å in non-treated particles, to 8,34Å in the surface treated ones, probably related to the decrease of the ionic radius from 0,72Å for Mn^{+3} to 0,67 for Mn^{+4}.

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RAPID THERMAL ANNEALING EFFECTS ON SINGLE Ta/CoFeB/MgO – BASED MTJ STACK WITH PERPENDICULAR MAGNETIC ANISOTORPY

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INTRODUCTION

Recently, rapid thermal annealing (RTA) is frequently used as a potential method to reduce interlayer diffusion, as compared with conventional annealing. In this paper, we investigated the impact of RTA on magnetic properties of single CoFeB/MgO-based perpendicular-MTJ stacks. A series of samples with the structure of Ta(5nm)/CoFeB(t)/MgO(1nm)/Ta(10nm) was sputtered and then annealed at 250, 300, 350 and 400°C for 2, 5 and 10 minutes, using RTA. Figure 1, shows the anisotropy variation from perpendicular to in-plane orientation with increasing CoFeB thickness. The optimum perpendicular anisotropy result has been obtained for t_{CoFeB} = 10Å after annealing at 250 ºC for 10 minutes, with a very high effective anisotropy (K_{eff}) = 3.7x10^6 erg/cm^3 and interface anisotropy (K_i)=2.37erg/cm^2 [1].

In the temperature range 250 – 350°C, the transition thickness (between 12-14 Å) strongly depends on annealing temperature and time. For RTA at 350°C interlayer diffusion is apparent resulting in isotropic hysteresis behavior for t_{CoFeB} = 8Å. RTA at higher temperature (400°C) completely destroys the perpendicular anisotropy.

A comparison of conventional annealing with RTA for the same stack will be presented. This comparison will point to the possible degradation of magnetic stack properties after prolonged conventional annealing.

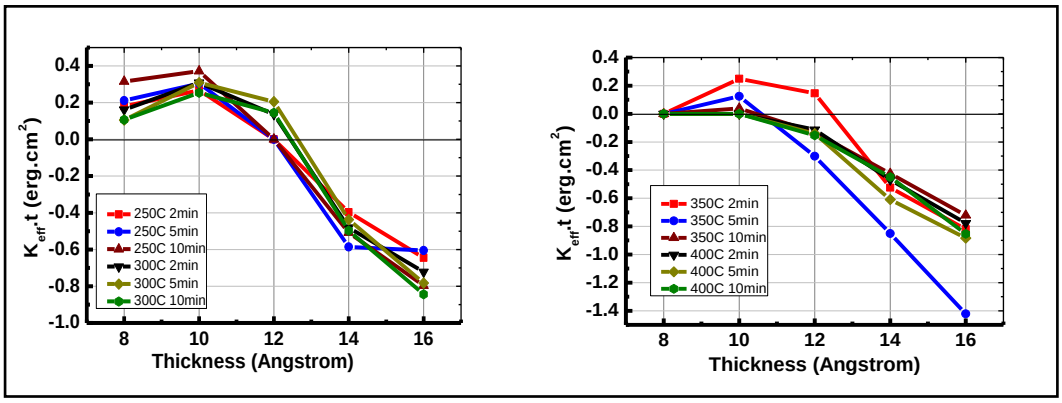

Figure 1: $K_{eff}t_{CoFeB}$ vs. t_{CoFeB} for different annealing temperature and time

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HOW TO EXPLAIN THE INDUCED PERPENDICULAR MAGNETIC ANISOTROPY FROM Pt THICKNESS AND ANNEALING IN Ta/Pt/Co/MgO

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The key deposition parameters for Perpendicular Magnetic Anisotropy (**PMA**) in magnetic nanostructures are numerous: thicknesses, annealing temperature … Tailor and explain **PMA** permit spintronics applications. Here, **PMA** is investigated in sputtered $Ta_{30Å}/Pt_{[X]}/Co_{5Å}/MgO_{20Å}/Ta_{15Å}$ for different Pt thicknesses (**X)** and annealing temperature ($\mathbf{T_{Ann}}$) by using complementary techniques: Extraordinary Hall Effects, SQUID, X-Ray Reflectivity and X-Ray absorption. **X** and $\mathbf{T_{Ann}}$ values vary in the range **(5-50-100)Å** and **(20-200-300-450)°C** respectively. In Fig.1(b)-(d) are plotted the different magnetic loops at RT (left-part) and 5K (right-part), with a comparison for Pt/Co/Pt [Fig.1(a)].

The PMA appears at RT for **X**>5Å whereas in-plane anisotropy is observed for lower **X**. The annealing temperature $\mathbf{T_{Ann}}$ reinforces PMA. The 5K data accentuates or induces **PMA**. The strong roughness associated to low density of $Pt_{X=5Å}$ and $Co_{X=5Å}$ cause Co-Ta bondings, favoring an in-plane anisotropy, as measured from structural measurements. For higher Pt thickness**,** PMA is due to Co-Pt and Co-MgO bondings. An annealing provokes intermixing between Co and Pt favorable to PMA.

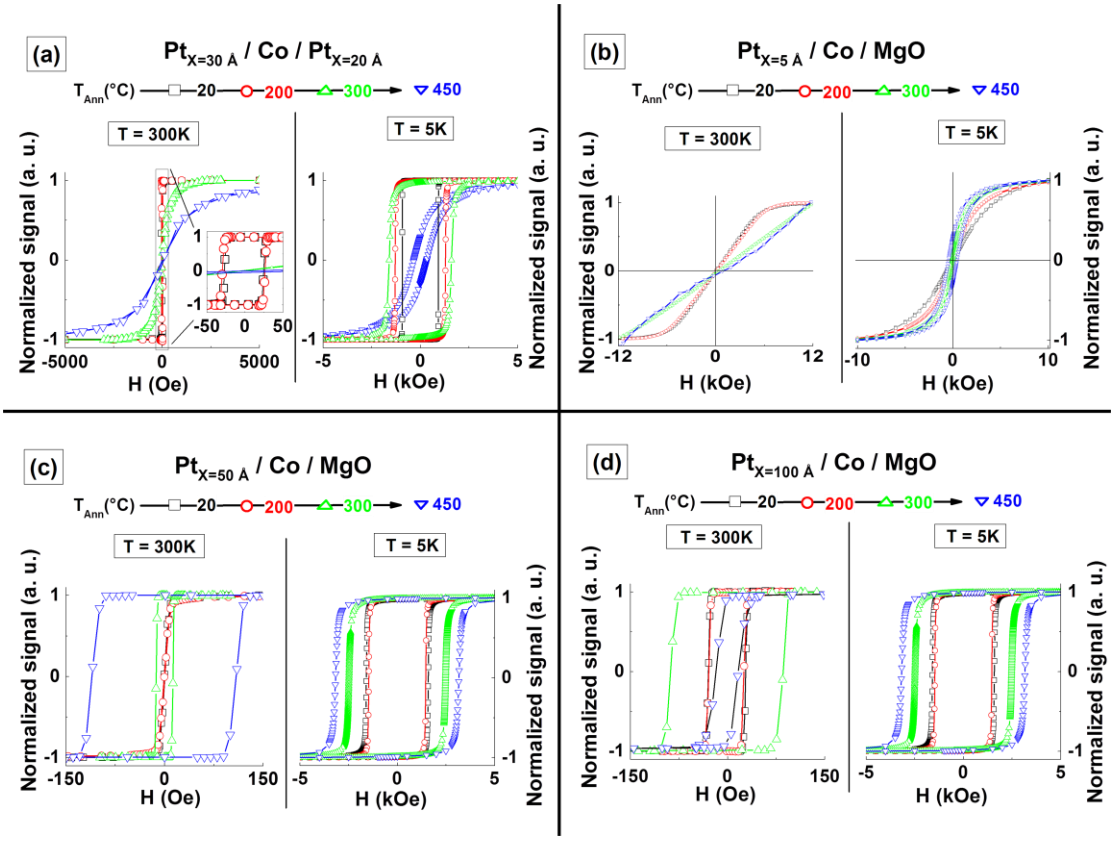

Figure 1: Magnetic loops of $Ta/Pt_X/Co/MgO/Ta$ for different Pt thicknesses (**X**) and annealing temperatures ($\mathbf{T_{Ann}}$) at RT and 5K. A comparison for Pt/Co/Pt [(a)] is added.

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MAGNETIC PROPERTIES OF $La_{0.8}K_{0.2}MnO_3$ NANOPOWDERS PREPARED BY GLYCINE-NITRATE METHOD

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INTRODUCTION

In our paper we study magnetic properties of $La_{0.8}K_{0.2}MnO_3$ nanopowders, which were prepared by glycine-nitrate technique [1]. Magnetization and AC susceptibility measurements were performed in magnetic fields up to 9 T and in the temperature range between 1.8 K and 400 K by a SQUID magnetometer MPMS and VSM in PPMS. Particular stress was paid to study of the exchange bias (EB) effect on as prepared and heat treated magnetic nanopowders. The exchange bias (EB) was discovered more than 55 years ago, by Meiklejohn and Bean [2], and its characteristic signature is the shift of the centre of magnetic hysteresis loop from its normal position at $H = 0$ to $H_E \neq 0$. EB usually occurs in systems which are composed by an antiferromagnet (AFM) that is in atomic contact with a ferromagnet (FM) after the system is cooled, below the respective Néel and Curie temperatures T_N and T_C, in an external cooling field H_{cf}. The EB effect in manganites has attracted attention for their potential application and was studied e.g. on $La_{x-1}Ag_xMnO_3$ [3]. Although the complex AFM background accompanied with FM component in these materials has already been found, the EB effect remains unclear and needs further investigation. The EB effect is very pronounced on as prepared sample and can be completely removed by heat treatment. Effect of heat treatment (particle size; ratio Mn^{3+} and Mn^{4+}) on magnetic properties, with special attention to EB, will be discussed in the paper.

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INTERFACIAL CONTRIBUTION TO IN-PLANE ANISOTROPIC MAGNETORESISTANCE

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We have studied in-plane AMR in cobalt films with overlayers having designed interface transparency. With an opaque interface, the AMR ratio is shown to vary in inverse proportion to the cobalt film thickness. Interface scattering is found to have opposing anisotropy to volume scattering, similar to the interfacial contribution to magnetic anisotropies.

Our study into ferromagnetic film-thickness dependence of the AMR in cobalt films uses layers deposited onto Ta seed layers for all cobalt thicknesses. This allows us to isolate any interfacial contribution to AMR from effects due to variations in the film microstructure with cobalt thickness. In order to isolate the contribution to AMR, we employed structures consist of Si/SiO/Ta[3nm]/Cu[3nm]/Co/overlayer[3nm]/Ta[3nm] with cobalt thickness ranging from 2nm to 40 nm and overlayers of either copper or iridium. Due to the similarity between the electronic structure of copper and cobalt [1], structures with copper overlayers have electrically transparent interfaces, and, due to the copper seed layers, preserve structural inversion symmetry. The different electronic structure of iridium in comparison to cobalt means that structures with iridium overlayers have more electrically opaque interfaces, in addition to broken structural inversion symmetry. Iridium also has strong spin orbit interaction (larger atomic number), which should enhance any Rashba contribution to AMR. We show that these multilayered structures allow the isolation of the in-plane AMR contribution due to the Co/Ir interface.

In summary, we have demonstrated an interfacial contribution to the anisotropic scattering which produces the AMR effect with structures containing an opaque Co/Ir interface. This contribution has scattering anisotropy which is opposite in sign to the bulk scattering anisotropy. This provides a novel explanation for the thickness dependence of $\Delta\rho$ and the AMR ratio.

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INTERPLAY BETWEEN DIPOLAR ENERGY AND MAGNETOCRYSTALLINE ANISOTROPY IN FE SINGLE CRYSTAL NQNOMAGNETS

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INTRODUCTION

Magnetic nanostructures are relevant due to their intrinsic scientific interest and to their potential for technological applications. The ability to engineer their magnetic behavior relies in controlling the different energy contributions governing their magnetization reversal [1]. In the case of arrays of magnetic dots, the geometry gives rise to an internal magnetostatic energy term related to the symmetry of the dots and to the formation of magnetic vortices [2].

RESULTS

We report on the vortex control in singlecrystal Fe nanotriangles, with different configurations of the crystalline axes, by experimental and simulation studies. While the angular dependence of the remanence evidences uniaxial anisotropy (fig. 1), controlled by the dipolar energy, the vortex nucleation and annihilation fields are controlled by the orientation of the crystalline axes (fig 2). We have improved the ability to tailor the vortex control in nanomagnets by adding a highly controlled source of anisotropy.

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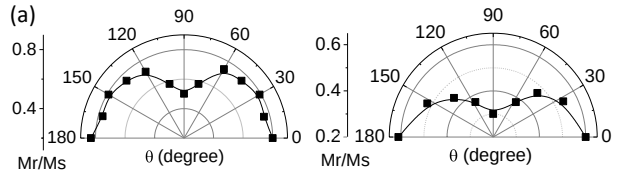

Fig. 1

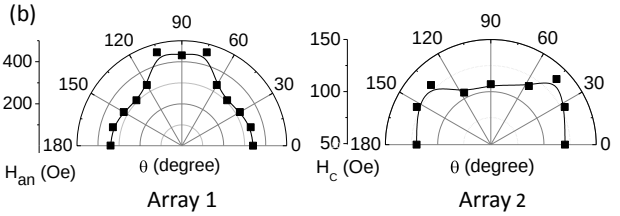

Fig. 2

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STRUCTURAL AND MAGNETIC PROPERTIES OF CORE-SHELL $NIFE_2O_4$@γ-FE_2O_3 NANOPARTICLES

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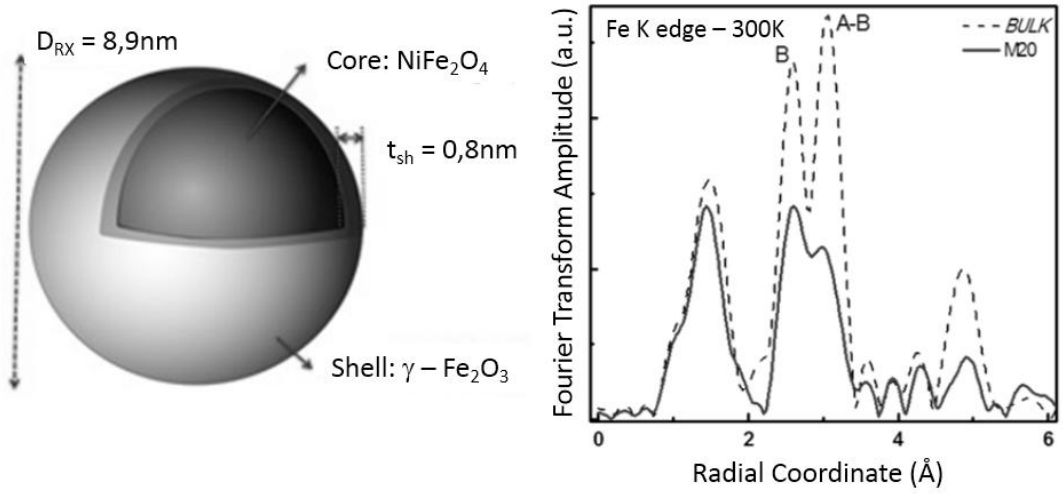
We explore here the local structure of core-shell $NiFe_2O_4$@γ-Fe_2O_3 nanoparticles well suited for the development of new pharmaceuticals [1]. X-ray Powder Diffraction (XPD), in-field Mössbauer spectroscopy and X-ray Absorption Spectroscopy (XAS) are combined with Magnetization measurements. Rietveld structure refinement of the XPD data is performed considering two phases of spinel crystallographic structure [2]. Among the results, it gives the inversion degree associated to the nickel ferrite core. The in-field Mössbauer spectra split into two well resolved contributions arising from the oppositely aligned spins of Fe^{3+} ions at A and B sites of the spinel structure. Then, an inversion degree of 0.89, independent on the particle size, can be found by fitting the spectra. This value well matches the XPD determination. These results are corroborated by the qualitative analysis of the XANES and EXAFS spectra at both cations-edge. The saturation magnetization of the particle varies with the fractions of core and shell materials and with the inversion degree.



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MAGNETIC AND STRUCTURAL CHARACTERIZATION OF POLYCRYSTALLINE V_2O_5/COV_2O_6 SAMPLES SYNTHESIZED BY PECHINI METHOD

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We present a study of structural and magnetic properties of V_2O5/CoV_2O_6 samples synthesized by Pechini method. The synthesis consists in adding NH_4VO_3 to a mixture of citric acid and ethylene glycol that result in a polymer which is eliminated in the calcination process while vanadium and cobalt ions are oxidized. Cobalt sulfate, 50 mol% was added to the solution and the resin obtained was calcined at 550°C in different periods: 2, 4, 6 and 10 hours.

X-ray diffraction measurements analyzed using Rietveld refinement allowed the study of the kinetics of formation of monoclinic CoV_2O_6 by Pechini method which is in accordance with the phase diagram already established for the system V_2O_5-CoO. We concluded that the increase in calcination temperature improves the formation of V_2CoO_6, however, V_2O_5 still constitutes the major part of the sample.

Although V_2O_5, presents paramagnetic behavior, magnetization measurements versus temperature in different magnetic fields show that the samples exhibit antiferromagnetic phase with T_N=14K. This behavior was observed for magnetic fields up to 70 kOe and was recently observed for pure V_2CoO_6 samples prepared by solid-state reaction. Our results show that V_2O5/CoV_2O_6 also presents a metamagnetic transition in function of applied magnetic field.

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MAGNETIC PROPERTIES OF EPITAXIAL Co FILMS DEPOSITED ON NANOSTRUCTURED SUBSTRATE OF Si (111)

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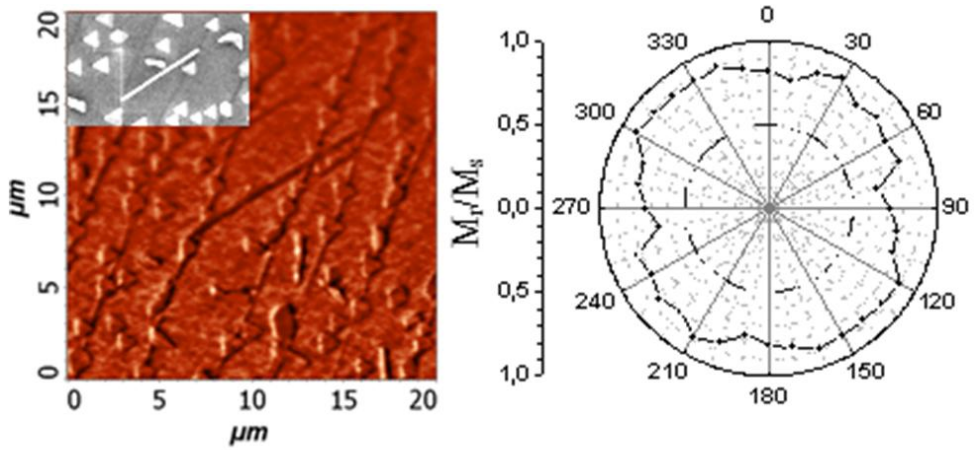
The effect of randomly distributed nanostructures on the magnetic properties of Co films was investigated. Samples were prepared by molecular beam epitaxy in ultrahigh vacuum. The preparation of Si(111) substrates and deposition conditions for Co and Cu were described in [1]. Before Co evaporation the three-dimensional pattern based on copper silicide nanostructures was self-organized. Then, the Co films with thickness of 40 A were deposited on the substrates with and without Cu buffer layers.

The nanostructures have a triangular, polygonal and nanostripe shapes. The magnetic structure of Co films is rather complicated. At saturation the white-black magnetic contrast is observed in MFM image, Fig.1a. This is due to the magnetostatic field distribution on the edges of nanostructures.



(a) (b)

Fig.1. (a) MFM image at saturation, the inset presents SEM image with area 10x7 μm^2; (b) the polar diagram of M_r/M_s for Si (111)-5.55x5.55-Cu/Co film.

Investigation of the magnetic hysteresis loops shows that the value of the coercive force H_c for Co films without Cu buffer is 270 Oe, but with buffer layer H_c is 70 Oe. The form of polar diagrams points out on the isotropic magnetic properties of films, Fig. 1b.

ACKNOWLEDGEMENT

Authors acknowledge the support of the Russian Ministry of Education and Science, the RFBR and the Scientific Fund of FEFU.

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TAILORING SIZE & COMPOSITION IN MANGANESE FERRITE NANOPARTICLES TO ENCHANCE MAGNETIZATION

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INTRODUCTION

Finite-size and surface effects in magnetic nanoparticles (MNPs) give rise to properties significantly different to the corresponding bulk materials. Superparamagnetic spinel ferrites nanoparticles MFe_2O_4 (M = Mn, Fe, Co, Ni) are currently considered among the most successful MNPs for medical applications [1], [2]. However, a well-known problem is the magnetization reduction emerging when their size decreases within the nanoscale regime, particularly for nanocrystals smaller than 20 nm, related to the larger percentage of atoms located on surface.

We have initiated studies [3] into manganese ferrite nanoparticles with enchanced magnetization focusing on their structural properties. A facile solvothermal approach was used to synthesize stable superparamagnetic manganese ferrite nanoparticles with relatively small sizes. By varying the oxidation state of manganese precursor, $Mn(acac)_2$ to $Mn(acac)_3$, different sizes, 8 and 5 nm, of $MnFe_2O_4$ nanoparticles were obtained respectively, while by tailoring the synthetic conditions iron-rich $Mn_{0.77}Fe_{2.23}O_4$ nanoparticles have been isolated with identical sizes and enhanced saturation magnetization. The magnetization values increased from 58.2 to 68.3 Am^2/kg and from 53.3 to 60.2 Am^2/kg for the nanoparticles of 8 nm and 5 nm, respectively.

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EXCHANGE BIAS AND MEMORY EFFECTS IN DENSE ASSEMBLIES OF NANOPARTICLES WITH A CORE/SURFACE MORPHOLOGY

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We use the Monte Carlo simulation technique to study the magnetic behavior of dense assemblies of $MnFe_2O_4$ nanoparticles with an average size of 4 nm. We use a mesoscopic model of three spins to take into account the ferrimagnetic character and the surface effects of the nanoparticles. We assume random orientation of the spins in the assembly. Nearest neighbours exchange interactions between the spins inside the nanoparticles and interparticle dipolar interactions and exchange interactions of the nanoparticles in contact are included in our simulations. The temperature dependence of the exchange bias effect and the memory effects on low field Zero-Field-Cooled (ZFC) and on the thermoremanent magnetization curves of the system [1] have been investigated. Our calculations demonstrate the dominant role of the interparticle exchange interactions in the assembly to the memory effect on the Zero-Field-Cooled (ZFC) curves. When dipolar and exchange interparticle interactions are absent memory effect becomes negligible. The exchange bias phenomenon appears below the temperature at which FC magnetization curve becomes temperature independent. Both simulation and experimental results confirm the spin-glass like behavior of the $MnFe_2O_4$ nanoparticles system.

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DIRECT SYNTHESIS OF $L1_0$FEPT NANOPARTICLES USING AU NANOPARTICLES AS NUCLEI CENTERS

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FePt nanoparticles in the chemically ordered tetragonal phase ($L1_0$) are important magnetic materials due to their unique magnetic properties, including high magnetocrystalline anisotropy (K_u ~ $8x10^6$Jm-3), high coercivity and chemical stability. Various chemical routes, that use high boiling-point organic solvents, lead to the formation of *fcc* FePt which can be transformed to the ordered *fct* structure by annealing at temperatures above 550 ^oC. The addition of a third metal such as Ag and Au lowering the *fcc* to *fct* transformation temperature below 500 ^oC. However, the post-annealing procedure induces complete decomposition of the protective organic layer surrounding the surface of each particle, thus the nanoparticles lose their solubility and most importantly their size and shape homogeneity.

Here, we present the direct synthesis of FePt nano-alloy particles in the $L1_0$ phase by thermal decomposition of $Fe(CO)_5$ and $Pt(acac)_2$ in paraffin oil in the presence of pre-synthesized Au nanoparticles and equimolecular mixture of oleic acid and oleyamine at different temperatures (300-360^oC). The size of Au nanoparticles is very crucial. The structural, and magnetic properties of the particles will be reported.

Work supported by DOE and EU-FP7-RAREFREEPERMAG.

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MAGNETOOPTICAL STUDIES OF NiFe/Cu/Co SPIN VALVE MULTILAYERS WITH INDUCED MAGNETIC ANISOTROPY

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Understanding of fundamental micromagnetic effects requires systematic study of exchange interactions between magnetic nanolayers. These interactions may be influenced by an application of external magnetic field during fabrication processes, which gives the possibility to control magnetic properties of nanolayers for applications in magnetoresistive read heads and spin-transfer-torque devices. Since micromagnetic effects manifest themselves as small changes in magnetic properties, MO spectroscopy in polar and longitudinal configurations and vector magnetometry are used as effective probe techniques.

In this work, we present a systematic study of physical properties of multilayered spin valves NiFe/Cu/Co with magnetic anisotropy induced by magnetic field (70 mT) applied during the deposition. Two sets of samples are investigated. First set was prepared by ion beam sputtering using Co, Cu and $Ni_{80}Fe_{20}$ targets at the Ar+ pressure of $1.2x10^{-4}$ mbar. Second set was prepared similarly but Ar+ irradiation was applied after each step of growth to increase the interface quality. The copper spacer thickness was 2, 3, 4, 5 nm. CoO layer acts as a buffer layer providing a better growth of Co overlayer. Polar MO Kerr effect spectra at saturation for both sets of samples are shown in Fig.1 and Fig. 2, respectively.

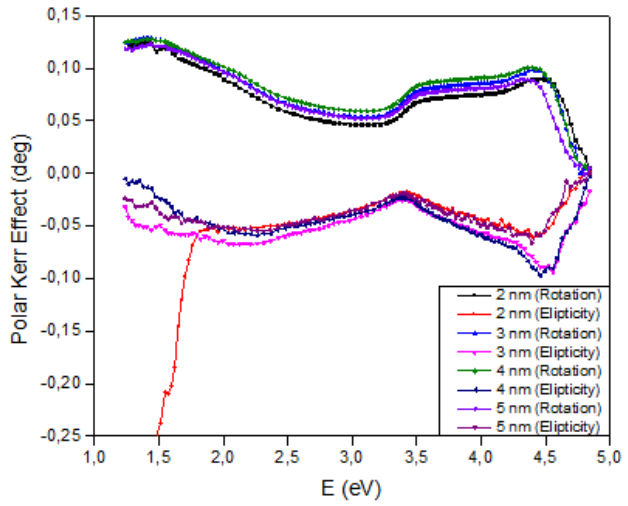

Fig.1 Polar MOKE spectra of non-irradiated samples

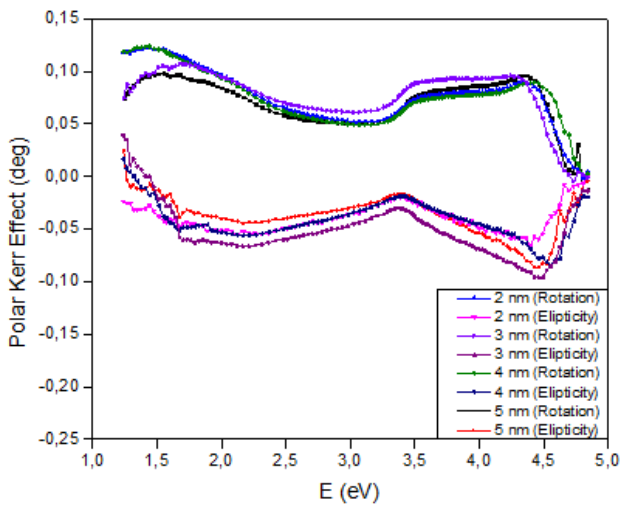

Fig.2 Polar MOKE spectra of irradiated samples

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SONOCHEMICAL SYNTHESIS AND CHARACTERIZATION OF FeCo NANOPARTICLES

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Soft magnetic NPs have gained a lot of attention during the last decades because of their possible application in high performance exchange-spring permanent magnets. In this regards the FeCo alloys represent the most interesting NPs materials and several chemical strategies have been successfully explored with the aim to control composition, morphology, size and magnetic properties. Only recently acoustic cavitation (sonochemistry) has been proposed for the synthesis of FeCo alloys leading mostly to formation of amorphous NPs in the case of primary sonochemistry.[1] I
n the present work we present our approach based on a modified surfactant-free polyol process promoted by secondary sonochemical synthesis suitable for formation of nanocrystalline materials. XRD analysis of the obtained black precipitate revealed formation of nanocrystalline FeCo alloy. The isolated material showed a maximum saturation magnetization of 200 emu/g and extremely low coercivity. TEM and HRTEM analysis showed formation of cubic nanocrystalline FeCo NPs with size distribution in the range of 10 – 200 nm as expected in absence of confining media during reaction.

This study has been supported by the European IRSES NANOMAG Project.

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STM STUDY OF APBS IN FE_3O_4 THIN FILMS

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Magnetite (Fe_3O_4) has fascinating electrical and magnetic properties, such as high conductivity, half-metallicity and high Curie temperature of 858 K. Therefore, The Fe_3O_4 thin films have been expected to be useful for fabrication spin-sensitive devices. However, Fe_3O_4 thin films are well known to contain a high density of antiphase domain boundaries (APBs) [1]. These APBs can generate a strong antiferromagnetic (AF) coupling across the interface of the APBs. As a result, magnetic properties of Fe_3O_4 thin films deviate from the bulk. In this work, we have applied scanning tunnelling microscopy and spectroscopy (STM/STS) to investigate the atomic configurations of the APBs and how the APBs influences magnetic properties of the film.

The Fe_3O_4(100) films were prepared on MgO substrates by electron beam evaporation of iron in an oxygen atmosphere. The surface of the Fe_3O_4 film was terminated by B-plane, and several types of APBs were observed by STM. We also observed an APB with atomic resolution as shown in Fig. 1. Our results indicate the existence of the strong AF-coupling between Fe-O-Fe pairs at the interface of the APB, and these AF-couplings influence the magnetic property of Fe_3O_4 thin films.

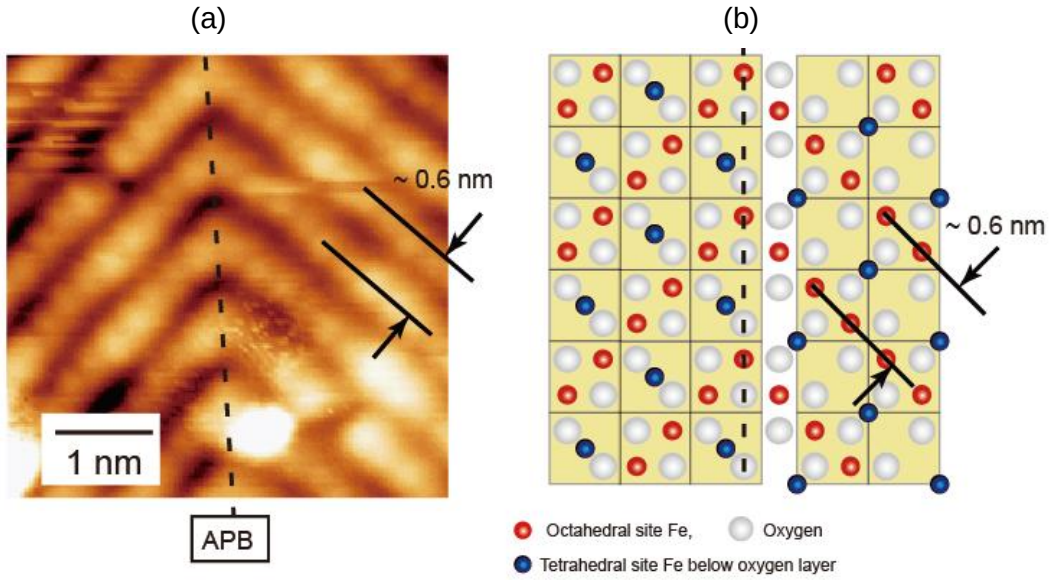

Figure 1. (a) STM image, (b) Surface atomic configuration model

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INTRODUCTION

The total length of your abstract is limited to 250 words (including title, affiliations, body text, references and acknowledgment) **not exceeding one page**, which is to be submitted in word document format, following the guidelines above. If you submit your abstract in a different format we have to reject it.

Write your body text using “standard” style, Arial font, size 10 pt. Include an empty line before starting each next section.

Abstracts for scientific work should generally follow the format of introduction, methods, results and discussion, references and acknowledgements (if required).

FIGURES AND TABLES

All tables and figures must be cited within the text. Add captions below figures and tables, using the “caption” style. Please number them consecutively using either “Figure” or “Table” prefix. Please ensure that the “wrapping” style in the figures is in-line with the text.

EQUATIONS

If you want to include equations, use the “equation” style for that paragraph and use the “math profile”. Use the MS-word equation editor, with defaults to “times new roman” and symbol “fonts.

$$F=mx\alpha \qquad [1]$$

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All references must be cited within the text. References appearing within the text should be numbered [1],[2],… and given at the end of the text sequentially.

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MAGNETIZATION REVERSAL AND MAGNETIC DOMAINS IN $FePt/Fe_3Pt$ EXCHANGE-COUPLED NANOCOMPOSITES

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Exchange-coupled composite (ECC) media, where each grain is composed of a hard and a soft phase, have been proposed to go beyond the magnetic recording "trilemma" by exploiting the hard/soft coupling to reduce the switching field.

We have grown epitaxial $FePt/Fe_3Pt$ nanostructures on MgO and $SrTiO_3$ and fully investigated the reversal process in the different magnetic regimes, i.e., Rigid Magnet (RM) and Exchange-Spring (ES) [1]. The magnetic regime at fixed soft phase thickness can be tuned by changing substrate and nominal composition of the soft phase. Coercive field strongly decreases with increasing Fe_3Pt thickness (H_C/H_C^{hard} down to 0.21).

Exploiting in-field Magnetic Force Microscopy (MFM), we have investigated the effect of inter-island interactions on first magnetisation and magnetisation reversal: the transition from RM to ES is continuous and not abrupt due to lateral interaction and magnetic domains formation; the reversible and irreversible portions of reversal process are characterised by domains with different shape (Fig.1). Finite difference 3D simulations have also been performed in order to investigate the effects of lateral interaction between hard grains, due to the presence of the soft phase.

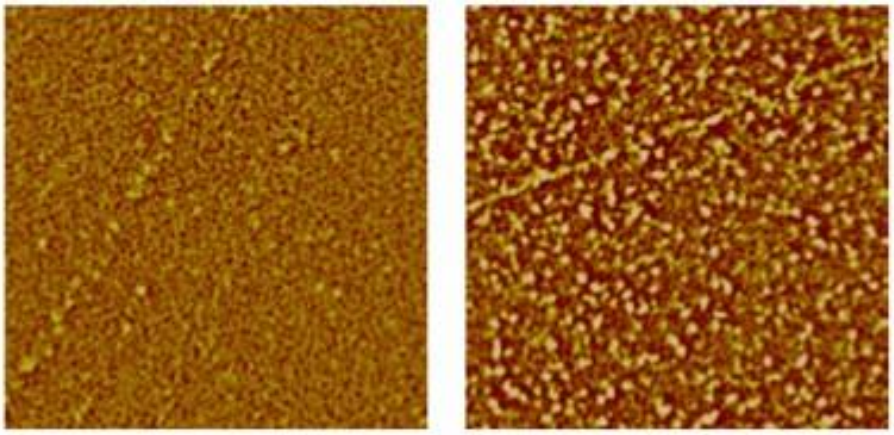

Figure 1. *5 μm^2 MFM images taken on $SrTiO_3$/FePt(3.5nm)/Fe_3Pt(3.5nm) during magnetisation reversal before (left) and after (right) applying the irreversibility field.*

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MAGNETOELASTIC EFFECT APPLIED IN BIOSENSORS

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Abstract:

The authors introduce some sensors based on magnetoelastic effect to measure glucose, acid phosphatase , tannin and Pseudomonas aeruginosa and so on. First we explain the basic principle of the sensor in detail., Wireless magnetoelastic sensing is a new type of sensing technology, wireless magnetoelastie sensor is based on elements of magnetostrctive, signal in the sensor is activated and transmitted by magnetic field, No physical connections between the sensor and the detection system are required, nor is any internal power required. The wireless nature of the magnetoelastic sensor makes it a powerful candidate for in situ and in vivo analysis.

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THE EFFECT OF SiO_2 CONTENT ON ACTIVATION VOLUMES IN ECC MEDIA

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The activation volume, V_{act} and the physical grain volume, V_m have been investigated on identical structures of exchange coupled composite (ECC) media with three levels of oxide based intergranular exchange decoupling. Time dependence measurements known as the waiting time method[(1)] have been used to determine V_{act}. Transmission Electron Microscopy (TEM) analysis has been carried out to investigate the grain size distribution and the composition distribution at the grain boundaries using bright field BF-HRTEM and high angle annular dark-field (HAADF) modes. We found that V_{act} and V_m increase as the oxide content is reduced[(2)]. The activation volume and the single grain volume are in excellent agreement for the samples with the highest oxide content indicating complete exchange decoupling. The BF-HRTEM and HAADF STEM image indicate excellent SiO_2 segregation at the grain boundary. This result implies that the activation volume in advance recording media can be estimated via the correlation to the grain size.

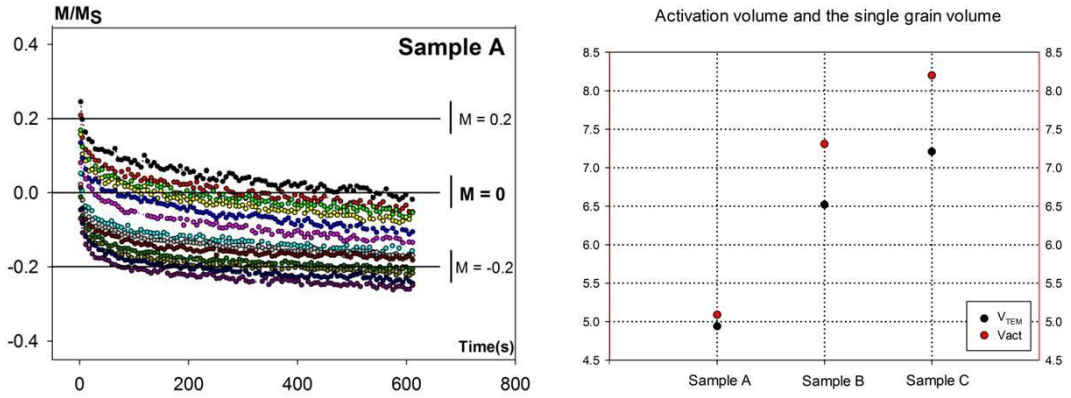

Figure 1a) Typical waiting-time data for Sample A and 1b) The comparison between V_{act} and V_{TEM} for all samples

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STUDY OF MICROSTRUCTURE AND MAGNETIC PROPERTIES OF $L1_0$ - FePt–C/SiO_2 THIN FILMS

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We present our results for magnetic recording applications where we tailor the nanostructure and magnetic properties of FePt films, by co-sputtering with C or SiO_2 . By this procedure we are able to control the variation of the magnetic anisotropy, the shape and size of the produced structure, along with the formation of isolated nanoparticles. Moreover continuous films deposition with high uniformity and narrow average size distribution are observed.

Achieving magnetic recording densities in excess of 1Tbit/in^2 requires not only perpendicular media with anisotropy larger than 6 MJ/m^3, which makes the FePt alloy as the best choice, but also narrow distribution and small sizes below 10 nm for a reduced S/N ratio. By adding C there is an advantage for grain size reduction [1] and improvement of average lateral diameter distribution.

Single films were prepared by magnetron co-sputtering FePt and either C or SiO_2 targets on single crystal MgO substrate, while in each case C or SiO_2 percentage varied up to 30%. With C addition in FePt we observed great grain diameter reduction along with desirable shape control. By adding SiO_2 an also significant reduction in diameter of isolated particles observed along with a great coercive field reduction.

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A NEW CRACKS DETECTION DEVICE FOR MAGNETIC STEELS

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A portable detecting device was developed for the magnetic detection of cracks in railway tracks. The device is equipped with permanent magnets, which produce a uniform magnetic field inside and near the surface of the magnetically soft steel of a railway track, and GMR sensors. Due to the high sensitivity of the GMR sensors, in variations of the component of the magnetic field which is parallel to the direction of motion, the detecting device is capable of producing voltage peaks or dips for quite small deviations of the near-surface magnetic field from the uniform field of the magnets. Finite element numerical simulations showed that the component of the magnetic field, which is parallel to the direction of motion, exhibits sharp peaks above cracks existing in railway tracks. Laboratory measurements, made on pieces of railway tracks and steel rods, verified that the GMR sensors produce sharp voltage peaks when move above the cracks and showed that their magnitude depends on the geometrical characteristics of the cracks. Based on these measurements, we conclude that the developed device can successfully detect cracks and defects in railway tracks and give information on their size.

ACKNOWLEDGEMENTS

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THE SYNTHESIS, CRYSTAL AND MAGNETIC STRUCTURE OTH THE IRON SELENIDE $BaFe_2Se_3$

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INTRODUCTION

The total length of your abstract is limited to 250 words (including title, affiliations, body text, references and acknowledgment) **not exceeding one page**, which is to be submitted in word document format, following the guidelines above. If you submit your abstract in a different format we have to reject it.

Write your body text using “standard” style, Arial font, size 10 pt. Include an empty line before starting each next section.

Abstracts for scientific work should generally follow the format of introduction, methods, results and discussion, references and acknowledgements (if required).

FIGURES AND TABLES

All tables and figures must be cited within the text. Add captions below figures and tables, using the “caption” style. Please number them consecutively using either “Figure” or “Table” prefix. Please ensure that the “wrapping” style in the figures is in-line with the text.

EQUATIONS

If you want to include equations, use the “equation” style for that paragraph and use the “math profile”. Use the MS-word equation editor, with defaults to “times new roman” and symbol “fonts.

$$F=mx\alpha \qquad [1]$$

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All references must be cited within the text. References appearing within the text should be numbered [1],[2],… and given at the end of the text sequentially.

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Magnetic properties of the layered oxypnictides (LnO)MnAs (Ln = La, Ce, Pr, Nd)

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Cerium oxypnictides (CeO)FeP[1], (CeO)FeAs[2], (CeO)CoP[3], (CeO)CoAs[4] have been reported to the Kondo system. In these systems, it is difficult to understand their features because both the Ce 4*f* and the transition metal 3*d* electrons contribute to the physical properties. Choosing the Mn atom as a transition metal element, it is reported that (LaO)MnAs is an antiferromagnetic semiconductor with the ordered Mn 3*d* moments. So, this material is thought to be suitable to investigate the effect of *f* electrons.

In this study, we have investigated the rare earth elements dependence on the magnetism to understand the contribution to physical properties of the 4*f* electrons of (LnO)MnAs (Pn = La, Ce, Pr, Nd).

Figure 1 shows temperature dependences of the magnetization. (CeO)MnAs, (PrO)MnAs and (NdO)MnAs shows the antiferromagnetic behavior at low temperature. (CeO)MnAs and (NdO)MnAs have the magnetic anomalies around 34 K and 24 K, respectively. So, it is speculated that the anomalies depend on the Mn-Mn distance directly.

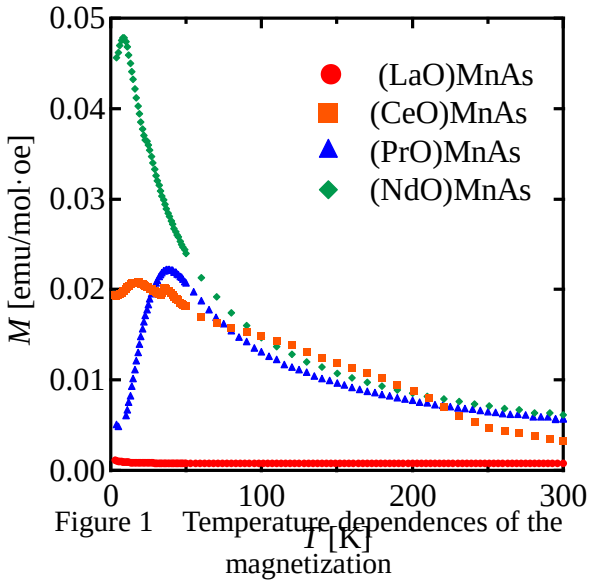

Figure 1 Temperature dependences of the magnetization

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NON-COLLINEAR MAGNETIC STRUCTURES OF TbCoO3 AND DyCoO3

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The orthoperovskites $TbCoO_3$ and $DyCoO_3$ with Co^{3+} in non-magnetic low-spin state have been investigated by neutron diffraction down to 0.2 K. Magnetic ordering is evidenced below $T_N \sim 3 – 4$ K, which is in agreement with earlier findings [1-3]. The observed arrangements, A_xG_y for $TbCoO_3$ and G_xA_y for $DyCoO_3$ in Bertaut's notation, are interpreted based on an analysis of the crystal field splitting of electronic multiplets of Tb^{3+} and Dy^{3+} ions [4], located in the *Pbnm* structure in sites of C_s point symmetry. It is shown that the long-range ordered moments originate in the lowest energy levels, in particular in accidental doublet of non-Kramers Tb^{3+} ($4f^8$ configuration) and in ground Kramers doublet of Dy^{3+} ($4f^9$). These both have Ising character, which is the actual reason for the non-collinear AFM structures.

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MAGNETOTRANSPORT AND THERMAL PROPERTIES OF 55 K SUPERCONDUCTOR $SmFeAsO_{0.85}F_{0.15}$

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Abstract

. This report underlines the magnetotransport and thermal properties of Bulk superconductivity in the FeAs-based $SmFeAsO_{0.85}F_{0.1}$ .The phase formation and structure are confirmed by Rietveld analysis of room temperature powder X-ray diffraction (XRD) data and electron microscopy was employed to unravel the micro structural details, such as perfection of the lattice and the grain morphology including size and boundaries. The electrical and magnetic measurements are performed to confirm the bulk superconductivity and understand the nature of electrical transport in the normal and superconducting state. The intra-grain critical current density (J_c) with applied magnetic field is calculated from isothermal DC magnetization (MH) plots using conventional the Bean critical state model. Superconductivity is observed at transition temperature (T_c) above 55 K without HPHT (high pressure high temperature) synthesis route. The value of J_c is found to be around 5.3 $\times 10^4$ A/cm^2 at 5 K in zero field. The dependence of thermally activated flux flow energy (U/k_B) on the applied magnetic field is also calculated. AC susceptibility measurements were performed for 55 K superconducting $SmFeAsO_{0.85}F_{0.15}$ sample at various amplitude of applied AC drive field and its granular nature is confirmed. The parent compound SmFeAsO is found to be magnetic with Fe spin density wave (SDW) like order below 150K, on the other hand the F doped $SmFeAsO_{0.85}F_{0.15}$ sample is bulk superconducting at below 55K. Both Fe (SDW) at 150K for SmFeAsO and 55K superconductivity in case of $SmFeAsO_{0.85}F_{0.15}$ sample are confirmed by Specific heat [$C_p(T)$] measurement.

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GEOMETRICAL FRUSTRATION IN SPIN-GLASS CLUSTERS

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The presence of spin glass (SG) order in geometrically frustrated (GF) systems is analyzed with a cluster SG model. The model considers infinite-range disordered interactions among cluster magnetic moments and short-range antiferromagnetic J1-J2 model couplings between Ising spins of the same cluster. The intercluster disorder is treated within the framework of one-step replica symmetry breaking. This produces an effective one-cluster problem that is solved exactly [1]. We build phase diagrams of the temperature versus the intensity of disorder J, where the SG phase appears at high J values. However, only the paramagnetic phase is found for small J values when the geometrical frustration is absent. Nevertheless, the presence of intracluster geometrical frustration (achieved by adjusting the ratio J1/J2) brings the SG order for smaller intensities of disorder. In this case, the geometrical frustration makes the clusters hypersensitive to weak disorder towards the SG phase. It means that small clusters in GF systems can help to stabilize the SG order in extremely weak disordered regimes.

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LOW-ENERGY DYNAMICS OF SPIN ½ SQUARE J1-J2 HEISENBRG ANTIFERROMAGNETS

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INTRODUCTION

We give a physical picture of the low-energy sector of the spin- ½ square J1-J2 Heisenberg antiferromagnet. Investigation of ground state in this model have been done in [3]. We have used the method that was developed in [1],[2]. It is shown that the square lattice can be presented as a set of plaquets which contain 4 spins and are arranged in a square lattice. As unperturbed Hamiltonian was chosen sum of all possible pairwise interactions of spins in plaquet with uniform factor J1. In this case each of plaquets has two degenerate singlet ground states which can be considered in terms of pseudospin. All interactions between plaquets and additional interactions inside plaquets (which need to restore J2 factor on diagonals) are considered as perturbation. Lower singlet band of this model have been described by effective Hamiltonian. Parameters of the effective Hamiltonian have been calculated up to the sixth order of the perturbation theory.

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MAGNETIC, STRUCTURAL AND Pr-O BOND CHANGES AT THE LOW TEMPERATURE TRANSITION IN $Pr_{0.50}Sr_{0.50}CoO_3$

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The electronic and magnetic properties of cobalt-based perovskites are largely determined by the electronic filling of the Co 3d valence band. The spin state of trivalent cobalt appears as a fundamental ingredient for the variety of magnetic and electric properties displayed by the $(Pr_{1-y}Ln_y)_{1-x}A_xCoO_3$ (*Ln*: lanthanide, *A*: alkaline-earth) family of compounds [1-3].

Pure Pr-based half-doped $Pr_{0.50}Ca_{0.50}CoO_3$ presents a metal-insulator transition (MIT) at T ~ 80 K. [1,4,5]. By entering the insulating phase a sudden bending of the Co-O-Co bond angles occurs, originated by a strong contraction of the Pr-O bonds. This facilitates a large hybridization between Pr-*4f* and O-*2p* states leading to a partial transformation of Pr^{3+} into Pr^{4+}. The electrons leaving Pr are transferred to Co ions, which get reduced [6,7]. In addition, x-ray absorption spectroscopy (XAS) at the Co $L_{2,3}$ edge and Co $K\beta_{1,3}$ emission lines confirm concomitant large Co spin state changes at the MIT [7].

In contrast, $Pr_{0.50}Sr_{0.50}CoO_3$ (PSCO) is always metallic, and ferromagnetic below T_c ~ 230 K, and presents an intriguing magnetostructural transition at T_A ~ 120 K [8]. From the analysis of neutron diffraction data we have observed a remarkable shortening of selected apical Pr-O bond distances across T_A. In addition, we have explored the possible role of the Pr-O hybridization on the structural and magnetocrystalline changes at T_A by means of x-ray absorption spectroscopy at the Pr $M_{4,5}$ edge. A different scenario to that observed in Ca-based compounds is presented, in which the changes in the Pr,O network modifies the magnetocrystalline anisotropy.

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NON EQUILIBRIUM VORTEX MATTER PHASE DIAGRAM OF $Ba_{1-x}K_xFe_2As_2$ SUPERCONDUCTOR ESTIMATED USING AC SUSCEPTIBILITY MEASUREMENTS

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The aim of the present work is the study of the non-equilibrium vortex matter phase diagram of the recently discovered $Ba_{1-x}K_xFe_2As_2$ superconductor, using high quality single crystals, by employing ac-susceptibility and specific heat measurements. The H_{c2}-line was estimated from specific heat measurements using an entropy conservation method. The irreversibility lines ($H_{irr}(T,\Theta)$) were estimated from the onset for non-zero amplitude of the third harmonic ac-susceptibility. The isothermal and isofield measurements of the real part of the fundamental ac-susceptibility $\chi'(T)$ revealed diamagnetic local minima near and below the superconducting transition. The local diamagnetic minima are directly related with local peaks in the critical current. The particular variation of the critical current is known as peak effect and has been observed in all type II superconductors with weak pinning disorder. Peak effect was observed only for fields $H>H^*$,($H^*\approx 2$ kOe). For magnetic fields near H^*, the diamagnetic local minima are transformed into sharp drops in the critical current, with height tending to zero as we approach the critical temperature. The peak effect line is located below and near H_{irr}-line. Comparison of our data for $Ba_{1-x}K_xFe_2As_2$ superconductor, with conventional, MgB_2 and cuprate superconductors will also be presented.

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ENGINEERING HIDDEN ORDER PARAMETERS AND QUARTETS IN CORRELATED NANOSTRUCTURES

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A general rule has been revealed recently [1] that predicts hidden symmetries and induced order parameters. This uncovers a universal interaction between the order parameters that have tendency to aggregate into *quartet*s of order parameters. Overlapping quartets form more complicated patterns of condensates. Many of these quartets involve magnetic order parameters. The relevance of the rule has been tested with fully solved multicomponent theories in the momentum space for dozens of examples of quartets, and it has been associated with numerous phenomena basically involving materials tuned near a quantum critical point regime where the emergence of domes via first order transitions prevents criticality.

Here we present the methodology adopted for real space calculations that allow an additional test of the rule of [1] in correlated nanostructures. We consider extended Hubbard models on square lattices and we solve them at the mean field level with the Bogoliubov De Gennes approach. We have implemented in the formalism all relevant symmetry channels allowing for a systematic study of the eventual emergence of many different types of quartets. We have considered various types of geometries and correlated nanostructures and we always confirmed with a series of numerical experiments, that engineering of the quartets is a totally realistic and relevant approach.

Moreover, unpredicted phenomena have been identified, resulting from the combination of the symmetry operations related with the involved quantum ordered states of the quartets with symmetry constraints resulting from the edges. Exploiting these findings we can propose new strategies for extracting the topologically non trivial states. Finally, engineered quartets may explain a number of puzzling phenomena, including phenomena at the interfaces of $LaAlO_3/SrTiO_3$ and other oxides interfaces.

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COMPARATIVE EVALUATION OF AC MAGNETIC HYPERTHERMIA EFFICIENCY OF FERRITE-BASED MAGNETIC NANOPARTICLES

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INTRODUCTION

In this study, Mn and Co ferrite nanoparticles were synthesized by a facile, low-cost, environmentally friendly and high yield methodology based on the aqueous coprecipitation of proper salts and evaluated as AC magnetic hyperthermia agents. Firstly, structural, morphological and magnetic characterizations were performed to determine crucial factors for optimizing their heating potential (such as size, polydispersity, saturation magnetization, coercivity). In order to study the impact of medium properties on heating mechanisms (Brownian and/or Néel relaxation, hysteresis losses) and consequently on AC magnetic hyperthermia, synthesized nanoparticles were dispersed in different solvents with varying concentration and viscosity, namely water and Agar. Eventually, nanoparticles with optimum features were, directly injected in three different cell lines: (a normal one and two cancer ones) to check their performance in-vitro. The quantifiable measure of heating efficiency i.e. the Specific Loss Power (SLP) was strongly affected by the dispersion medium and its properties. The comparative results of the AC hyperthermia efficiency of ferrite nanoparticles in combination with the in-vitro study coincide with the magnetic features and their tunability may be further exploited for AC magnetic hyperthermia driven applications.

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Fe@SiO_2 CORE-SHELL MAGNETIC NANOPARTICLES: CHEMICAL AND COLLOIDAL STABILITY STUDIES FOR BIOMEDICAL APPLICATIONS

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This abstract describes the synthesis of core-shell Fe@SiO_2 magnetic nanoparticles (MNP), which combines high magnetization of the metallic core with the biocompatibility and wide versatility for functionalization of the silica shell. Fe@SiO_2 MNP were obtained by controlled reduction of magnetite MNP previously coated with silica using modifications of Stöber method [1]. Uniform Fe_3O_4 MNP of 15 nm and 30 nm were obtained by thermal decomposition of iron oleate [2] and precipitation of an iron(II) salt ($FeSO_4$) in aqueous medium [3]. MNP were coated with a 5 nm thick silica layer (Figure 1). The controlled reduction and subsequent passivation lead to particles consisting of a small iron core responsible for a high saturation magnetization and superparamagnetic behavior at room temperature, surrounded by an iron oxide and a silica layer responsible for the chemical and the colloidal stability at pH 7. These mentioned properties make this material a strong candidate for biomedical applications.

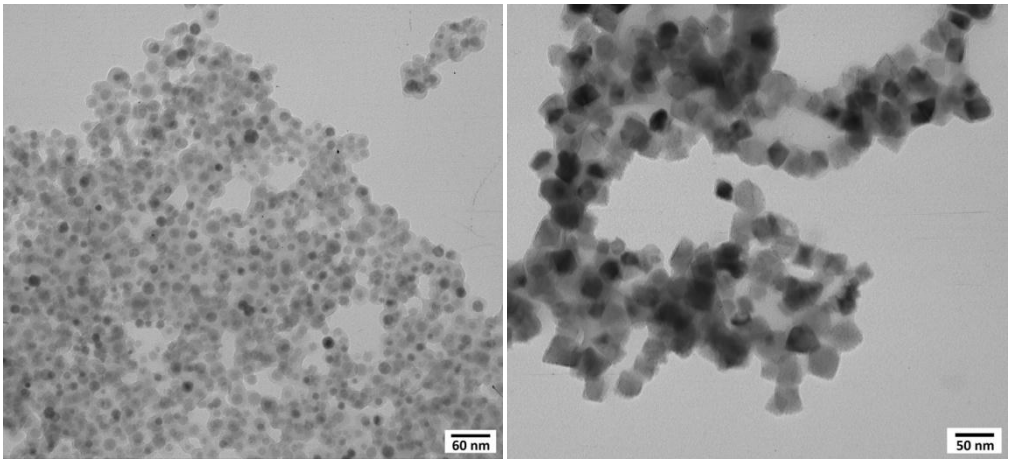

Figure 1. Silica-coated magnetic nanoparticles.

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CORE-SHELL FE/FE-O AND HOLLOW FE-O BASED NANOPARTICLES FOR HYPERTHERMIA APPLICATIONS

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Iron/iron oxide core-shell and hollow maghemite nanoparticles were synthesized by the thermal decomposition of iron pentacarbonyl in the presence of octadecene and oleylamine as surfactants. The particles size was tuned by controlling the injection temperature of iron precursor and by changing the concentration of oleylamine, while the core-shell and hollow morphology have been obtained by tuning the oxidation steps. The surface of such nanoparticles was modified through removal of the organic, hydrophobic layer and adsorption of TMAOH, which provides the nanoparticles with sufficient surface charge to be fully re-dispersed in aqueous solution. After surface modification, particles are well suspended in water and retain their core–shell and hollow morphology. The hyperthermia behavior of aqueous solutions of both the core/shell and hollow nanoparticles is currently under investigation and the results will be reported.

This study has been supported by NSF and the European IRSES NANOMAG Project N. 295190.

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AMPEROMETRIC SENSOR FOR GLUCOSE-6-PHOSPHATE USING PRUSSIAN BLUE MODIFIED SCREEN-PRINTED ELECTRODE

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ABSTRACT

Glucose-6-phosphate (G6P) plays an important role in carbohydrate metabolism of all living organisms [1]. Compared to the conventional analytical methods available for estimation of G6P, the biosensors having relative simplicity, specificity, low-cost and fast response time are a promising alternative [2]. In this study, we have developed a G6P biosensor based on screen-printed electrode [3] utilizing Prussian Blue (PB) nanoparticles and two other enzymes, glucose-6-phosphate dehydrogenase (G6PDH) and glutathione reductase (GR). G6PDH catalyzes the specific dehydrogenation of G6P consuming cofactor $NADP^+$ and produces 6-phosphogluconate and NADPH [4]. Again, in presence of GR, PB nanoparticles undergo redox reaction at WE surface and oxidize the product NADPH to $NADP^+$. PB nanoparticles also acted as a mediator and thereby enhanced the rate of electron transfer in a bi-enzymatic reaction. PB nanoparticles were synthesized using co-precipitation technique [5]. The Fourier transform infrared spectroscopy and energy-dispersive X-ray spectroscopy studies confirmed the formation of PB, whereas, the atomic forced microscopy revealed that PB nanoparticles were about 25-30 nm in diameter. Various optimization studies, such as pH, enzyme and cofactor loading, etc. were conducted to obtain maximum amperometric responses for G6P measurement. The developed G6P biosensor showed a broad linear response in the range of 0.01-1.25 mM (figure 1) with a detection limit of 2.3 □M and sensitivity of 63.3 □A/mM at a signal-to-noise ratio of 3 within 15 s at an applied working potential of -100 mV. The proposed G6P biosensor also exhibited good stability, excellent anti-interference ability and worked well for serum samples.

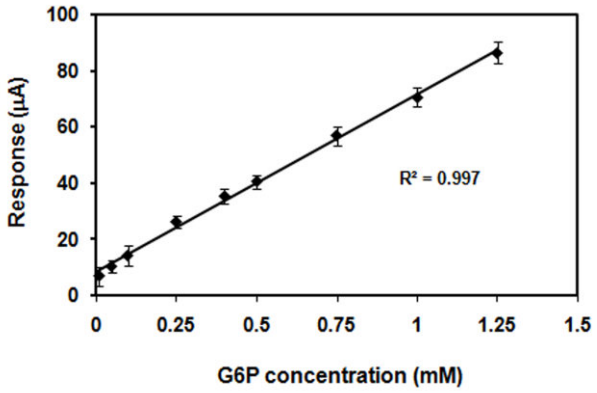

Figure 1. Calibration curve for G6P estimation using PB nanoparticles and enzyme-modified SPE (n=3)

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MAGNETOSTRUCTURAL PHASE SEPARATION INDUCED BY GEOMETRICAL FRUSTRATION

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Complex electronic-phase inhomogeneities are often encountered in transition metal oxides with simultaneously active multiple degrees of freedom. In insulating spin systems they are rare, though predicted, and can be born out of geometrical frustration leading to competition of different states.

The triangular lattice antiferromagnet α-$NaMnO_2$ is intriguing in this respect as it features unexplained coexistence of long- and short- range magnetic correlations below the Néel ordering and anisotropically strained crystal structure above it [1]. Here, we review our comprehensive structural and magnetic studies, including high-resolution synchrotron X-ray diffraction, local-probe NMR and μ^+SR, which in a complementary fashion provide a new insight to α-$NaMnO_2$ [2]. The current experiments reveal an unprecedented magnetostructurally inhomogeneous ground state, with nanoscale regions of competing monoclinic and triclinic structures (Figure 1) entailing different magnetic order. This intriguing state that stems from the near-degenerate structures and is endorsed by the inherent geometrical frustration of the triangular spin lattice, provides a paradigm of nanoscale inhomogeneity in an insulating spin system coupled to phonons.

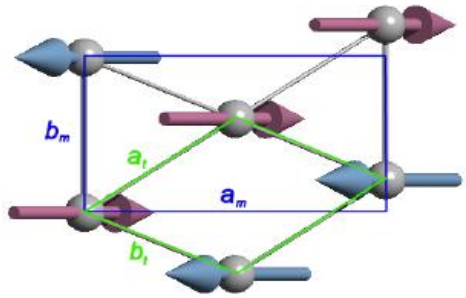

Figure 1. Schematic of the lattice-distortion in α-$NaMnO_2$ at the transition (Néel ordering) from the monoclinic (m) to the triclinic (t) phase. The Mn-Mn antiferromagnetic spin-2 chains shift along b_m-axis.

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THE EVOLUTION FROM SPIN ICE TO SPIN LIQUID IN THE COMPOUNDS $Ho_{2-x}Tb_xTi_2O_7$

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The spin ice and spin liquid are two new kinds of spin cooperation ground state behaviors based on magnetic frustration[1]. $Ho_2Ti_2O_7$ was firstly discovered to be typical spin ice compound[2], while up to now, $Tb_2Ti_2O_7$ is only one compound to be confirmed as spin liquid[3]. We synthesized $Ho_{2-x}Tb_xTi_2O_7$ (x=0 , 0.5 , 1 , 1.5 , 2) series polycrystalline compounds, and investigated the evolutions of structure and basic magnetic properties of these compounds by the measurements of x-ray diffraction in room temperature and of magnetic susceptibility between 2K-300K under 50 Oe magnetic fields, respectively. The fitting lattice constants, Van-Vleck paramagnet factor χ_0, Curie's constants, Curie-Weiss temperature, and effective Bore moment are exhibited in Table.1. Further, we can estimate the energy scalar D of long-distance dipole interaction for pyrochlore structure compounds $Ho_{2-x}Tb_xTi_2O_7$ in their magnetic interaction Hamiltonian [4]:

$$H = -J\sum_{(ij)} \vec{S}_i^{z_i} \cdot \vec{S}_j^{z_j} + Dr_{nn}^3 \sum_{j>i} \frac{\vec{S}_i^{z_i} \cdot \vec{S}_j^{z_j}}{\left|\vec{r}_{ij}\right|^3} - \frac{3(\vec{S}_i^{z_i} \cdot \vec{r}_{ij})(\vec{S}_j^{z_j} \cdot \vec{r}_{ij})}{\left|\vec{r}_{ij}\right|^5}$$

Based on effective Bore moments and lattice constants, the dipole interaction contents D for all investigated compounds are also given in table 1.

Table 1 : Fitting parameters of $Ho_{2-x}Tb_xTi_2O_7$

x	Lattice constants (nm)	X_0 (10^{-3}emu/mol)	Curie's constants (K)	Curie-Weiss temperature (K)	Effective moment (μ_B)	D (K)
0	1.0091	0.75	12.84	0.60	10.11	2.94
0.5	1.0102	0.14	12.75	-4.10	10.07	2.89
1	1.0108	-0.59	12.18	-8.53	9.85	2.76
1.5	1.0160	-0.93	12.13	-15.38	9.82	2.71
2	1.0162	-1.87	11.96	-18.00	9.75	2.68

The results of table 1 show that with increase of x, i.e. the crossover from spin ice $Ho_2Ti_2O_7$ to spin liquid $Tb_2Ti_2O_7$, the lattice constants of the compounds increase, but, Curie's constants, the effective moment, the energy scalar D of dipole interaction decrease. Especially, Curie-Weiss temperature changes from positive value of pure $Ho_2Ti_2O_7$ to negative values of Tb doping compounds $Ho_{2-x}Tb_xTi_2O_7$, revealing a transition from ferromagnet to antiferromagnet accompanied with the crossover from spin ice $Ho_2Ti_2O_7$ to spin liquid $Tb_2Ti_2O_7$

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THERMODYNAMIC BEHAVIOR OF DILUTED TRIANGULAR ISING ANTIFERROMAGNET IN A FIELD

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INTRODUCTION

It is known that a geometrically frustrated Ising antiferromagnet on a triangular lattice (IATL), due to high degree of degeneracy, shows no long-range ordering at any finite temperature. However, application of an external magnetic field or injection of quenched nonmagnetic impurities, either uniformly or selectively, can at least partially lift this degeneracy, relieve frustration and lead to long-range ordering.

METHOD

We study the thermal behavior of IATL in the presence of the magnetic field and both uniform and selective dilution by an effective field theory (EFT) with correlations. We calculate temperature-field dependencies of standard thermodynamic quantities, such as the magnetization and the internal energy, and the corresponding response functions, i.e. the magnetic susceptibility and the specific heat, for various degrees of the dilutions.

RESULTS AND DISCUSSION

The joint effect of the geometrical frustration, magnetic field, dilution and thermal fluctuations are found to cause some peculiar and unexpected behavior of these quantities in certain regions of the parameter space. The most interesting results are verified by Monte Carlo simulations to detect possible artefacts of the used EFT approximation.

ACKNOWLEDGMENTS

This work was supported by the Scientific Grant Agency of Ministry of Education of Slovak Republic (Grant No. 1/0234/12). One of us (MB) was also supported by the Faculty of Science UPJŠ (Grant ID. VVGS-PF-2013-94).

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CHANGE IN SPEED OF ELECTROMAGNETIC WAVES IN $TbMnO_3$ WITH CYCLOIDAL SPIN ORDER BY EXTERNAL PRESSURE

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Multiferroics (materials with coupled electric and magnetic properties) open up wide prospects for applications in the field of information and energy-saving technologies. The large group of multiferroics comprises media characterized by nonuniform distribution of the magnetic order parameter. The modulated magnetic structures contribute a number of features in the spectrum and dynamics of spin, acoustic and electromagnetic excitations in materials. $TbMnO_3$, for example, has a cycloidal antiferromagnetic structure at temperatures $T < 28$ K [1]. The coupled spin, electro-dipole and electromagnetic waves in $TbMnO_3$ with cycloidal antiferromagnetic structure had been theoretically investigated earlier [2], however the change in speed of electromagnetic waves by an external pressure have not been studied enough.

Studies on the change in speed of electromagnetic waves by external pressure showed that there are some frequency ranges where electromagnetic wave does not propagate, i.e. band gaps is observed. The band gaps frequencies and width depend on the external pressure. Near the band gaps the speed of electromagnetic waves can be changed. So, it is possible to tune the speed of electromagnetic waves in $TbMnO_3$ by the external pressure.

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INFLUENCE OF La AND Ni COSUBSTITUTION ON MAGNETIC AND DIELECTRIC PROPERTIES OF BiFeO3 MULTIFERROICS

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ABSTRACT

The present report deals with the systematic study of the crystalline structure, magnetic and ferroelectric properties of sol-gel process synthesized polycrystalline $Bi_{1-x-y}La_xFe_{1-y}Ni_yO_3$ ($0 \le x \ge 0.2$ and $0 \le y \ge 0.2$) ceramic samples. X-ray diffraction (XRD) patterns revealed that controlled La substitution at Bi site in the popular multiferroic $BiFeO_3$ completely eliminates the usual impurity phases. Detailed Rietveld refinement showed continuous structural evolution of orthorhombic Pbnm phase with the increasing Bi site La and Fe site Ni substitutions due to Fe sites induced lattice distortion. A clean signature of enhanced multi-ferroic behaviour is observed for Ni and La co-substituted samples, due to the size confinement effect of nano-crystallites, the exchange interaction between Fe^{3+} and Ni^{2+} ions and the change in Fe-O-Fe bond angles caused by the co-substitution. The dielectric constant is increased two-fold in low frequency region with the Lanthanum and Nickel co substitutions at A (Bi) and B (Fe) -sites respectively. The Zero-field-cooled (ZFC) and field-cooled (FC) magnetization curves show spin glass like behavior with an embedded ferromagnetic component.

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Magneto-electric characterization of multiferroic $BiMn_7O_{12}$

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Magnetoelectric multiferroics, systems where electrical and magnetic ordering coexist, are extremely interesting for multifunctional devices, with applications in the field of magnetic recording and also in spintronics for the development of new devices based on the additional degrees of freedom given by ferroelectricity [1].

An interesting material belonging to the class of lone-pair driven multiferroics is the quadruple perovskite BiMn7O12 in which ferroelectricity is induced by the stereochemical effect produced by the Bi^{3+} ion. $BiMn_7O_{12}$ polymorphs differing in Mn^{4+} content obtained by solid state reaction synthesis in high pressure and high temperature conditions [2], monoclinic (1.5% Mn^{4+}), rhombohedral (3.0%Mn^{4+}) and cubic (4.5% Mn^{4+}), strongly differ in terms of magnetic and dielectric properties.

In the present work we will compare the magnetic and dielectric characterization carried out for the sample polymorphs, in particular the monoclinic one, and we will discuss the effect of a poling electric field on the magnetic response.

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TEMPERATURE DEPENDENCE OF MAGNETOTRANSPORT PROPERTIES IN $BiFeO_3$ THIN FILMS BY PULSED LASER DEPOSITION

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Multiferroic materials simultaneously exhibiting ferroelectric and magnetic ordering are intensively studied for perspective applications as a result of the coupling between their dual order parameters. They can be used in spintronics and as multi-state memory devices which can be addressed either electrically or magnetically.

In the last decade, an enhanced spontaneous magnetization has been observed in $BiFeO_3$ thin films produced by pulsed laser deposition (PLD) technique could, owing to their more disordered and polycrystalline structure.

In this work, epitaxial and polycrystalline BFO thin films were deposited by pulsed laser deposition on Si and $SrTiO_3$ single crystals with different orientattions. A 60 nm thin $SrRuO_3$ layer, also prepared by PLD, was used as a bottom electrode for the ferroelectric hysteresis characterization. The epitaxial nature of the films on the (100), (110) and (111) crystallographic directions was confirmed by XRD. The thickness of an individual BFO film oscillates between 100-200 nm.The phase and composition of the films were confirmed by X-ray diffraction and Energy Dispersive X-ray spectroscopy, respectively. The magnetization behavior in the temperature range 5 – 300 K has been studied in all deposited films. Magnetoresistance response (MR) has been measured as a function of temperature (in the same temperature interval) in the field range 0 – 70 kOe with a standard four-point technique. MR ratio for a given value of magnetic field H is defined as $MR = [R(H)) - R(H=0)] / R(H=0) \cdot 100$. For T < 100 K, all the films display an high-field, non-saturating, negative magnetoresistance response together with a positive maximum at a magnetic field decreasing with measuring temperature. For higher temperatures, the field behavior of magnetoresistance changed into a parabolic shape, typical of ordinary magnetoresistance. Correspondingly, magnetic hysteresis loops changed from a highly ferromagnetic state to a much weaker ferromagnetic contribution superimposed to a diamagnetic phase. The magnetoresistance response will be interpreted in the light of the magnetic state.

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TEMPERATURE DEPENDENCE OF HYPERFINE FIELDS IN ε-Fe_2O_3 NANOPARTICLES

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We present here the temperature dependence of the parameters from Mössbauer spectra of □-Fe_2O_3 nanoparticles in a silica matrix. Samples were prepared by sol-gel technique starting from molecular precursors both for Fe_2O_3 and for silica [1] and they were characterized by XRD, TEM, HRTEM (see Fig.1) and DC magnetic measurement. X-ray powder diffraction pattern of □-Fe_2O_3 was identified and□Fe_2O_3 and □-Fe_2O_3 as minor iron oxide phases were observed. Using the fit of log-normal distribution to the experimental distribution of particles, obtained from the TEM micrographs, the characteristic size of particles d_0 ~ 24 nm was derived. The coercivity of ~2.1 T at room temperature was observed. The transmission Mössbauer spectra were acquired in the external magnetic fields up to 6 T in the temperature range 4.2-300 K which covers the magnetic states of both above and below the transition at ~100 K. The information on the effective hyperfine fields and orientations of the local magnetic moments derived from the spectra support the concept of the core-shell model [2,3] for the □-Fe_2O_3 nanoparticles with essentially collinear ordering of the moments in the core and a random one in the shell.

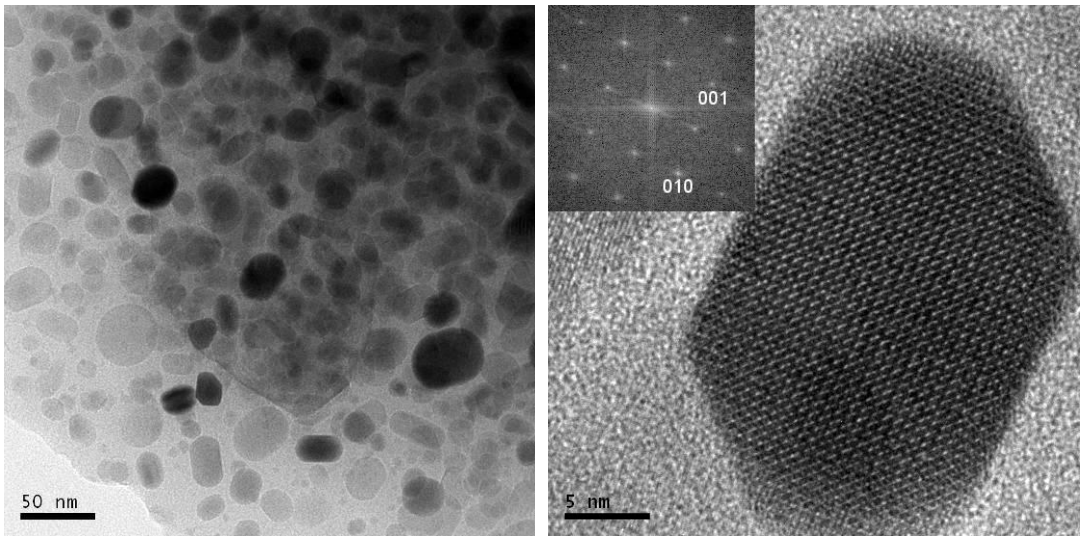

Figure 1: Images of □-Fe_2O_3 particles in SiO_2 matrix – TEM bright field (left), HRTEM with diffraction pattern (right) viewed along direction [100]

Acknowledgement: The authors thank for the support under the grants GACR P204/10/0035 and GAUK 8313/2013.

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THEORY OF QUANTUM PHASE TRANSITION IN $Ba_3Cr_2O_8$ SPIN-DIMER SYSTEM

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Quantum spin liquids have been intensively studied in last few decades. They are characterized by a finite correlation length at zero temperature and a gap in energy spectrum. One of the types of such a systems is dimer systems, which consist of weakly coupled dimers with strong antiferromagnetic interaction between spins within a dimer. $Ba_3Cr_2O_8$ has dimer structure where Cr^{5+} ions carries S=1/2 momentum. At low temperatures properties of crystal are described by Heisenberg Hamiltonian with anisotropic couplings because of low C2/c crystal symmetry [1].

Earlier authors in letter [1] proposed some model of exchange interactions in the crystal and in study [2] other authors made some calculations with such a model with Hartree-Fock-Popov approach. We found that their model conflicts with experimental data and proposed a new one. Zero field properties such as energy spectrum were successfully described by our model. Properties of quantum phase transition near critical field were calculated using technique from [3], they are also in good agreement with experimental data.

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CHARGE ORDER IN MAGNETITE BELOW VERWEY TRANSITION STUDIED BY ^{57}Fe MÖSSBAUER SPECTROSCOPY

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Magnetite Fe_3O_4 is a mixed-valence transition metal oxide with with inverse spinel structure. At high temperatures the crystal symmetry is cubic (symmetry space group *Fd3m*) and both NMR and Mössbauer spectroscopy do not distinguish Fe^{2+} and Fe^{3+} ions on the octahedral [*B*]-sites, pointing to their delocalized character. At the Verwey temperature ($T_V \approx$ 120-125 K) magnetite undergoes a first-order phase transition [1-2]: the crystal symmetry is lowered to monoclinic and the electric conductivity drops down by more than two orders of magnitude pointing to the electron localization. In the simple model proposed by Verwey [3], ferric and ferrous ions alternate regularly on the [*B*]-sites. Senn reports in [4] the low temperature superstructure of magnetite, determined by high-energy X-ray diffraction with an almost single-domain grain. Ordering of distorted FeO_6 octehedra show that Verwey´s hypothesis is roughly correct and that the charge order is consistent with a recent calculation [5].
NMR measurements [6-7] agreed with the monoclinic superstructure with *Cc* space group symmetry and thus 16 inequivalent [*B*]-sites for iron. We present here isomer shifts and quadrupolar splitings from in-field Mössbauer spectra at 4.2 K of single-crystalline (100) platelet. The Mössbauer spectra were fitted with help of the values of hyperfine fields derived from NMR [7] of the same single crystal at the same temperature in order to eliminate a large number of fitting parameters. After cooling the sample below T_V a preferential orientation of the magnetic moments is indicated normal to the plane of the platelet.

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MAGNETIC STRUCTURE AND PROPERTIES OF A Sr_3CuIrO_6 SPIN CHAIN

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We have studied the magnetic structure and properties of Sr_3CuIrO_6 as a function of temperature and field, using AC susceptibility, magnetization, and neutron powder diffraction. Three characteristic temperatures T_2 = 17 K and T_1 = 5.5 K and T_f ~ 5 K were observed in the susceptibility data, and we propose that this materials is a spin glass below T_f.

T_1 is only detectable in the presence of an applied field perpendicular to <101>. T_2 and T_f are present with and without field, though both are field dependent and T_f also shows strong frequency dependence. This indicates spin glass behavior, and is supported by a splitting of field cooled and zero field cooled magnetization curves below 5 K, and by magnetisation versus magnetic field curves at 2 K, which show a small hysteresis, with a saturation moment of $0.4\mu_B$ per formula unit for fields up to 9 T perpendicular to <101>, and no saturation below 9 T for fields parallel to <101>.

Below T_2 our measurements are also characteristic of a spin glass, but we believe the phases above and below T_f are distinct and of different origin.

No evidence of long range magnetic order was found from neutron diffraction.

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COUPLING OF LATTICE, ORBITAL AND SPIN DEGREES OF FREEDOM IN FRUSTRATED p-ELECTRON COMPOUND Cs_4O_6

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Complexity of phases is a common theme in systems with simultaneously active degrees of freedom – spin, charge, orbital, and phonon [1]. Exotic spin ground states, multiferoic behavior and nanoscopic phase segregation of competing phases in such systems were so far almost exclusively limited to the *d*−electron systems. On the other hand the magnetism in p−electron systems is rare as p-orbitals generally show strong tendency toward formation of covalent bonds. However, in alkali oxides the valence electrons reside in states with almost purely oxygen character. In superoxide anion O_2^- three electrons occupy doubly degenerate π^* molecular orbitals making them extremely susceptible to the structural distortions. In a prototypical CsO_2 this led to the particular π^* orbital ordering forming a one-dimensional $S = 1/2$ antiferromagnetic spin chains [2]. This order is strongly coupled to the tilting and displacement of O_2^- units providing an additional orientational degree of freedom.

In A_4O_6 sesquioxides (A=alkali metal) a mixed valence state arising from the coexistence of O_2^- and O_2^{2-} anions is promising even more complex behavior. Experimental and theoretical investigations of Rb_4O_6 suggested that it is a magnetically frustrated insulator where charge fluctuations are suppressed by the strong on-site electron correlations [3,4]. Here we report on the comprehensive ^{133}Cs NMR and X-band EPR study of isostructural Cs_4O_6 [5]. We found a highly disordered low-temperature magnetic state of frozen O_2^- moments below 50 K. Orbital order melts at around 150 K and at higher temperatures strong orbital fluctuations were found. Large amplitude O_2 librations set in above 320 K. Employing different cooling procedures, i.e. slow versus rapid cooling, O_2 units orientationally order differently just below room temperature and define the particular low-temperature orbital and magnetic state. Cs_4O_6 thus appears as an exciting strongly correlated electron system with a simple cubic structure but with strong coupling between the O_2 molecular orientational ordering, π^* orbital ordering and exchange interactions between O_2^- moments. In this respect it is analogous to the more studied d− electron systems where similar phenomena can be found for instance in manganites, cobaltates, nickelates or even cuprates.

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OCCURRENCE OF SINGLE CRYSTAL $La_{0.57}Ba_{0.43}Mn_{1.41}O_{7.30}$ NANORODS on $La_{0.67}Ba_{0.33}MnO_3$ PEROVSKITE MANGANITE

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Single crystal nanorods of $La_{0.57}Ba_{0.43}Mn_{1.41}O_{7.30}$ were found to grow on $La_{0.67}Ba_{0.33}MnO_3$ due to self-fluxing. The diameter of the nanorods range from 100 to 200 nm and have a length of about 5 to 200 microns. The morphological and compositional properties of the rods were investigated by scanning electron microscopy using energy dispersive spectroscopy and by high-resolution electron microscopy. X-ray diffraction studies verified the rhombohedral perovskite structure for both the nanorods and the main material. The temperature dependence of magnetization was measured under 100 Oe in zero-field-cooled (ZFC) and field-cooled (FC) protocols. The Curie temperature was above the room temperature in single crystal rods. The single crystal rods kikuchi line was observed electron backscatter diffraction which was used to crystallographic information to determined the crystal structure.

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PROPAGATION OF ELECTROMAGNETIC WAVES IN LAYERED STRUCTURE TYPE II SUPERCONDUCTOR – TYPE II MULTIFERROIC

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About 10 years ago a novel class of multiferroics (type II multiferroics), in which magnetism causes ferroelectricity, has been discovered [1]. In such materials spontaneous polarization appears due to cycloidal anti- or ferromagnetic structure. On the other hand, another material, which is also very promising for practical use, - superconductors - has long investigated. The electrodynamical properties of structures type-II superconductor – ferromagnetic, superconductor – dielectric [2,3] have been studied earlier. However, the electrodynamical properties of structure type-II superconductor – type II multiferroic have never been studied. Present work is devoted to theoretical investigation of electromagnetic waves propagation in such structure, placed in external magnetic field, on example of well known materials $Y_1Ba_2Cu_3O_7$ and $TbMnO_3$.

The study shows, that electromagnetic wave can be enhanced by a moving lattice of Abrikosov's vortices. This effect depends on transport current density in superconductor layers, its thickness, external magnetic field and incidence angle of the electromagnetic wave. This enhancing is also different for electromagnetic waves of different frequencies. So, electrodynamical properties of such structure may be efficiently controlled by many parameters.

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NON-THERMAL EXCITATION OF SPIN PRECESSION IN A COBALT/GARNET HETEROSTRUCTURE

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Recent experiments on light-induced demagnetization use femtosecond laser pulses to manipulate spins in thin ferromagnetic metal films via thermal effect. Non-thermal optical control of the magnetization has been demonstrated in ferrimagnetic garnet systems via a photoinduced magnetic anisotropy. The basic idea of the investigation had been to use a photomagnetic garnet film as underlayer for the growth of ultrathin Co films. Ultrafast magnetization dynamics in such Co/garnet heterostructures by femtosecond laser excitation using time-resolved magneto-optical tools has been studied. The amplitude and precession frequency of the magnetization dynamics were measured for different amplitude of external magnetic field and linear polarization of the pump light. It is demonstrated that damped oscillations in the Faraday rotation transients representing a precessional motion of the magnetization vector are observed in both 2 nm Co layer and garnet of the bilayer with two distinct frequencies with difference about two time of the magnitude [1]. The obtained results shows the possibility of non-thermally exciting and controlling the magnetization of a ferromagnetic metal layer using femtosecond laser pulses by the ultrafast photomagnetism effect in a garnet underlayer.

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ULTRAHOT BOSE-EINSTEIN MAGNON CONDENSATE IN A PHASE SPACE

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Bose-Einstein condensation (BEC) of quasi-particles (QPs) such as magnons [1] or photons [2] can be achieved even at room temperature by increasing density of a QP gas. It was assumed (see for example [1]) that due to the huge number of thermal QPs at 300 K the QP temperature remained constant and a small quantity of additionally injected particles changed only the chemical potential of the gas. Our observations show the paramount importance of thermal effects in this process.

The transient dynamics of a magnon gas was measured in a phase space by means of Brillouin light scattering spectroscopy [3] in a single-crystal ferrimagnetic film (yttrium iron garnet) at room temperature. Magnons were injected to the narrow spectral area at 7 GHz by parametric electromagnetic pumping**.**

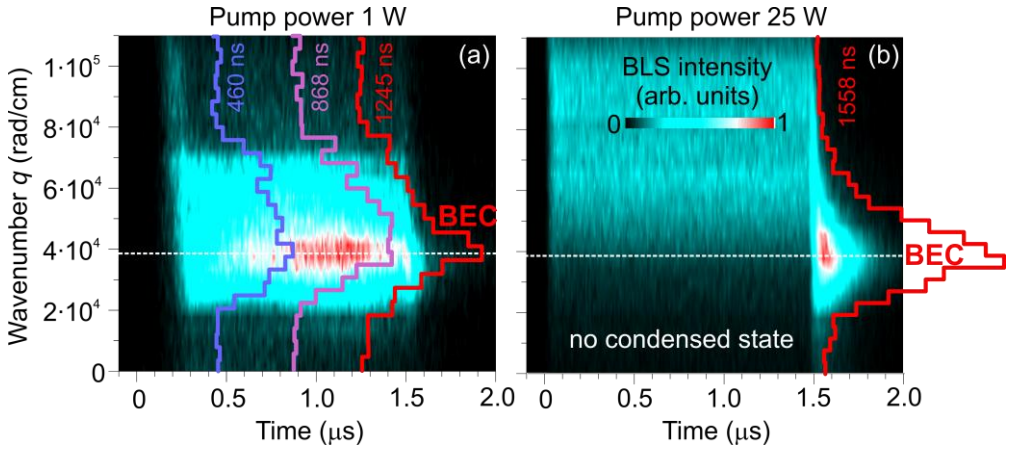

Figure 1. Evolution of gaseous magnons and magnon BEC at the bottom of QP spectrum.

At low pumping power of 1 W, corresponding to moderate heating of the magnon gas, the clearly visible spontaneous concentration of magnons at the global energy minima (5 GHz, 3.93×10^4 rad/cm) occurs (Fig.1a). The increase of the pumping power results in depopulation of the lowest energy state. At pumping power of 25 W the magnon gas is drastically (up to 30'000 K) overheated and no condensation developed during the pump pulse (from 0 to 1.5 μs). The BEC appears as a result of a local spectral cooling of the free-relaxing magnon gas after the pump is switched off (Fig.1b). Thus, the magnon BEC evolves in a narrow spectral region which temperature significantly (thousands kelvins) exceeds the temperature of the thermal bath.

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