(I) Magnetostrictive effect
(II) Magnetic shape memory materials

Kathrin Dörr and Sebastian Fähler, IFW Dresden
Postfach 270116, 01171 Dresden, k.doerr@ifw-dresden.de, s.faehler@ifw-dresden.de

Table of Contents

Magnetostriction is a property of magnetic materials that causes them to change their shape when subjected to a magnetic field. It was first observed in 1842 by J. Joule in a Ni sample. It is a manifestation of the spin-orbit coupling.
Magnetostrictive materials are used to convert magnetic into kinetic energy and vice versa, i. e. they are utilized in actuators and sensors. Key parameters for application are the achievable strain and stress, working field and temperature. Maximum ordinary magnetostriction reaches values of 0.2 % in a field of H = 2 kOe for Terfenol-D (TbxDy1-xFe2). However, strains can be in the range of several percent if the magnetic field drives a reorientation of the crystal structure (by moving twin boundaries like in a martensite) or even induces a different phase. Both mechanisms are found in magnetic shape memory alloys which show record strains up to 10 %.
This lecture introduces the fundamental mechanisms of magnetostriction and the resulting requirements for materials. Some of the currently studied magnetic shape memory alloys are discussed.

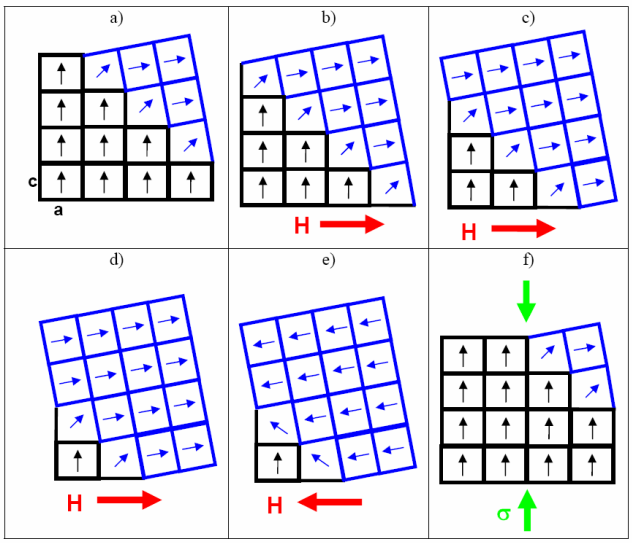

Fig.1: a) to d) Magnetically induced structure reorientation in a magnetic shape memory alloy. Field-induced movement of a twin boundary causes strains up to 10 %. e) The field reversal is strain-free. f) Recovery of initial state by compressive stress.

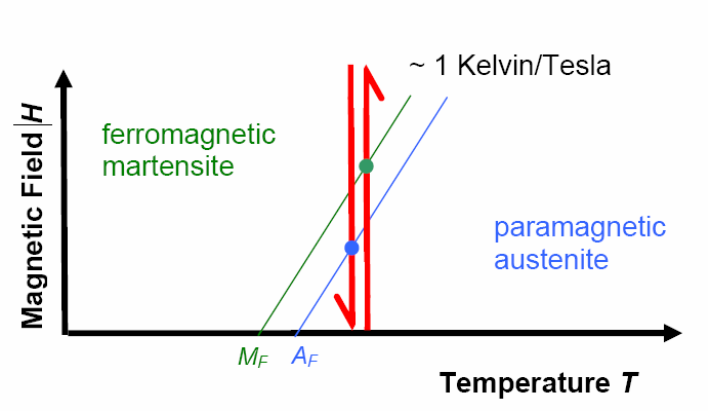

Fig.2: Field-induced transition between a ferromagnetic martensitic and a paramagnetic austenitic phase during an actuation cycle of MIM (magnetically induced martensite) type. MF and AF mark the martensitic and austenitic finish temperature, respectively.

References:

[1] M. Marioni, R. O'Handley, S. Allen, Appl. Phys. Lett. 83, 3966 (2003)
[2] O. Heczko, L. Straka, J. Appl. Phys. 94, 7139 (2003)
[3] M. Wuttig, L. H. Liu, K. Tsuchiya, R. D. James, J. Appl. Phys. 87, 4707 (2000)
[4] P. J. Webster, K. R. A. Ziebeck, S. L. Town, M. S. Peak, Phil. Mag. B 49, 295 (1984)
[5] K. Ullakko, J. K. Huang, C. Kantner, R. C. O´Handley, V. V. Kokorin, Appl. Phys. Lett. 69, 1966 (1996)
[6] A. Sozinov, A. A. Likhachev, N. Lanska, K. Ullakko, Appl. Phys. Lett. 80, 1746 (2002)
[7] A. N. Lavrov, S. Komiya, Y. Ando, Nature 418 (2002) 385
[8] R. D. James, M. Wuttig, Phil. Mag. A 77 1273 (1998)
[9] S. Raasch, M. Doerr, A. Kreyssig, M. Loewenhaupt, M. Rotter, J.-U. Hoffmann, Phys. Rev. B 73 064402 (2006)