Pseudodipolar model of surface magnetostriction of thin layers with roughness

T. Szumiata, M. Gzik-Szumiata, K. Brzózka, M. Gawroński, and B. Górka

Department of Physics, Technical University of Radom, 26-600 Radom, Poland

An effective magnetostriction model for monocrystalline thin films of cubic structure is presented. In order to describe a magnetoelastic energy, a pseudodipolar spin-spin interaction was considered which is suitable for modeling both anisotropic exchange coupling and single-ion anisotropy. Motivation of these theoretical studies are the results of the experimental papers [1, 2] which point to the possible effect of roughness and surface strain on magnetostriction in metallic thin films. The object of our investigations was a single magnetic film of t thickness possessing surfaces with cubicoidal steps of σ depth and ξ size repeated in the plane with q space period (Fig. 1). A pseudodipolar magnetoelastic energy was expressed as a sum of two terms: (i) proportional to the value and (ii) - to the space derivative of the exchange integral (or anisotropy radial function) taken for the nearest neighbors distance.

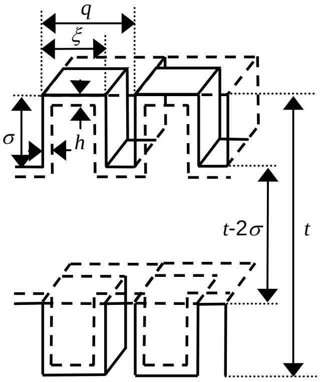

Fig. 1. Schematic picture of roughness structure of thin film surfaces.

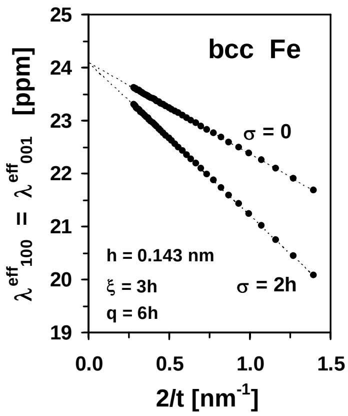

Fig. 2. Thickness dependence of pseudodipolar magnetostriction of ideal and rough Fe films.

Appropriate lattice summations of strain dependent energy contribution was calculated symbolically. Only in the first atomic layer at the surface a significant difference of magnetoelastic energy was observed with respect to the film interior. An effective magnetostriction constant for rough film was determined by estimating the volume of surface region (of h thickness equal to a half of lattice constant a_0) and considering the magnetostriction data for bulk material. Linear dependence of effective magnetostriction constant on thickness reciprocal of bcc-Fe film is presented in Fig. 2. Finally, we compared our magnetostriction results with magnetic dipolar contribution calculated in [3].

[1] Y.K. Kim, T.J. Silva, Appl. Phys. Lett. **68** (1996) 2885
[2] M.P. Hollingworth, M.R.J. Gibbs, S.J. Murdoch, J. Appl. Phys. **94** (2003) 7235
[3] H. Szymczak, M. Rewieński, R. Żuberek, J. Magn. Magn. Mater. **139** (1995) 151

Name of the presenting author (poster session II): Tadeusz Szumiata
e-mail address: t.szumiata@plusnet.pl, t.szumiata@pr.radom.pl
http://www.pr.radom.pl/