MAGNETIC AND STRUCTURAL PROPERTIES OF THE ARRAYS OF MAGNETIC NANOWIRES AND LAYERS OF $Co_{(1-x)}Fe_x$ ALLOYS

H.R. Khan[1,2] and K. Petrikowski[1]
[1]FEM, Materials Physics Department, Schwaebisch Gmuend, Germany and [2]Department of Physics, University of Tennessee, Knoxville, TN. , U.S.A.

Arrays of magnetic nanowires possess very different magnetic properties from their parent bulk materials (1, 2). The diameter, interwire distance and the length of the nanowires effect the magnetic properties such as coercivity (H_c), remanence (M_r) and saturation magnetization (M_s). The magnetic properties are profoundly changed by the magnetostatic interaction among the nanowires. These nanomagnet arrays are interesting both for the practical use e.g. high density magnetic storage media as well as for the fundamental understanding. $Co_{(1-x)}Fe_x$ alloys possess the largest M_s values at room temperature. We have fabricated the arrays of nanowires of 18 nm diameter and interwire distance of 30 nm having compositions $Co_{(1-x)}Fe_x$ (x= 10, 35, 45 and 65 at.%) and length varying between 1.8 and 7 µm by electrodeposition in the pores of anodic alumina (Al 1% Mg) substrates obtained by anodic oxidation. The layers of the same compositions and the thickness varying between 1.2 and 4.0 µm are also deposited on the copper substrates using the same electrolyte. The crystallographic structure as well as the preferred crystallographic orientation of the nanowires and layers are investigated by X-ray diffraction. The nanowire arrays and the layer of composition $Co_{90}Fe_{10}$ consist of hcp and bcc phases. The nanowire arrays and layers of compositions with higher Fe content consist of only bcc structure. The nanowire arrays show a strong perpendicular magnetic anisotropy due to the shape anisotropy and also due to (002) preferred orientation in the case of $Co_{90}Fe_{10}$. The magnetization as a function of field (up to 1 Tesla) and temperature (77 K – 100 K) are measured. The easy axis of magnetization of the arrays of nanowire is parallel to the axes of the nanowires (Fig. 1) and the values of $H_{c\perp}$ vary between 2.477 and 2.690 kOe at room temperature. An enhancement is observed up to 3.294 for the $Co_{55}Fe_{45}$ nanowire arrays at 77 K. The ratio (M_r/M_s) varies between 0.87 and 1.0. In comparison to the nanowire arrays the layers show inplane magnetic anisotropy (Fig. 2) and saturation magnetization values at room temperature vary between 550 G and 3.262 kG and show an enhancement at 77 K. Analysis of the magnetic data of nanowire arrays in relation to the composition, crystallographic structure, diameter and interwire distance and a comparison with the bulk layers will be described.

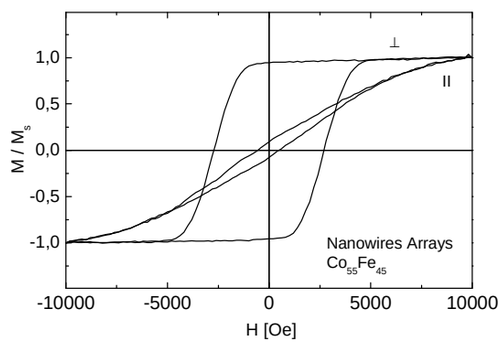

Fig. 1 M / M_s vs. H of nanowire arrays of $Co_{55}Fe_{45}$ (diameter 18 nm)

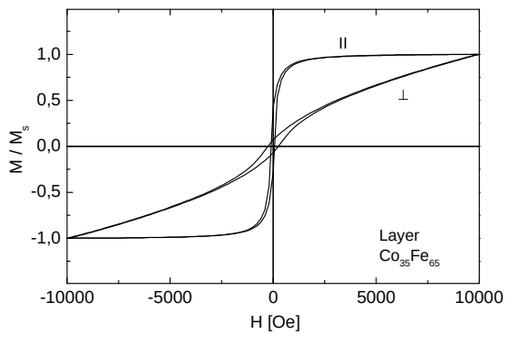

Fig. 2 M / M_s vs. H of bulk layer of $Co_{35}Fe_{65}$ (thickness 1.2 µm)

Acknowledgements
This work was supported by the Bundesministerium für Wirtschaft through Arbeitsgemeinschaft industrieller Forschungsvereinigungen Otto von Guericke e.V. and Grant no. AiF 11429N.

References

1. H.R. Khan and K. Petrikowski, Journal of Magnetism and Magnetic Materials 215-216 (2000) 526-528
2. H.R. Khan and K. Petrikowski, Materials Science and Engineering C (2002) 345-348