

Influences of Film Thickness on the Electrical and Magnetic Properties of CoFeAlO Films

Nguyen Duy Ha¹, Le Anh Tuan², Cheol Gi Kim³, Chong-Oh Kim²,

Seong-Cho Yu³, The-Long Pham⁴ and Manh-Huong Phan^{5*}

¹The Kamerlingh Onnes Laboratory, Leiden University, P.O. Box 9504, 2300 RA Leiden, The Netherlands
²Research Center for Advanced Magnetic Materials, Chungnam National University, Daejeon 305-765, Korea

³Department of Physics, Chungbuk National University, Cheongju 361-763, Korea

⁴Microstructures Group, Department of Physics, University of Bristol, Bristol BS8 1TR, England

⁵Advanced Composites Centre for Innovation and Science, University of Bristol, Queen's Building, Bristol BS8 1TR, England

*Corresponding author: M.H.Pham@bristol.ac.uk, Phone: +441173317917, Fax: +441179272771

Surface magnetism is a topic of growing interest in the world of thin films. This is because symmetry breaking in thin films causes considerable modifications in their near-surface magnetic behavior [1,2]. One of the most pressing issues relating to surface magnetism is nowadays to understand what factors realistically determine such differences in the magnetic properties of the thin films from the corresponding bulk materials.

In this work, the influences of film thickness on the electrical and magnetic properties of CoFeAlO films have been systematically investigated via means of vibrating sample magnetometer, permeability spectra and magneto-optical Kerr effect. The film samples with varying thickness of $t = 600, 800$ and 1200 nm were fabricated by the RF magnetron reactive sputtering technique, using Si (100) substrate under a field of 120 Oe that was applied parallel to the substrate plane. The input power and the mixed Ar + O₂ (3%) pressure were 300 W and 2 mTorr, respectively. It has been shown that the electrical resistivity (ρ) decreases when the film thickness increases; $\rho = 412.5$ for the $t = 600$ nm sample decreases to $= 368.2$ for the $t = 1200$ nm sample. The coercive force and anisotropy field, measured along the easy-axis direction, decreases as the film thickness increases. It is interesting to note that, along the hard-axis magnetization direction, the magnetic hysteresis loop is reversed and the coercive force is negative for $t = 600$ and 800 nm samples. However, this peculiar feature disappears in the case of the $t = 1200$ nm sample, which is probably attributed to the microstructural change occurring in the sample with regard to increasing film thickness. A two layers model has been proposed to explain the reversed magnetization phenomenon in the films. It has also been found that, at a frequency of 1 GHz, the effective permeability measured along the hard-axis magnetization direction decreases from 1252 to 1000 as the film thickness increases from 600 to 1200 nm, respectively. This is likely related to the decrease in the hard-axis anisotropy field as confirmed by VSM and MOKE. The results obtained from VSM and MOKE reveal an increase in magnetic anisotropy in the near-surface region of the film.

REFERENCES

- [1] T. Kaneyoshi, Introduction to Surface Magnetism, CRC, Boca Raton, FL, 1991.
- [2] N. D. Ha, N.T. Thanh, H.B. Kim, C.G. Kim, C.O. Kim, E. Gan, S. Shima, and M.H. Phan, Sol. Stat. Commun. 135, 721 (1999).

Exchange Coupling in FePt-FePt₃ Nanocomposite Films

K.-W. Lin^{1*}, J.-Y. Guo¹, C.-Y. Liu¹, H. Ouyang¹, J. van Lierop², N. N. Phuoc³, and T. Suzuki³

¹Department of Materials Science and Engineering, National Chung Hsing University, Taichung 402, Taiwan

²Department of Physics and Astronomy, University of Manitoba, Winnipeg, R3T 2N2, Canada

³Information Storage Materials Laboratory, Toyota Technological Institute, Nagoya 468-8511, Japan

*Corresponding author: kwlin@dragon.nchu.edu.tw, Phone: +886 4 22851068, Fax: +886 4 22857017

Exchange coupling between a ferromagnet (FM) and an antiferromagnet (AF) is the result of the interaction between FM and AF moments at their common interface [1]. In this study, the structural and magnetic properties of exchange coupled nanocomposite FePt-FePt₃ films were investigated. The [Pt(20 Å)/Fe(15 Å)]₁₀/Pt(30 nm) multilayers were prepared by using an ion-beam deposition technique [2]. X-ray diffraction and transmission electron microscopy results showed that the as-deposited Pt/Fe multilayers consisted of f.c.c. Pt ($a = 3.93$ Å) and b.c.c. Fe ($a = 2.91$ Å) phases. After rapid thermal annealing (600 °C, 6 min.), the samples consisted of a FM f.c.t. FePt ($a = 3.84$ Å, $c = 3.72$ Å) phase and an AF f.c.c. FePt₃ ($a = 3.85$ Å) phase. Annealing created an ordered FePt phase that resulted in a large room temperature coercivity ($H_c \sim 3200$ Oe) compared to the as-deposited film ($H_c \sim 25$ Oe). While no exchange bias field ($H_{ex} \sim 0$) was measured at room temperature, the annealed sample showed significant $H_{ex} \sim 500$ Oe at low temperatures (150 K $\leq T \leq 250$ K), indicative of exchange coupling between FePt and FePt₃. The nanocomposite FePt-FePt₃ films exhibited a strong temperature dependence in H_c . Surprisingly, by contrast to the typical $H_c(T)$ behavior observed in bilayer FM/AF thin films, the $H_c(T)$ of the nanocomposite FePt-FePt₃ films decreased with decreasing temperature. Further increasing the annealing temperature to 700 °C resulted in the decrease of H_c . This is attributed to the transformation of FePt₃ into FePt phase (evidenced by enhanced H_c) at higher annealing temperature.

REFERENCES

- [1] H. Ouyang, K.-W. Lin, C.-C. Liu, S.-C. Lo, Y.-M. Tzeng, Z.-Y. Guo, and J. van Lierop, Phys. Rev. Lett., accepted for publication (2007).
- [2] K.-W. Lin, P.-H. Ko, Z.-Y. Guo, H. Ouyang, and J. van Lierop, J. Nanosci. Nanotech., 7, 265 (2007).