Magnetic Properties of Composites FePt/FeRh Fabricated by Chemical Synthesis*

Hnin Yu Yu Ko, Sho Inoue, Nguyen Nam, Wei Lu and Takao Suzuki
MINT, University of Alabama
*The work was performed at Toyota Technological Institute, Nagoya, Japan

A very high magnetic anisotropy material, such as FePt, is essential for future ultra-high density magnetic recording, as reported[1]. The FeRh of ordered CsCl-type structure undergoes a first-order phase transition from the antiferromagnetic (AF) to ferromagnetic (FM) state at around 100C[2,3]. A successful fabrication of FeRh nano-particles was first repoted by Hnin and Suzuki, which showed the first-order transition of AF to/from FM[4]. This paper discusses the magnetic properties and structures of nano-composite particles of FePt/FeRh fabricated by chemical synthesis method.

Nanoparticles of FePt were synthesized by the co-reduction of iron (II) chloride tetrahydrate and platinum acetylacetonate by superhydride in the presence of oleic acid, oleylamine, 1,2-hexadecanediol, and benzyl ether. Nanoparticles of FeRh were prepared using source material of rhodium (III) acetylacetonate. The detail of preparation is reported elsewhere[5]. For the synthesis of nanocomposite FePt/FeRh, the solutions of pre-prepared FePt and FeRh were mixed with respective composition and stirred for a few hours. All of the preparation processes were carried out under the atmosphere. Post-annealing was carried out in vacuum < $5x10^{-3}$ Pa at 600 C for several hours. The two composites have been fabricated with the mole ratio of (a) $Fe_{64}Pt_{36}/Fe_{39}Rh_{61}$ = 5/1 (FePt-rich phase) and (b) $Fe_{64}Pt_{36}$ /$Fe_{45}Rh_{55}$=0.5/1 (FeRh-rich phase), respectively. X-Ray diffraction patterns indicate that i) as-deposited FePt nanoparticles are of a chemically disordered fcc structure with FePt (111) and (200) peaks, ii) that the annealed FePt is the chemically ordered fct structure, iii) as-deposited FeRh nanoparticles are of the disordered fcc structure, while annealed particles of FeRh is of the ordered phase. Further,an annealed nanocomposite of FePt /FeRh is found to be of the mixture of the order- and disordered phases. The high-resolution–transmission electron microscopy images of FePt /FeRh nanocomposites reveal nano-particles of about 3 nm in size with a uniform distribution.

Figure 1 shows the M vs. T curves for annealed (600C,6h) (a) FeRh nanoparticles and (b) FePt / FeRh nanocomposites. A sharp magnetic-phase transition with a hysteresis width of 5C has occurred in the composite of FePt/FeRh, whereas the hysteresis width for FeRh nanoparticles was about 140C. Although both nano-composites show different magnetization behaviors on temperatures, it is observed that a strong exchange coupling between ferromagnetic (FePt) and anti-ferromagnetic (FeRh) phases exists in both cases.

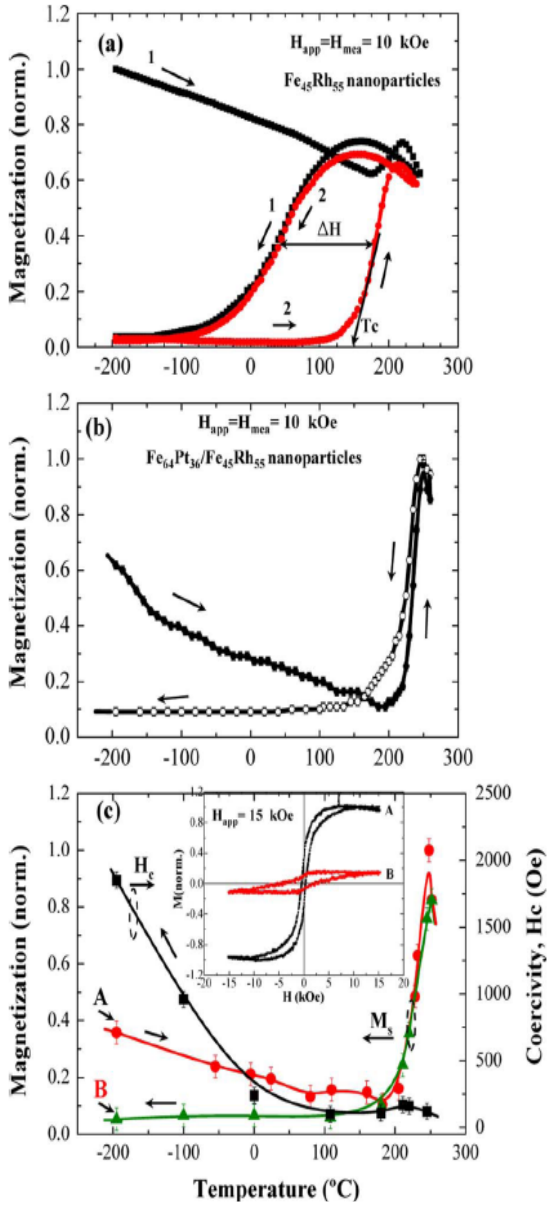

Fig.1 M-T curves for annealed (a) FeRh nanoparticles, (b) and(c) for FePt /FeRh nano-composites under H=10kOe and 15 kOe, respectively. The arrows show the direction of the temperature cycle. △H and Tc represent thermal hysteresis width and critical temperature. Numbers "1" and "2" refer to the first and second heating and cooling cycles.
The temperature dependences of coercivity under the field cooling process [Fig.1(c) insert]: M-H loops at "A" and"B."

References:
[1] S. Kang, J. Jia, S. Shi, D. E. Nikel, and J. W. Harrell, *Appl. Phys.Lett.*, 86, 062503–1(2005).
[2] G. Shirane, C. W. Chen, and P. A. Flinn, *Phys. Rev*., 131, 183 (1963).
[3] J. U. Thiele, S. Maat, and E. E. Fullerton, *Appl. Phys.Lett.*, 82, 2859 (2003).
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(b)

Fig.2(a) Hc and M vs T. (b) H_E vs T for FePt(50)/FeRh(50)

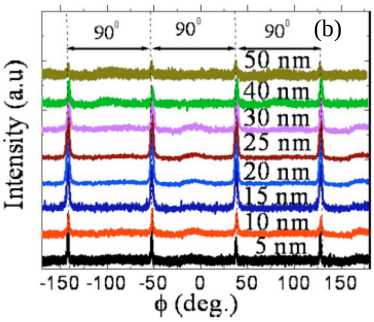

Fig.1 (a) XRD and (b) φ scan for FePt/FeRh (50nm) bilayers with various t_{FePt} thickness.

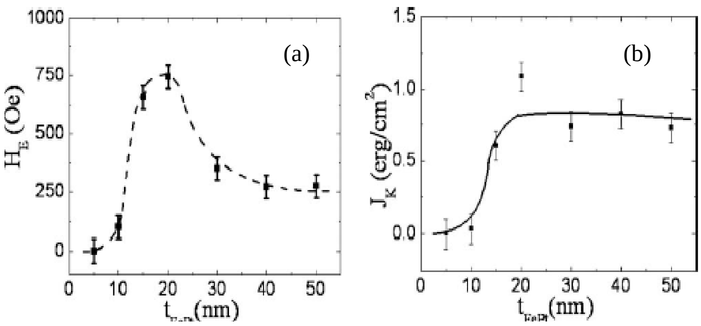

Fig.3 Exchange bias field H_E and Unidirectional anisotropy constant J_K for FePt/FeRh(50nm) bilayer.