Exchange Bias Mechanism of Ferromagnetic/Antiferromagnetic Coupling in FePt/FeRh Bilayers*

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It is known that the chemically ordered FeRh alloys exhibit the first-order magnetic transition from antiferro- to ferromagnetic phase upon heating at around 100C[1]. Thiele *et al*.[2] and Maat *et al*.[3] showed that the coercivity of FePt/FeRh bilayer thin films decreased sharply through an exchange coupling at the transition temperature of the FeRh layer, thus could be a potential candidate for heat-assisted high density magnetic recording media application. However, there has been very little systematic experimental study of the exchange coupling mechanism of such Ferro/Antiferro magnetic bilayers In order to elucidate the exchange coupling mechanism, a systematic experimental investigation of structural and magnetic properties of FePt/FeRh bilayers is carried out.

Bilayers of FePt(t_{FePt})/FeRh(50nm)/MgO with t_{FePt} from 5 to 50nm were fabricated using $Fe_{50}Rh_{50}$ and $Fe_{50}Pt_{50}$ alloy targets by sputter-deposition technique. The substrate temperatures were in the range of 300 – 500C, and the base pressure prior to deposition was better than $5x10^{-8}$Torr. The compositions of FePt and FeRh layers, determined by EDS were $Fe_{48}Pt_{52}$ and $Fe_{49}Rh_{51}$, respectively. Magnetic properties were characterized by VSM, Torque and MOKE, as well as MFM.

Figure 1(a) and (b) show the XRD spectrum of the bilayers with various t_{FePt} for the ($\theta - 2\theta$) and φ scan, respectively, indicating the single-crystalline ordered phase of FeRh, but not confirming the $L1_0$ ordered phase of FePt. Figure 2 (a) shows the magnetization vs. temperature for a single layer FeRh and bilayer FePt/FeRh. The transition temperature for the bilayer is decreased as compared to that for the single layer, the reason for which is believed due to the presence of the effective field resulted from the FePt film, which is favorable for decreasing the transitgion temperature, as demonstrated by the work by Cao et al.[4]. Figure 2(b) shows the temperature dependence of magnetization, coercivity and exchange bias field of FePt/FeRh bilayers. A sharp transition takes place over a temperature range from 120~180C, where H_c decreases sharply due to an exchange coupling. The exchange bias field decreases with temperature up to about 200C where the transition from the antiferro- to ferromagnetic phase is completed. The unidirectional anisotropy constant Jk through the exchange coupling is given in Fig. 3, to be estimated about 0.5~0.8 erg/cm^2.

In summary, the sharp decrease in H_c at around the transition temperature between AF and FM phases for the bilayer FePt/FeRh is observed, higher than that for a single FeRh layer due to the effect of the magneto-static effect resulting from the FePt layer.

References: [1].M.Fallot, Ann.Phy.10,291(1938). [2]. J.-U.Thiele *et al*., *App.Phy.Let*.. 82, 2859 (2003). [3]. S.Matt *et al.*, *Phy.Rev*.B72,214432 (2005). [4].J.Cao et al., *J.App.Phy*. 103, 7F501 (2008).

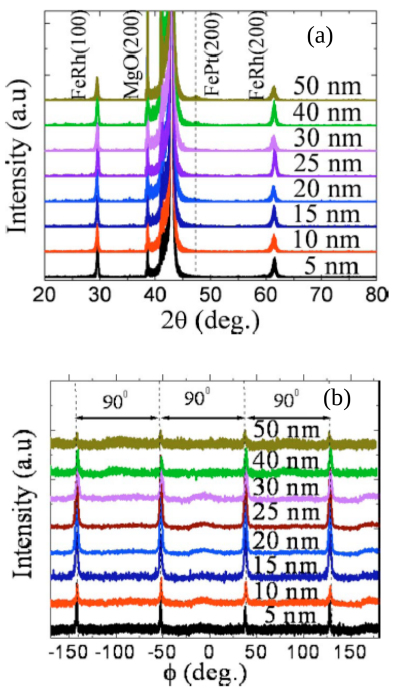

Fig.1 (a) XRD and (b) φ scan for FePt/FeRh (50nm) bilayers with various t_{FePt} thickness.

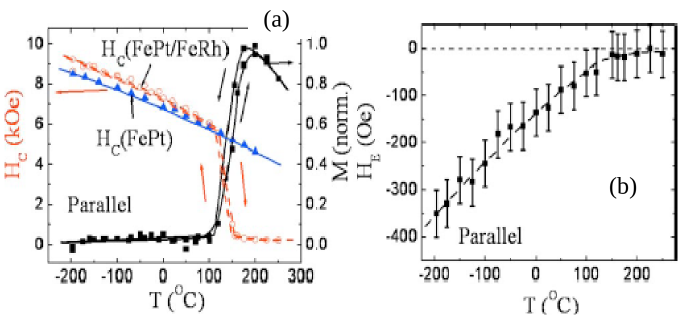

Fig.2(a) Hc and M vs T. (b) H_E vs T for FePt(50)/FeRh(50)

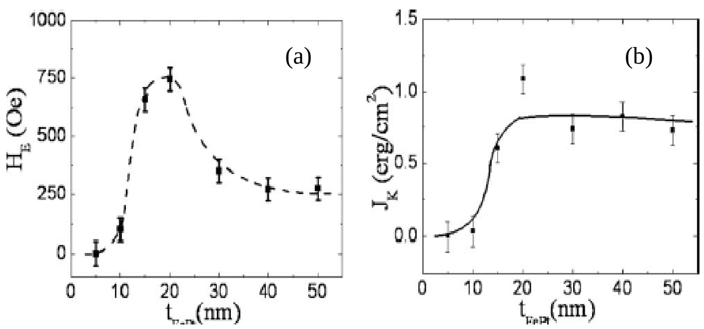

Fig.3 Exchange bias field H_E and Unidirectional anisotropy constant J_K for FePt/FeRh(50nm) bilayer.