

The Study of Structural and Magnetic Transition from Epitaxial Fe/Pt Multilayers to Ordered FePt Thin Films under Annealing

Yu-Sheng Chen (陳佑昇), Chih-Hao Lee (李志浩),
M. -Z. Lin (林銘哲), and Yen-Fa Liao (廖彥發)

Department of Engineering and System Science, National Tsing Hua University, Hsinchu, Taiwan

The $L1_0$ ordered FePt alloy system is a very promising candidate for ultra high recording density media, reach 1 Terabit/inch², due to its high magnetocrystalline anisotropy constant ($K_u \sim 6.6\text{--}10 \times 10^7$ erg/cm³) and perpendicular magnetic anisotropy (PMA) property. The transition from the disordered FePt phase to the ordered one is a very important research topic. In this study, the structural and magnetic transition from epitaxial Fe/Pt multilayers to ordered FePt thin films under annealing were observed with X-ray diffraction, VSM, and XMCD. The structural and magnetic properties as function as annealing temperatures are the key points.

The order parameter increasing with the annealing temperature. After annealing at 500 °C, the FePt (001) ordered peak was observed, the c/a value reached maximum due to the interdiffusion of Fe and Pt atoms under ordering. After annealing at 700 °C, the order parameter reached above 0.95, the $L1_0$ ordered FePt film with growing along (001) orientation epitaxially was obtained.

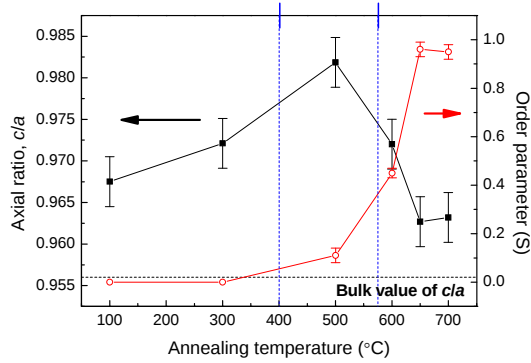


Figure 1. The order parameter and c/a ratio of Fe/Pt multilayers as functions of annealing temperatures.

The out-of-plane MCD signals increased roughly with increasing annealing temperatures. Approximately, the out-of-plane spin-to-orbital ratio was proportional to the order parameter. The strong interfacial hybridization produces enhanced perpendicular orbital moment and spin-to-orbital ratio in the $L1_0$ structure. The orbital moment and spin-to-orbital ratio become anisotropic due to the stronger spin-orbital coupling between Fe and Pt layers. It indicates that the ordered FePt film has strong PMA effect. It can be inferred that the higher order parameter, the stronger hybridization and spin-orbital coupling between Fe and Pt atoms occurs. Also, the higher orbital magnetic moment anisotropy implies that the out-of-plane spin-to-orbital ratio becomes larger.

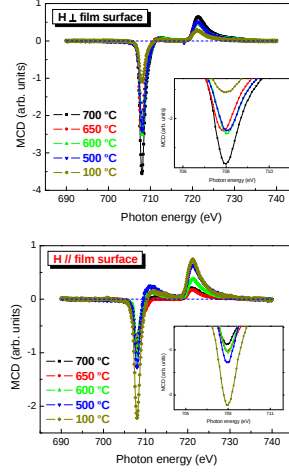


Figure 2. The out-of-plane and in-plane MCD spectra of Fe/Pt multilayers as functions of annealing temperatures.

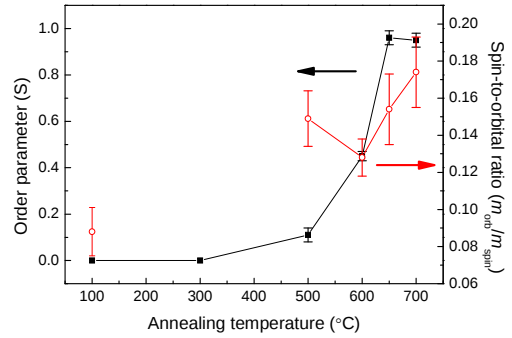


Figure 3. The order parameter and out-of-plane spin-to-orbital ratio of Fe/Pt multilayers as functions of annealing temperatures.

The out-of-plane spin-to-orbital ratio ($=0.174$) is far from the theoretical predicted value ($=0.025$) [1] and the previous experimental value ($=0.0998$) [2]. Since the order parameter of FePt alloy films in this experiment (above 0.95) is larger than that in C. J. Sun group experiment, it might be the major reason for the high out-of-plane spin-to-orbital ratio in this experiment. In addition, the experimental value is larger than the theoretical value. It might be due to the theoretical calculation only considering about the element state. If the hybridization between Fe and Pt layers in the $L1_0$ FePt structure must be considered, it should produce large magnetic moments.

References :

- [1] I. Galanakis, M. Alouani, and H. Dreyssé, Phys. Rev. B **62**, 6475 (2000).
- [2] C. J. Sun, G. M. Chow, G. H. Fecher, J. S. Chen, H.-J. Lin, and Y. Hwu, Jpn. J. Appl. Phys. **45**, 2539 (2006).