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1. **Main Research Result**

- 1) Chemical ordering of (111)-oriented CoPt ultrathin continuous layers in CoPt/AlN multilayer structure has been investigated. It is found that upon thermal annealing at 600°C, CoPt layers undergo ordering transformation even when the CoPt layers are as thin as 2 nm. The degree of ordering increases with increasing the layer thickness. For the 600°C annealed CoPt/AlN multilayer film with 2 nm thick CoPt layers, due to the ordering, out-of-plane coercivity is increased to 3330 Oe, while large perpendicular magnetic anisotropy constant of 8.1×10^6 erg/cm³ is exhibited. These coercivity and anisotropy energy are appropriate for the practice use as magnetic recording media. It is clear that for such a structure, ordering transformation does not impair the perpendicular magnetic anisotropy induced by the interface and magnetoelastic effects. The easy axis of magnetization still lies in the layer normal direction, i.e. [111] direction, although for L1₀ structure it is supposed to lie in the [001] direction. But L1₀ ordering does contribute to the enhancement of coercivity.
- 2) The magnetic behavior of CoPt-AlN granular structure laminated with AlN layers has been studied. Ultra-thin multilayer structure, [CoPt0.5nm/AlN0.5nm]₄, is used as the precursor of the magnetic layers, which are separated by 5nm-thick AlN layers. Upon thermal annealing, the ultra-thin multilayer transforms into CoPt-AlN granular structure, and the thick AlN layers remain to be spacers. When the film was annealed at 400 °C, the out-of-plane direction becomes the easy axis of magnetization, although the coercivity remains small. TEM observation has proved that CoPt shows disc-like shape at such an annealing temperature. When increasing the annealing temperature to 600 °C and above, the films show “isotropic” magnetic behavior due to the formation of equiaxial CoPt particles in the magnetic layers

2. **List of publication**

Referred

- 1) Youxing Yu, Ji Shi, and Yoshio Nakamura, Magnetic behavior of CoPt-AlN granular structure laminated with AlN layers, Journal of Applied Physics, 109, 07C103 (2011).
- 2) Takashi Harumoto, Shinji Muraishi, Ji Shi, and Nakamura Yoshio, Emergence of (001) preferred orientation in AlN film using ultra-thin intermediate Pt layer, Materials technology, 26 (2011) 32-34.

- 3) Takashi Harumoto, Shinji Muraishi, Ji Shi, and Nakamura Yoshio, Highly textured (111) Pt substrates for preferred orientation controlled AlN films, *Materials Science Forum*, 675-677 (2011) 1259-1262.
- 4) Jian Wang, Shinji Muraishi, Ji Shi, and Nakamura Yoshio, Antiferromagnetic layer thickness dependence of exchange bias in sputter-deposited Co/CoO/Co trilayer, *Materials Science Forum*, 675-677 (2011) 1263-1266.
- 5) Youxing Yu, Ji Shi, and Yoshio Nakamura, Enhancement of perpendicular coercivity for CoPt top layer in CoPt/AlN multilayer structure, *Journal of Applied Physics*, 108, 023912 (2010).
- 6) Youxing Yu, Ji Shi, and Yoshio Nakamura, Thickness-dependent perpendicular magnetic anisotropy of CoPt layer on CoPt/AlN multilayer, *IEEE Trans. Magn.*, 46(2010), p.1663-1666.
- 7) Xingzhi Ning, Xiaofang Liu, Ronghai Yu, Ji Shi, Yoshio Nakamura, Room-temperature ferromagnetism in cobalt and aluminum codoping tin oxide diluted magnetic semiconductors, *Materials Transactions*, 51 (2010) 557-560.

Oral

- 1) Magnetoresistive effect in Co-Ti-O films with oxygen-concentration modulation, 7th Pacific Rim International Conference on Advanced Materials and Processing, August 2-6, 2010, Cairns, Australia.
- 2) Antiferromagnetic layer thickness dependence of exchange bias in sputter-deposited Co/CoO/Co trilayer, 7th International Forum on Advance Materials, June 26-28, 2010, Dalian, China

Poster

- 1) Magnetic behavior of CoPt-AlN granular structure laminated with AlN layers, 55th Annual Conference on Magnetism & Magnetic Material Science and Technology, November 14-18, 2010, Atlanta, USA

3. **International Collaboration**

Joint researches have been conducted with research groups at Tsinghua University and Dailain University of Technology.