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Nanostructure and magnetic properties in highly coercive $L1_0$ FePt films

K. Takanashi[1], T. Shima[1], Y. K. Takanashi[2], K. Hono[2], G. Q. Li[3] and S. Ishio[3]
[1] Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[2] National Institute for Materials Science, Tsukuba 305-0047, Japan
[3] Venture Business Laboratory, Akita University, Akita 010-8502

Magnetization processes in nanometer-sized magnets with a large uniaxial magnetic anisotropy are of great scientific and technological interest, since nanoscale patterned or particulate magnets may lead to important applications in forthcoming magnetic devices such as high density recording media and bias magnets in monolithic microwave integrated circuits. The magnetization process, and therefore the coercivity should depend strongly on the characteristic size and the morphology of materials. In a previous paper,[1)] we reported that high coercivity (H_C) exceeding 40 kOe was achieved in highly FePt (001) ordered films with island structure which were epitaxially grown on MgO (001) substrates, and the variation of magnetic properties with the FePt thickness was discussed on the basis of the film morphology change that was observed by transmission electron microscope (TEM). In this paper, the extensive study on the relationship between nanostructure and magnetic properties for both the FePt films grown on MgO (001) and MgO (110) substrates are presented.

FePt (001) films with perpendicular magnetization and FePt (101) films with a canted easy magnetization axis (c-axis) were prepared by multiple dc magnetron sputtering directly onto MgO (001) and MgO (110) substrates, respectively, at the temperature T_S=700 ˚C. The nominal film thickness t_N was varied from 5 nm to 100 nm. The film morphology changes from a particulate to a continuous state depending on t_N. Fig. 1 shows the t_N dependence of H_C. At the critical thickness ($t_N \approx 50$ nm) where the film morphology changes from a particulate to a continuous state, a drastic decrease in H_C has been observed for the FePt (001) films. On the other hand, no jump of H_C has been observed for the FePt (101) films, which is attributable to the presence of pinning sites for the domain wall movement.

For the further improvement of H_C, FePt(001) films were also prepared on MgO(001) substrates at T_S=780 ˚C. Huge H_C of 70 kOe at room temperature and 105 kOe at 4.5 K have been obtained for t_N=5 nm (Fig. 2). To our knowledge, this is the highest value of the coercivity in FePt films reported so far. TEM observation suggests that the achievement of high H_C arises from the reduction in the internal strain formed during the coalescence of FePt particles leading to the reduction in the dispersion of the easy magnetization axes in particles.

References

1) T. Shima *et al*., Appl. Phys. Lett., **81** (2002) 1050.

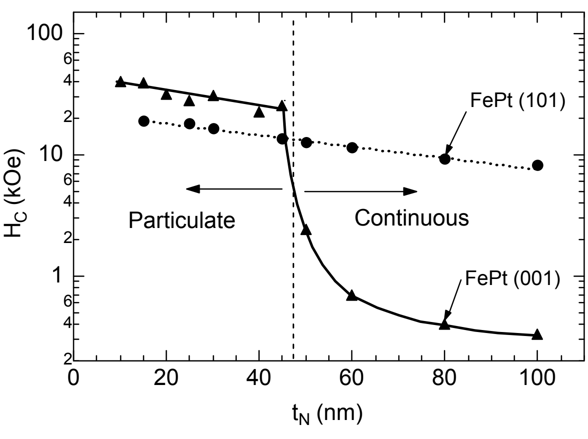

Fig.1 Nominal thickness (t_N) dependence of coercivity (Hc) for FePt (001) and FePt (110) films.

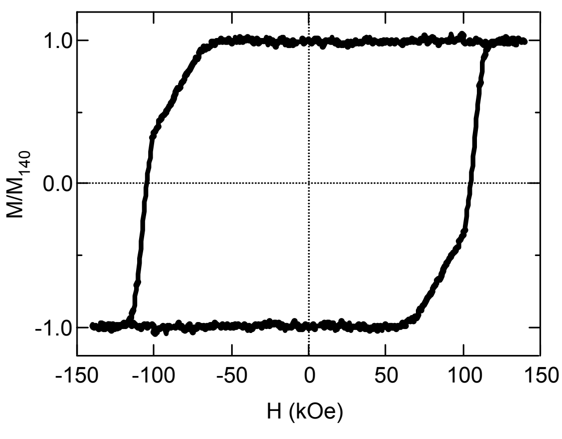

Fig. 2 Magnetization curve at 4.5K for a FePt (001) film with t_N=5nm.