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Fabrication of Oriented Hard-Magnetic Alloy Nanoparticles and Their Characterization

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Nano-sized oriented L1o-FePt and FePd nanoparticles were fabricated by a successive-deposition technique of Pt(Pd) and Fe onto a heated single crystal NaCl substrate, followed by a post-annealing for the ordered alloy formation[1,2]. Structures of these particles were characterized using transmission electron microscopy (TEM) and electron diffraction. EDS analysis using a nano-probe indicated a composition difference from particle to particle, but the distribution is narrow with a standard deviation of 3at.%. Post-deposition annealing at the temperatures higher than 873K (FePt) and 723K (FePd) lead to a formation of the L1o ordered phase. Coercivities (at 300K) obtained were 5KOe (FePt) and 3KOe (FePd) after annealing at 873K for 1h. Coercivities at 10K were about as twice as those at 300K, indicating the existence of thermal fluctuation of magnetic moment. Long-range order parameters of these particles were determined by electron diffraction, taking the multiple scattering into consideration[3]. In these binary L1o-FePt and FePd nanoparticles, orientation of particles (film-normal) are more or less along their principal three crystallographic axes with a statistical randomness. However, third-additive elements like Cu[4] and Co[5] drastically improve the perpendicular magnetization (normal to the film plane). Number-fraction of nanoparticles with their magnetic-easy axis (c-axis) oriented normal to the film plane increased up to 90% or more, especially in the case of Co addition to the FePd alloy. In the L1o-FeCoPd nanoparticles saturation magnetization was found to be increased with Co composition as same as the case in the Fe-Co crystalline alloys.

RF-sputtering was also introduced in this study. RF-sputtered FeCuPt thin films on NaCl substrate with a substrate temperature of 340°C showed a formation of two-dimensionally and densely dispersed <100> oriented L1o-FeCuPt nanoparticles[6]. The cercivity is not high (Hc~1.4KOe) because of the lower atomic order at this temperature. But, this shows a possibility of direct synthesis of High-Hc oriented L1o-FePt particles at a low temperature below 400°C by adding Cu.

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DB03

Low temperature fabrication of (001) FePt on amorphous substrates

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Low-temperature ordering of the high-anisotropy $L1_0$ FePt phase has been extensivelystudied in recent years. Since the diffusionof Fe and Pt atoms is the rate-control step of the ordering, a lotof studies focus on how to accelerate the diffusion by adding the third elements[1], ion irradiation[2], and forming gas annealing[3]. Although the (001) $L1_0$ FePt phasecan be grown on MgO substrates, the growth of (001) films on amorphous substrates is still critical for the applications of perpendicular recording media. In this study, a simple "co-sputtering process" was used to fabricate the multilayer-like (001) FePt films on SiO_2 or glass substrates. The "co-sputtering process" was performed by using a sputtering system with a revolution sample holder. To shorten the diffusion length for the formation of the ordered phase, we achieved the pseudo "layer-by-layer" deposition mode by tuning the revolution rate of the sample holder and the deposition power of Fe and Pt sputtering sources.

The ordered FePt phase with (001) preferred orientation was obtained by an annealing process at 350 °C. The coercivity larger than 7 KOe wasachieved regardless of the deposition order of Fe and Pt layers. To further promote the quality of the layer growth and to reduce the exchange coupling between grains, the multilayer with the structure of $Fe/Pt/SiO_2$ was fabricated. A large perpendicular coercivity (>7 KOe) and good squareness were obtained with well-separated FePt grains after 350 °C annealing for 2 seconds.

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