Interfacial Structure of Ferrofluid Thin Layer Confined by Two Glass Plates

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Interaction among the colloidal particles and structures consisting of the colloidal particles has been an interesting subject for many industrial applications. Especially, a ferrofluid, so called a magnetorheological fluid in which single domain magnetic colloidal particles are dispersed is not only a useful material but an accessible system for computer simulations, since the system is mainly governed by simple magnetic dipolar interactions. However, contrary to such a simple interaction, it exhibits variety of structures at the surfaces and interfaces. In the ferrofluid free surface (LS-40, *Taiho Co. Ltd.*), a layering structure of which periodicity perpendicular to the surface direction almost equals to the diameter of the magnetic particles (average diameter is 12 nm), is formed. Moreover, the lateral structure of the layering structure is found to be characterized by a low-fractal dimension and high-density: fractal dimension of the aggregates is about 1.1 indicating chain-like aggregations and the coverage of the particles is more than 70% in the free surface [1].

Recently, distribution of the super paramagnetic colloidal particles in a ferrofluid under a confined geometry is investigated by a transmitted X-ray diffraction (TXR) technique [2]. Two flat Pyrex glass plates achieveed the confined geometry: The ferrofluid film was sandwiched by the flat glass plates; the gap between them is less than the wavelength of visible light. (2003B0329-ND1d-np). When the thickness of the ferrofluid film is sufficiently large, any layering structure is recognized at the ferrofluid/glass interface. However thickness of the ferrofluid film is fairly small (less than 400 nm), another layering structure is found to appear; the interface structure is characterized by a depletion layer of the colloidal particles close to the interface, which gives a sharp contrast with the layering structure observed at the free surfaces.

In the present study, we intend to confirm the novel interfacial structure with various thickness values of the ferrofluid film. In order to produce the confined geometry with various thicknesses, a delta-shaped gap is employed with two Pyrex glass surfaces on which one of the edges was coated by a spin-coated polystyrene thin-film with 100 nm thick. We could vary the gap values between about 300 nm and 400 nm by moving the incident X-ray illuminating areas. The interfacial structure was also characterized by TXR. Wavelength and the beam size were tuned to 0.005 nm and 30 μm x 100 μm, respectively. The interference fringes pattern was indicated in the whole TXR spectrum in this study. Therefore, the present study strongly manifests the robustness of the novel interfacial structure at the ferrofluid/glass interface, which is probably realized only in the confined geometry.

REFERENCES

[1] I. Takahashi, N. Tanaka and S. Doi, *J. Appl. Cryst.* **36** (2003) 244.

[2] I. Takahashi et al., *Jpn. J. Appl. Phys.* **42** (2003) 7493.

Evaluation of crystalline structure of nano-ferromagnets buried in self-organized porous alumina nanohole array

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We analyzed crystalline structure of nano-scaled Co column array buried in porous alumina nanohole array by electroplating using SOR X-ray diffraction.

For sample preparation, pure aluminum film were sputtered on Si(111) substrate, and they were anodically oxidized in oxalic acid solution with 40V. Porous nanohole array of 90 nm pitch were formed. Then, two types of the samples were fabricated by electroplating using Co-sulfate solution with ac 15 V; the Co columns formed on amorphous alumina barrier layer, and the Co columns formed on Si(111) substrate directly.

Figure 1 shows a cross-sectional TEM image of Co columns array buried in porous alumina template with amorphous alumina bottom barrier layer. The average diameter was 60 nm. It is clear that each Co column has a polycrystal structure. We observed hexagonal Co (0004), (10-10), (10-11), peaks by 2θ– θ scanning. However, there was no clear superior peak, and crystal orientation was random. M-H properties exhibited that a coercive field increased with an increase in the height and saturated to 2.0 kOe when an aspect ratio is larger than 3. For actual application to magnetic recording, the coercive field must be as high as 10 kOe, and further improvement in the crystalline anisotropy is required.

Figure 2 shows Cross-sectional SEM image of a Co nano-columns formed on Si (111) substrate directly. Figure 3 shows X-ray diffraction peak of hexagonal Co(0001). We found that hexagonal Co (0001) was aligned perpendicular to the substrate surface when Co columns were formed directly on the Si(111) substrate.

For future studies, further control of crystalline anisotropy and its relationship to M-H properties are essential, and futher study using SOR-X-ray is required.

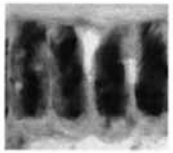

Fig.1 Cross-sectional TEM image of a Co nano-columns buried in porous alumina template with amorphous alumina

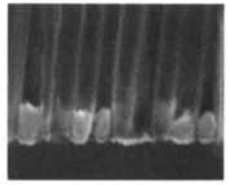

Fig.2 Cross-sectional SEM image of a Co nano-columns formed on Si (111) substrate directly.

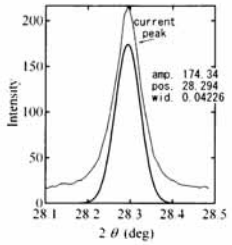

Fig.3 X-ray diffraction peak of hexagonal Co(0001) of Co nano-columns formed on Si(111) substrate directly.