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Fabrication and Characterization of Ultrahigh Density Fe-Pt Nanowire Arrays on Glass Substrate

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Fe-Pt alloy, especially chemically ordered $L1_0$ FePt with fct structure, are important materials in permanent magnetic applications because of their large uniaxial magnetocrystalline anisotropy ($K_u = 6.6 \times 10^6$ J/m^3) and good chemical stability. Conventional investigations on Fe-Pt magnetic films were mainly conducted using vacuum deposition techniques, followed by an annealing to produce ordered phases.[1] Recently, a continuous FePt coating was prepared by electrodeposition and the magnetic performances were investigated.[2] In the present study, we report a novel approach to fabricate Fe-Pt alloy nanowire arrays within nanoporous anodic alumina films on ITO/glass substrates by Al anodization and a *dc* electrodeposition. Moreover, as a possible application, magnetic characteristics of the Fe-Pt nanowires were also investigated.

The starting specimen was a highly pure aluminum layer (99.99%, 1.5~2 μm) that was sputter-deposited on a glass substrate (25 × 110 × 1.1 mm) covered with a tin-doped indium oxide film (ITO: 120 nm, 10 Ω/□). The specimens were first anodized potentiostatically in oxalic or sulfuric acid solutions to obtain porous alumina films with different pore densities and dimensions, and then immersed in a phosphoric acid solution to remove the insulative barrier layer of the anodic alumina films. The porous alumina nanostructures on ITO/glass substrates were used as template electrodes in a *dc* electrodeposition to obtain Fe-Pt alloy nanowires within the nanopores. Electrodepsoition were performed in an electrolyte mainly containing $FeSO_4.7H_2O$ and $H_2PtCl_6.6H_2O$ under constant potentials or current density, until the pores of alumina films were completely filled by Fe-Pt alloys. The electrodeposited specimens were finally annealled at 673~973 K to get $L1_0$ FePt structure. The morphology of the surface and the fracture sections of the specimens were observed by FESEM with EDXA. The crystallographic structures of electrodeposited specimens were analyzed by XRD and TEM. The magnetization of the specimens was measured by a SQUID measurement.

The anodic alumina films obtained from oxalic and sulfuric acid solutions have highly porous structures with parallel channels of ϕ4~30 nm and pore densities of 2.7×10^{11} ~ 4.8×10^{12} pore/inch^2. The films possess characteristic barrier layers that are much thinner than the pore walls.[3] This enables the barrier layers to be removed by a chemical dissolution while still preserving the porous structures on substrates.[4] Through a *dc* electrodeposition, iron ions and platinum complex ions are reduced into metals and deposited in the nanopores of alumina films on ITO/glass, forming a composite nanostructure. The compositions of Fe-Pt alloys can be controlled within 10~95 at%Fe through deposition potential or current density. The diameters and the aspect ratios of Fe-Pt nanowires are adjustable within ϕ20~60 nm and 50~160 by anodizing conditions, pore-widening time, Al film thickness, and deposition time. **Figure 1** shows an example of ordered Fe-Pt nanowire array embedded in the porous alumina film formed in an oxalic acid solution. The Fe-Pt nanowires grow from the ITO/glass substrate along the pores of the alumina template, leading to a periodic nanowire array with ~ϕ50 nm in diameter and ~50 nm in wire-spacing. From the surface morphology (**Fig.1b**), almost all of the pores of alumina film (black regions) are filled with Fe-Pt alloys (white dots), leading to a high density nanowires array. The EDX analysis (**Fig.1c**) confirms the formation of Fe-Pt alloy (atomic ratio: Fe:Pt = 51:49) in alumina films on ITO/glass. The Fe-Pt nanowire arrays after annealed at 973 K showed a strong magnetization in perpendicular direction, inferring a promising future for magnetic recording applications.

References

1. R. A. Ristau, K. Barmak, L. H. Lewis, K. R. Coffey, and J. K. Howard, *J. Appl. Phys.*, **86**, 4527 (1999).
2. F. M. F. Rhen and J. M. Coey, *Abstracts of the 203rd ECS Metiing in Paris*, No.655.
3. S. Z. Chu, K. Wada, S. Inoue, and S. Todoroki, *J. Eletrochem. Soc.*, **149 87)**, B321 (2002).
4. S. Z. Chu, K. Wada, S. Inoue, S. Todoroki, Y. K. Takahashi, and K. Hono, *Chem. Mater.*, **14** (11), 4595 (2002).

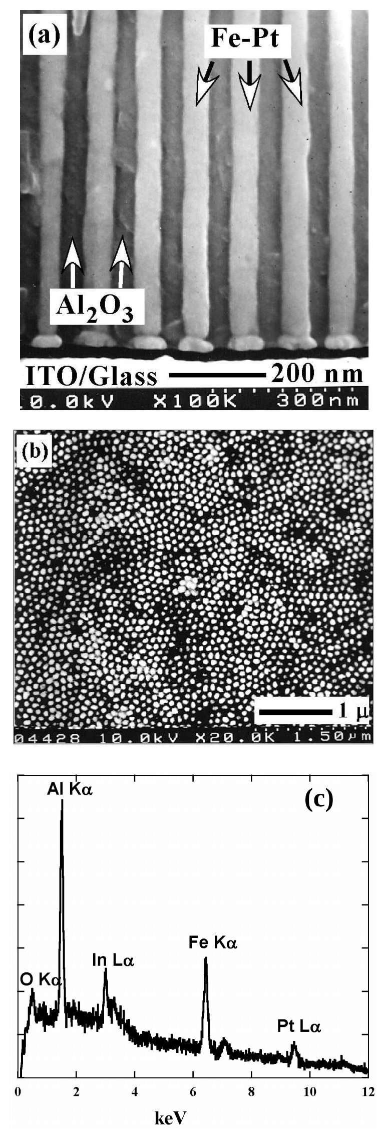

Fig.1 Microstructures of Fe-Pt nanowires embedded in porous alumina films on ITO/glass substrate. (a) FESEM image of a vertical fracture section, (b) BSI image of surface morphology, and (c) the EDAX spectrum of (b).