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HIGH ELECTRICAL RESISITIVITY AND MAGNETIC PROPERTIES OF NANOGRANULAR $Co_x(Al_2O_3)_{1-x}$ THIN FILMS

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The fine grain materials and composites[1,2] of fine grain entities are materials of special interests because of these unique features, granular metallic solids display a rich variety of interesting characteristics, many of which are induced by their intricate nanostructure. In this paper, we will describe the fabrication processing and investigating microstructure, magnetic properties, electrical resistivity and high frequency characteristics of the films were fabricated and analyzed by RF reactive magnetron sputtering, x-ray diffraction (XRD), vibrating sample magnetometer (VSM), four points probe, and permeameter, respectively. Composition of the films was measured by Auger electron spectroscopy (AES). Figure 1 shows effect of partial pressure of oxygen on microstructures of the films. Using the Scherrer's equation $d = (\lambda \times cos\theta)/B$, we calculated and obtained the grains size of the $Co_x(Al_2O_3)_{1-x}$ in range of 3-5 nm. Figure 2 shows hysteresis loops of $Co_x(Al_2O_3)_{1-x}$ (x = 0.3) for both easy and hard directions, which are very well-defined.

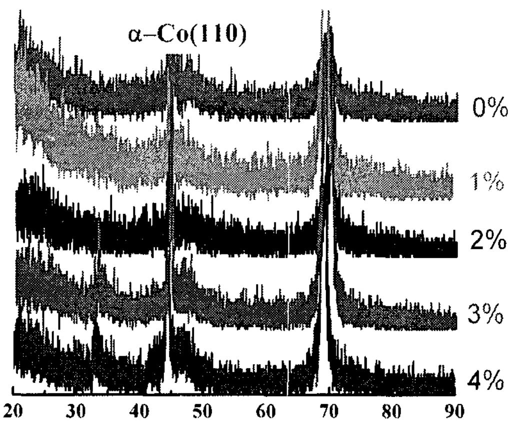

Figure 1. X-ray diffraction patterns of the $Co_x(Al_2O_3)_{1-x}$ with different partial pressure of oxygen

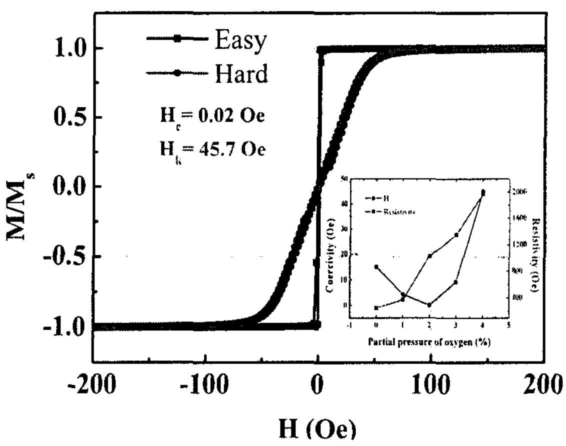

Figure 2. Hysteresis loops of $Co_x(Al_2O_3)_{1-x}$ (x = 0.3). Inset figure is dependence of the coercivity and resistivity of the films on partials pressure of oxygen

The $Co_x(Al_2O_3)_{1-x}$ (x = 0.3) films was fabricated at partial pressure of oxygen of 2 vol. % exhibited good soft magnetic properties: low coercivity *(H_c)* of 0.02 Oe, high anisotropy field *(H_k)* of 45.7 Oe, and high saturation magnetization *($4\pi M_s$)* of 13.2 kG. It revealed that the pressure of the sputter gases is the most important deposition parameter because

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the magnitude of K_u and nanogranular structures formation in the films depends upon it. In addition, these films also performed a very high electrical resistivity over 1000 μΩcm and high effective permeability at high frequency over 600 and nearly constant up to 1 GHz. These may be caused by very fine grains (α-Co (110)) and dispersive in insulator (Al_2O_3) matrix as shown in Fig. 1(x) (the broaden peak at 2θ = 40-50°). On the other hand, the soft magnetic properties of the films are only obtained when films were fabricated at partial pressure of 2 vol. %. It suggests that present of the oxygen during fabricating the CoO phase will be produced at the grain boundary. The existent of nanogranular structure and CoO phase in the films would be attributed to the very low coercivity of films.

In conclusion, effects of partial pressure of oxygen and Al_2O_3 contents to the microstructure and magnetic properties of $Co_x(Al_2O_3)_{1-x}$ films with x = 0 - 0.5 have been investigated. XRD observation found that they have nanogranular structure with grain size of 3-5 nm. The $Co_x(Al_2O_3)_{1-x}$ film with x = 0.3 and fabricated at input power of 300W, 2mTorr and partial pressure of oxygen of 2 vol. % exhibit very good magnetic properties ($4\pi M_s$ of 13.2 kG, H_c of 0.02 Oe, H_k of 45.7 Oe, μ_{eff} of 600 at 1 GHz) and high ρ of over 1000 μΩ.

References

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