GC06

Manipulation Ferromagnetic Resonance Frequency of Soft FeCo Films with High Saturation Magnetization

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Soft magnetic thin films with a high saturation magnetization (over 20 kG) and a large ferromagnetic resonance frequency are strongly desired for the application of advanced electro-magnetic devices. FeCo films can be prepared with saturation magnetization of 24.5 kG. The coercivity of the films can also be decreased to several Oe by suitable doping [1] or a sandwiched structure [2]. In this paper, we describe a new soft magnetic material with saturation magnetization as high as 24.3 kG and hard-axis coercivity as small as 0.8 Oe. Moreover, ferromagnetic resonance frequency of the materials can be easily tailored in the range from 2.0 GHz to 5.8 GHz.

Artificial structures, such as bilayers, sandwiched structure, granular structure, have been reported to obtain FeCo films with low coercivity. Here we propose a multilayered structure of $(Fe_{65}Co_{35}/Co)_n$. In which the $Fe_{65}Co_{35}$ layer is 50 nm thick, and the Co layer is ranging from 1 nm to 5 nm thick, composing 2-9% of the volume of the multilayered structure. The multilayers were deposited by a facing targets sputtering system with two sets of FeCo targets and Co targets. Hysteresis loops of the multilayers were determined by a vibrating sample magnetometer. Typical coercivities of the multilayers are 0.8 and 15 Oe in the hard and easy axis, respectively. The coercivities of the multilayers are almost independent on the Co layer thickness. Saturation magnetization decreases from 24.3 kG for Co layer thickness of 1 nm to 23.5 kG for Co layer thickness of 5 nm. The anisotropy field, H_k, increases from 30 Oe to 190 Oe with the increases of the Co layer thickness from 1 nm to 5 nm. The hard-axis magnetic permeability of the multilayers was measured by a permeance meter. Ferromagnetic resonance frequency of the multilayers increase from 2.0 GHz to 5.8 GHz with the increase of the Co layer thickness from 1 nm to 5 nm. Transmission electron microscopy results shows that single layered FeCo films have grains as large as 80 nm. However, in the mulilayered films, the mean grain size is about 10 nm. Smallgrain size in the new structure is believed to be the main reason to obtain films with reduced cocivities. The increase of the anisotropy field with the introducing of the Co layer is believed due to the high magnetic anisotropy of the hcp Co.

In conclusion, we have successfully manipulated ferromagnetic resonance frequency of FeCo films from 2.0 GHz to5.8 GHz. The new multilayers have saturation magnetization above 23.5 kG and hard axis coercivity as small as 0.8 Oe. The magnetic properties and permeability spectra show that the new multilayers are promising for applications of high-density magnetic write head in hard disk drives as well as integrated thin film inductors operating in the gigaherz range.

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GC07

FeCoHfN Soft Magnetic Thin Films with High Frequency Characteristics

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An increasing demand for miniaturization of communication products has been motivating research on monolithic integration of electric devices and systems. Magnetic thin films can be utilized to fabricate micro inductors, and to enhance the inductance and quality factor of magnetic inductors. The magnetic thin films provide good choices in the component of diminutive dimensions, and the development of the process for the electromagnetic devices in high frequency is of enormous interests. In order to enhance the resonant frequency, the higher anisotropy and the higher electric resistivity are urgent requirement. In this study, the (Fe-Co)-Hf-N soft-magnetic thin films have been fabricated by rf reactive magnetron sputtering. The nitrogen content was controlled by varying the N_2/Ar ratio. The as-deposited films without post annealing exhibit larger anisotropy field (H_k) of 150 Oe, lower coercivity (H_c) of 4.6 Oe, and higher electrical resistivity (ρ) of 500 $\mu\Omega$cm. In addition, these films maintain relativity high saturation magnetizations over 15 kG. As a result, the resonance frequency f_r and the permeability of the film are above 3 GHz and 100, respectively. It is believed that this film is promising for practical applications as a high-frequency ferromagnetic material.