RC03

High-Frequency Magnetoimpedance Effect in Co-Fe-Hf-O Nanocomposite Films

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The recent discovery of the so-called giant magnetoimpedance (GMI) effect in ferromagnetic wires and ribbons has provided further success in developing highly sensitive magnetic sensors for technological and industrial applications [1,2]. Nevertheless, the basic requirements necessary for manufacturing high-performance magnetic sensors using these materials on electronic circuit board level are still not completely fulfilled [3]. It is suggested that scientists attempt to resolve these issues and also meet the demands imposed by the limits of engineering.

To this prospective, ferromagnetic films can be more promising candidate materials, because the use of thin film technology for GMI is preferable in many applications owing to its compatibility and integrated circuit technology which enables miniaturization, avoiding alignment issues, and wire soldering. They can also be ideally used for high-frequency sensing applications. The aim of the present work is to investigate the high-frequency magnetoimpedance (MI) effect in nanocomposite Co-Fe-Hf-O magnetic films with varying thicknesses (t = 1, 1.5 and 1.8 μm), in order to check whether or not oxide magnetic films can be used for high-frequency sensing applications. The samples were deposited by reactive rf-sputtering using an Ar+O_2 atmosphere with a base pressure of less than 2.0×10^{-7} Torr, onto Si(100) substrates at ambient temperature. It has been shown that in the frequency range of 100 - 1000 MHz, for the film samples investigated, the MI effect first increases with increasing frequency, reaching a maximum at 696 MHz (~10%), and then decreases at higher frequencies. This effect increases with increasing film thickness. It reveals that the high-frequency MI effect can arise mainly from high-frequency spin-dependent tunnelling among lateral separated Fe-Fe(Co) clusters. It has been demonstrated that the condition of the ferromagnetic resonance is not a sole factor for the observed MI effect.

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RC04

Enhancement of GMI Effect in Electroplated Permalloy Thin Films by an Organic additive

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Soft magnets have been used for various devices including GMI (Giant Magneto-Impedance) sensors and magnetic read heads. They were usually fabricated with vacuum deposition methods such as DC sputtering and electron beam deposition. Electroplating technique is also a useful method for fabrication of soft magnetic thin films because it allows relatively fast deposition of high purity products. Proper soft magnets has low coercivity and high permeability. It is known that smooth surface is required to obtain low coercivity. We investigated a means to control the properties of Permalloy thin films by using organic additives and obtained low coercivity resulting from smooth surfaces.

The substrate was N-type Si(100). A 20 nm thick Cu seed layer was deposited with electron-beam evaporation for use as a working electrode. The plating electrolyte was composed of $NiSO_4$, $FeSO_4$, and H_3BO_3. A brightening agent, SNPS, was added to the bath with the concentration varying in the range of 0.2-1.0 mol/L. Electroplating was carried out using a three-terminal method. Magnetic property of thin films was measured by a VSM (vibrating sample magnetometer), and the surface roughness was observed by an AFM (atomic force microscope) in an area 1 μm×1 μm. GMI was measured using an impedance analyzer.

In the absence of SNPS in the bath, the surface roughness of the thin film was ~7.6 nm. However, as we increased the concentration of SNPS, the surface roughness was reduced to ~2.7 nm. Accordingly, coercivity (Hc) was reduced from 0.92 Oe to 0.29 Oe. The reduction of coercivity led to an increase of magneto-impedance ratio (MIR) up to 20%. We observed a strong correlation between the reduction of surface roughness and low coercivity in proportion to the concentration of SNPS. This improvement is attributed to the increased nucleation and surface diffusion caused by the additive contained within the electroplating electrolytes. We demonstrated that, while the improvement of surface planarity evidently reduced coercivity, a smaller grain size should be accompanied by a further reduction in coercivity. The improved magnetic properties can be utilized for the fabrication of various magnetic devices and sensors.

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