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High-frequency Magnetic Inductor with an as-deposited FeCoAlO Thin Film Core

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The magnetic materials operating at GHz require high saturation magnetization (Ms), appropriately high anisotropy field (Hk), and high electrical resistivity (ρ). Generally, these materials are post-annealed in the presence of magnetic field at 300 to 600 °C for nanocrystallization, which dramatically restricts the integration of the ferromagnetic materials with other components in practical application. It is therefore desired that the as-deposited magnetic materials exhibit a high frequency ferromagnetic properties. In this study, FeCoAlO films with Al and O compositional gradient were prepared by magnetron co-sputtering method. It is interesting to note that the as-deposited FeCoAlO film revealed high Ms of 18-22 kG, high Hk over 120 Oe, and high ρ in excess of 2500 $\mu\Omega$cm. As a result, good high frequency ferromagnetic properties with permeability over 100 and self-resonance frequency in excess of 3 GHz were obtained. This film was used to be integrated with Cu micro inductor. Evident enhancements of inductance (L) and quality factor (Q) were achieved. The increments of L and Q are about 15 and 100% at 2 GHz, respectively. The magnetic film is operating up to 4.6 GHz. These facts indicate that FeCoAlO film is a potential magnetic material for the miniaturization of the electronic devices and the simplificationof fabrication technology.

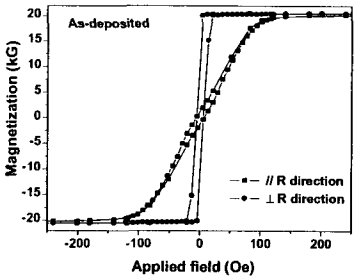

Fig. 1. Typical hysteresis loops of the as-deposited FeCoAlO film.

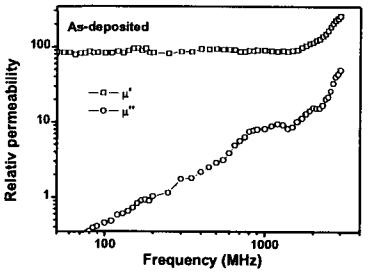

Fig. 2. A typical frequency dependence of relative permeability of the as-deposited FeCoAlO film.

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Synthesis and Characterization of Highly Permeable CoFe-based Nano-alloys

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Nanocrystalline soft magnetic materials have superior properties such as high saturation magnetization with low coercivity and find applications as advanced electromagnetic materials [1-4]. Particularly, high-permeability magnetic nanomaterials for high-temperature applications have been vigorously pursued to meet the ever-increasing requirementsthat can not be met by existing materials. Nanocomposite soft magnetic materials are directed towards high frequency of operation, in contrast to conventional ferrites of poor magnetic properties at high frequencies at elevated temperature. Mechanochemical synthesis of such metallic nanocomposites is achievable using high energy ball milling. We have designed and synthesized new magnetic materials based on CoFe by using the exchange coupling between neighboring magnetic nanograins to overcome the anisotropy and demagnetizing effect. In this presentation, we focus on the investigation of compositions, nanostructures, magnetic and electromagnetic properties of the nanopowders synthesized from Fe and Co with doping of minute amount of elements by mechanical alloying. XRD patterns show the nanocrystalline states of the products by relative distinct peaks, identified with a bcc crystal structure. SEM scans reveal their particular morphologies, which are consolidated by TEM images of nanosized particles, in the range of teens nanometers. XPS spectra show a shell-core structure of the nanocrystalline structure of the nanoparticles with a Co-shell and an enriched Fe-core, in addition to existence of two more carbons [4]. Meantime, it is found from VSM measurements that these nanostructured materials are excellent soft magnetic composites with very high saturation magnetization. Finally, the nanosized CoFe alloys have been demonstrated by microwave measurements to possess superior or comparable properties, particularly the permeability at broad microwave frequencies, compared to the results reported in the literature and commercial products. In sum, we synthesized highly permeable doped CoFe alloys by mechnochemistryand characterized their properties.

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