

High-frequency Ferromagnetic Properties of FeCoZr Nanocrystalline Films

Yung Wang Peng^{1*}, Shandong Li^{1,2}, Masahiro Yamaguchi³, and Jeng Gong Duh⁴

¹Center for Nanotechnology, Materials Science, and Microsystems National Tsing Hua University, Hsinchu Taiwan 30013, Republic of China

²Department of Physics, Fujian Normal University, Fuzhou 350007, China

³Department of Electrical and Communication Engineering, Graduate School of Engineering, Tohoku University, Sendai 980-8577, Japan

⁴Department of Materials Science and Engineering National Tsing Hua University, Hsinchu Taiwan 30013, Republic of China
*Corresponding author: jgd@mx.nthu.edu.tw, Phone: +886 571 5131 31164, Fax: +886 574 2281

Future communication devices require high frequency, high quality factor and small size. Integration of ferromagnetic materials with electronic component is a solution of chip integrating circuits. For this purpose, FeCoZr magnetic thin films with high uni-axial anisotropy were fabricated by RF co-sputter and post magnetic annealing. The crystal size of FeCo alloys can be decreased by adding Zr element due to its less solubility in FeCo alloy. The crystal size of FeCoZr thin film calculated by Scherrer equation is less than 23nm. The film exhibits a uni-axial anisotropy after magnetic field annealing at 400°C for 1 hr. Optimal high frequency ferromagnetic properties are achieved at the composition of 19 at% Zr, in which strong uni-axial anisotropy field of 250 Oe and high ferromagnetic resonance frequency in excess of 4 GHz were obtained. These facts suggest that FeCoZr nano-crystalline film is a potential candidate in high frequency electromagnetic devices operating in GHz bands.

High-frequency Ferromagnetic Properties of (Fe₅Co₅)_xHf_y Thin Film

Shandong Li^{1,2,3*}, Yung-Wang Peng¹, Su-Yueh Tsai⁴, Jeng-Gong Duh⁵, Youwei Du¹

¹Nano, MEMS and Materials Center, National Tsing Hua University, Hsinchu Taiwan 30013, Republic of China

²Department of Physics, Fujian Normal University, Fuzhou 350007, China

³National Laboratory of Solid State Microstructure, Nanjing University, Nanjing 210093, China

⁴Precision Instrument Center, National Tsing Hua University, Hsinchu Taiwan 30013, Republic of China

⁵Department of Materials Science and Engineering, National Tsing Hua University, Hsinchu Taiwan 30013, Republic of China
*Corresponding author: lishd@tpu.edu.cn, Phone: +886-0916687709, Fax: +886-3-5742281

The magnetic materials operating at GHz require high saturation magnetization (Ms), appropriately high anisotropy field (Hk), and low coercivity (Hc). In this study, (Fe₅Co₅)_xHf_y films with Hf compositional gradient from 7.7 to 15.8 at% were prepared by magnetron co-sputtering method. It was found that the magnetic properties of the samples significantly depend on the Hf composition. A strong uniaxial anisotropy with a maximum anisotropy field of 400 Oe was obtained for the samples annealed in presence of a magnetic field. With the increase of Hf composition, Ms firstly increases to 22 kG, then linearly decreases to 16 kG. Similarly, the anisotropic fields linearly increase from 18.2 (at Hf 7.7 at%) to 400 Oe (at Hf 13.5 at%), then rapidly decrease to 140 Oe (at Hf 15.8 at%). As a result, high-frequency ferromagnetic properties of the samples are altered with the variation of Hf composition. Samples with higher or lower Hf contents exhibit relatively low self-resonance frequency (SRF). However, in a wide Hf composition range from 8 to 13.5 at%, samples have a higher SRF in excess of 2.5 GHz. The sample with optimal Hf content of 9.7 at% exhibits permeability over 100 and SRF in excess of 3 GHz. These facts indicate that FeCoHf film is a potential magnetic material for the miniaturization of the electronic devices in GHz applications.

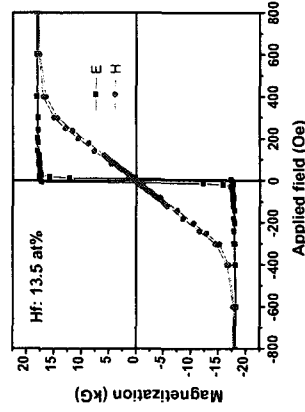


Fig. 1. Typical hysteresis loops of the magnetic field annealed FeCoHf film, showing a strong uniaxial anisotropy.

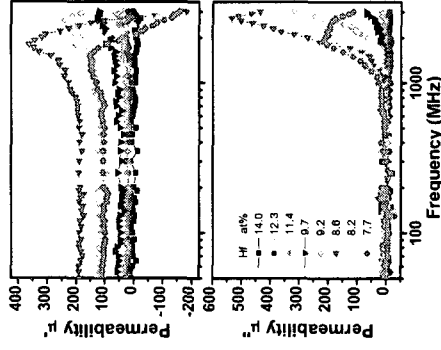


Fig. 2. Hf composition dependence of high-frequency ferromagnetic properties for the magnetic field annealed samples.