# Magnetic and magnetostrictive properties of nanogranular Co-Fe-Al-O films for GHz magnetoelastic device application

**J.C. Sohn[1], D.J. Byun[1], and S.H. Lim*[2]**

[1] Dept. of Materials Science and Engineering, Korea Univ., Anam-Dong 5-1, Sungbuk-Ku Seoul 136-701, Korea
[2] Korea Institute of Science and Technology, P.O.Box 131, Cheongryang-dong, Sungbuk-Ku, Seoul 130-650, Korea

*Corresponding author: e-mail: sangho@kist.re.kr, Phone: +82 2 958 5415, Fax: +82 2 958 6851

Mobile wireless systems such as mobile telephones and high-speed wireless local area networks are moving to GHz frequency bands to realize faster data transmission and multiple access. Magnetic properties required for GHz magnetoelastic device applications are high $4\pi M_S$ , an appropriate $H_K$ that increases the ferromagnetic resonance frequency, high electrical resistivity that reduces eddy current loss, and a good field sensitivity of magnetostriction. Nanogranular magnetic thin film is attractive because it potentially satisfies the above requirements. Co-Fe-Al-O nanogranular films with (Fe,Co) nanograins in an amorphous Al-O matrix were reported to show very good soft magnetic properties even in the GHz range [1]. An Fe-Co alloy with an approximately equiatomic composition exhibits a very large magnetostriction (of the order of 100 ppm), so this alloy can be suitable for GHz magnetoelastic device applications. Co-Fe-Al-O nanogranular thin films were fabricated by RF-magnetron sputtering under an $Ar+O_2$ atmosphere. The $Ar/O_2$ ratio was varied to change the oxygen content in the thin films. It is found that the microstructure, electrical and magnetic properties are greatly affected by the oxygen content. X-ray diffraction and transmission electron microscopy experiments show that the microstructure consists of bcc Fe-Co nanograins (2~7 nm) and an amorphous Al-O matrix. The crystalline grains are in most cases separated each other, resulting in a very large resistivity up to $10^4$ μΩcm. The $4\pi M_S$ of the films deposited in 0 % $O_2$ flow ratio is near 21 kG and decreases linearly down to 13 kG with increase of $O_2$ flow ratio, while $H_K$ increases linearly from 0 Oe to 65 Oe and then abruptly decreases to 0 Oe again at 16.67 % $O_2$. Fig.1 shows frequency dependence of relative permeability of $(Co_{58}Fe_{35}Al_7)_{100-x}O_x$ films. The FMR frequency is 2.38 GHz which is almost in agreement with the calculated results. The real part of permeability is flat up to 1.3 GHz with a very low imaginary part of permeability. A simple calculation shows that a higher FMR frequency can easily be achieved by introducing shape anisotropy. The thin film also exhibits a large saturation magnetostriction (~45 ppm) and a very good field sensitivity of magnetostriction. It is concluded that the present thin films, based on the results of magnetic and magnetostrictive properties, can be suitable for magnetoelastic applications in the high frequency range.

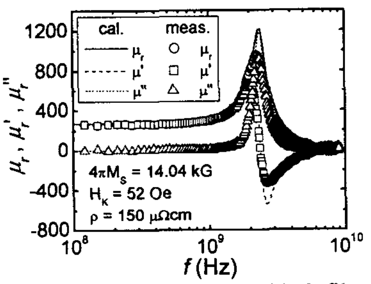

Fig.1 $\mu$ vs $f$ of $(Co_{58}Fe_{35}Al_7)$-O films

## References

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