Theoretical and experimental permeability spectra of nanogranular Co-Fe-Al-O films for GHz magnetoelastic device applications

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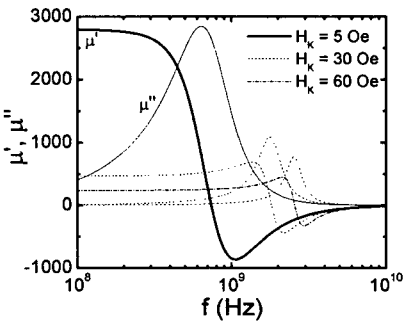
The effects of the parameters $4\pi M_S$, H_K, α (damping constant), d (film thickness) and ρ (resistivity) of soft magnetic thin films on the permeability spectra are calculated, using Landau-Lifshitz equation [1], inside a frequency range by holding one of the parameters constant and changing the others. For this calculation, Landau-Lifshitz equation is solved for the intrinsic relative permeability with assumptions which are the external field applied perpendicular to the easy axis and the magnetization dominated only by domain rotation. And then both effects of eddy current loss and ferromagnetic resonance loss on the intrinsic permeability are taken into account to obtain the expression for the effective relative permeability. The permeability spectra calculated by the obtained expression for the effective relative permeability are compared to the measured ones using nanogranular CoFeAlO films for two different samples. Good agreement between theoretical and experimental values is observed. Fig. 1 shows the frequency spectra of the calculated relative permeability for three different values of H_K with $4\pi M_S$ = 14 kG, g = 2, α = 0.02, d = 0.1 μm, and ρ = 100 μΩcm. The level of μ' at low frequency is low and the cut-off frequency is high at a high H_K value. μ'' shows a low resonance peak at a high H_K. The behavior of μ', as function of H_K, agrees well with the Stoner and Wolfarth theory. When the exciting field is applied perpendicular to the easy axis, the magnetization reversal is taking place by spin rotation. This consideration leads to the conclusion that for anisotropic magnetic thin films, significant values with a low exciting field are obtained only when the applied field is perpendicular to the easy axis. At low frequencies, when the exciting field is applied along the easy axis, the initial permeability, due to the motion of Bloch walls, is large and rolls off at about a few tens of kilohertz. When the exciting field is applied perpendicular to the easy axis, the permeability is generally low and is due to spin rotation. In this case the roll-off frequency may approach a few hundred megahertz and can even reach over a few gigahertz with a shape anisotropy introduced in the materials. The other influences of $4\pi M_S$, α, d and ρ of soft magnetic thin films on the permeability spectra will be discussed.



Calculated μ vs f for several values of H_K.

References

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