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Effect of Ag and Cu spacers on the magnetoimpedance of permalloy-based multilayers

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Abstract – In this work, we perform a comparative study of the magnetoimpedance (MI) effect in NiFe/Ag and NiFe/Cu multilayers at frequencies from 100kHz to 1.8GHz. We show that the complex peak structure observed in Py/Ag multilayers is not observed in Py/Cu multilayers. The maximum MI ratios obtained were 240% for Py/Ag and 250% for Py/Cu multilayers, both with 100 bilayers. It is shown that the shape of both, *Z* vs. *H* and *Z* vs. *f* curves can be tailored by changing the nature and thickness of the non magnetic spacer in these materials.

The magnetoimpedance (MI) effect corresponds to the change in the complex impedance $Z = R + iX$ of a ferromagnetic conductor under simultaneous *ac* and *dc* magnetic fields. This effect is observed mainly in soft magnetic materials because its origin is the dependence of the effective impedance of the material on the effective magnetic permeability $\mu(I_{ac}, f, H)$, which in turn depends on the *ac* and *dc* magnetic fields intensity and frequency. At fixed frequency and probe current amplitude, the permeability dependence on *H* is controlled by the skin depth, which has the consequence that *H* changes the current density profile [1] of such a sample. Materials that present good MI ratios are, in general, uniform and regularly shaped samples with weak anisotropies, e.g. magnetic amorphous ribbons, wires, and sheets. The MI effect is much more interesting when the sample is a single or multilayered film [2], as these nanostructured materials have potential applications in read heads and field sensors with small size and integrated electronics.

In this work we present an extensive experimental study of the high-frequency response magnetization and magnetoimpedance of Permalloy based multilayered films produced with two different non-magnetic spacers: Ag and Cu. An additional advantage for these materials is that they are currently used in AMR or GMR devices. We show that the magnetoimpedance of these multilayered samples present interesting features and magnitude, which bring new horizons for application and device design. The complex impedance spectra were measured with a HP4396A impedance analyzer in the frequency range 100kHz – 1.8GHz. Here, the maximum applied magnetic fields were H_{max}= ±150Oe and the *ac* current amplitude was set to 4.4mA_{rms}. The samples have rectangular geometry with 3.5mm x 10.5mm.

Interesting magnetoimpedance results have been obtained for all samples as appropriate probe current frequencies, the most interesting results for these measurements, in particular the MI ratios, were observed in samples with Py/Metal thickness ratio t_{Py}/t_{Ag}= t_{Py}/t_{Cu}=4. The Py/Ag and Py/Cu samples present 240% [3] and 250%, respectly, for 10nm of Permalloy and 2.5nm of Cu or Ag, both with 100 bilayers (see figure 1). Moreover, for some Py/Ag samples with small number of bilayers, the impedance curves shown multiple-peaks structure (see figure 2), characteristic of multiple absorption FMR.

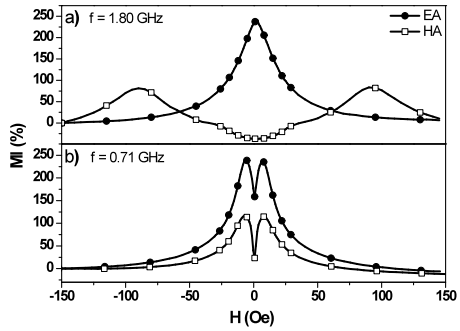

Figure 1: a) Py(10nm)/Ag(2.5nm) and b) Py(10nm)/Cu(2.5nm) samples, both with 100 bilayers.

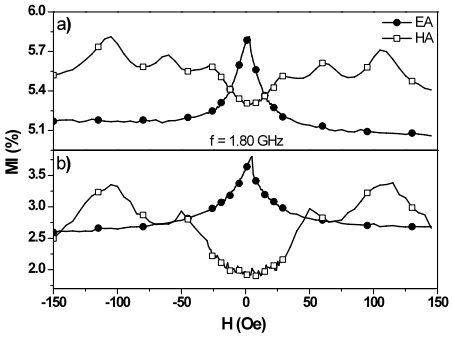

Figure 2: Py(10nm)/Ag(2.5nm) samples with a) 15 and b) 50 bilayers.

References

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