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Morphology, magnetic properties and magnetoresistance of as deposited and oxidized Fe thin films electrodeposited on Si

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Abstract – We report on the morphology, magnetic properties and magnetoresistance of Fe thin films, in the as-deposited state and after subsequent oxidation in water vapor or CO/CO_2 atmospheres. The Fe layers were electrodeposited on hydrogen-terminated Si single crystal substrates. The surface roughness of iron thin films was investigated by ex situ atomic force microscopy (AFM) measurements and the results analyzed according to scaling theory. Granular Fe films with morphological characteristics dependent of the deposition potential showed coercive fields decreasing with increasing thickness. Negative magnetoresistance was observed for both configurations of current parallel or perpendicular to an in-plane magnetic field. The oxidation in water vapor and CO/CO_2 atmospheres resulted in samples with magnetoresistive effects in the range of 1.0 to 1.2 %, about a factor 4 higher than the values observed for as-deposited Fe layers.

The study of metal/semiconductor interfaces has gained significantly in importance in recent years, with the advent of spintronics [1]. Such interfaces in fact are considered suitable as efficient spin polarizers for injection of spin currents [2], or as spin filters in magnetic metal base transistors [3].

In this work, Fe layers were electrodeposited on hydrogen-terminated Si single crystal substrates from aqueous electrolytes containing iron sulfate at a pH of 2.3. Granular Fe films with morphological characteristics dependent of the deposition potential showed coercive fields decreasing with increasing thickness (figure 1). Negative magnetoresistance was observed for both configurations of current parallel or perpendicular to an in-plane magnetic field. This indicates that the as deposited granular-films already contain an oxide barrier at the grain boundaries leading to a magnetoresistance that overcomes the anisotropic parts of it. By oxidation in water vapor and CO/CO_2 atmospheres resulted in samples with magnetoresistive effects in the range of 1.0 to 1.2 %, about a factor 4 higher than the values observed for as-deposited Fe layers (figure 2). The negative MR in both directions for as deposited and oxidized samples had in common the highest values at the coercive field, characteristic of systems with magnetoresistance due to field induces alignment of adjacent grains.

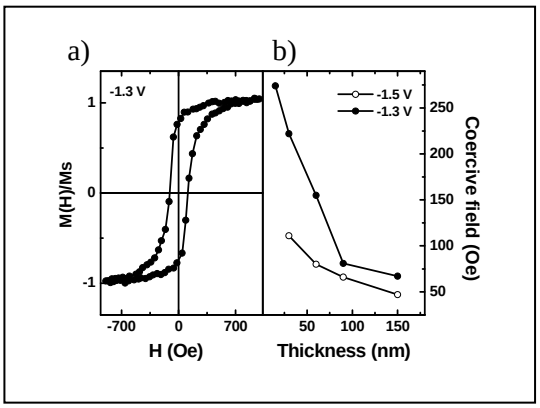

Figure 1: Normalized magnetization curve (M/Ms - magnetization/saturation magnetization) measured with the magnetic field applied parallel to the sample surface for a Fe/Si sample prepared at -1.30 V and thickness of 30 nm, b) coercive field as a function of the thickness at deposition potentials of -1.30 and -1.50 V.

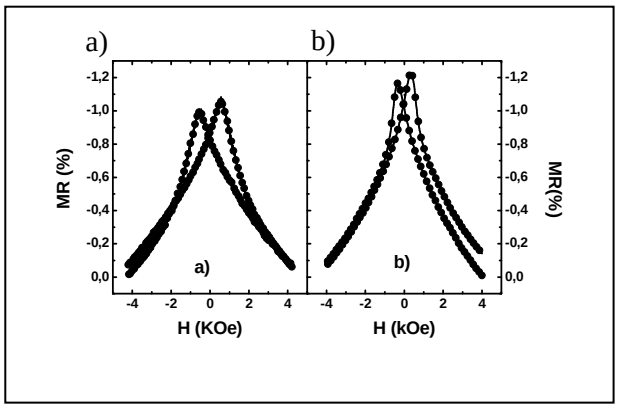

Figure 2: Negative magnetoresistance of 60 nm thick Fe layers oxidized in a) water vapor and b) CO/CO_2 atmospheres at 400 ^{o}C for 1.5 h.

References

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