MAGNETIC PROPERTIES IN STRAINED DOUBLE EPITAXIAL NICKEL FILMS WITH PERPENDICULAR MAGNETIC ANISOTROPY.

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Magnetic films with perpendicular magnetic anisotropy (PMA) are used to improve some technology performances, such as areal density for magnetic recording [1] and are involved in the fabrication of planar nanowires because of their potential use in domain-wall devices proposed for data storage [2] and logic applications [3]. These devices may include several layers with PMA which made the knowledge of the magnetic properties in the resulting system an important issue to optimize device operation. The Cu/Ni/Cu system exhibits perpendicular magnetization for nickel thickness ranging from, approximately, 2 nm to 13 nm and has been a model for the technologically substantial phenomenon of perpendicular magnetization [4]. Here, we present a study of magnetic and structural properties in epitaxial double nickel films: Cu(5 nm)/Ni(3 nm)/Cu(t_{Cu})/Ni(3 nm)/Cu(100 nm)/Si(001), with the interleaving copper layer thickness t_{Cu} ranging between 0 nm and 6 nm. The results reveal the intimate relation between the strain state of the nickel block and its magnetic behaviour.
Figure 1 shows the coercive field H_c and the in-plane strain ε, determined by high resolution grazing incidence x-ray diffraction (GIXRD), done in the BM25B beamline of ESRF using a photon energy of hν=15 keV. Assuming the H_c depends on square root of the density of dislocations $\rho^{1/2}$ [5], the line in figure 1 is a fit of H_c to a law proportional to a-$b\varepsilon^{1/2}$, where *a* and *b* are constants. A portion of the strain in the layer can be released by the formation of misfit dislocations. A mechanism proposed for the formation of dislocation is the glide of the existing threading dislocations in the layer, therefore the dislocation line forms a 90 ^{o} angle at the Cu-Ni interface increasing the dislocation line and taking plastically a part of the misfit strain η. The dimension of the core of these misfit dislocations correspond to a few times the Burgers vector *b*, and the misfit strain between two materials is accommodated by elastic and plastic δ strain (η=ε+δ). The latter is given by ρ*b*sinβsinα[6], where β is the angle between the interfacial plane and the slip plane of the dislocation and α is the angle between the Burgers vector and dislocation lines. Thus the measurement of ε in the epilayer allows estimating ρ.
The correlation between K_{eff} and ε is presented in Fig. 2. Both quantities increases in value for t_{Cu}< 1.8 nm and remain roughly constant above that value. This fact clearly indentifies a magnetoelastic term, proportional to $B_{eff}\varepsilon$ (B_{eff} is the effective magnetoelastic stress), in the magnetic anisotropy energy.

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References:

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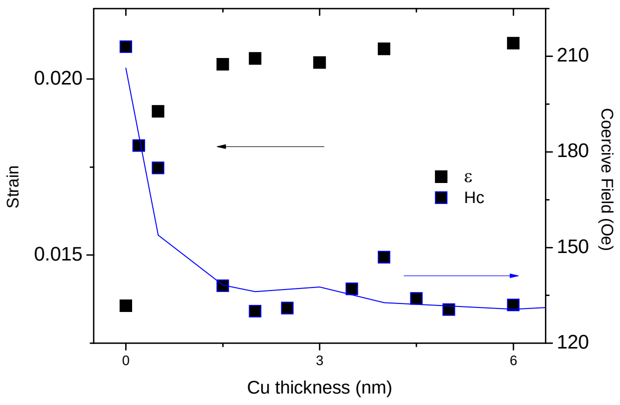
Figures:

Figure 1



Figuere 2