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Structure and magnetism of Co films on MgO(100)

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Abstract - The structural and magnetic properties of Co monolayers grown on MgO(100) surfaces at different temperatures under molecular beam epitaxy condition have been explored. The results indicate, for films deposited at room temperature, the formation fcc-like Co films with magnetic easy axis along the [100] direction.

MgO single crystals are frequently used as substrates for the growth of thin metallic films due to their high chemical, thermal and mechanical stability, which are important properties for the production of magneto-electronic devices. In particular, Fe/MgO interfaces have been widely employed in the study of magnetic anisotropies, as well as in the production of magnetic tunnel junctions [1]. As both Fe and MgO can be epitaxialy grown on GaAs, their large scale application in metal-insulating heterostructures is a feasible task. Another potential candidate for the metal in such heterostructures is Co [2,3].

In this work, Co films were grown on MgO(100) surfaces in ultra high vacuum under molecular beam epitaxy condition. The structure and magnetism of Co monolayers deposited at temperatures ranging from 25 °C to 500 °C and thicknesses up to 30 Å have been explored. The structural characteristics of the films were determined during the growth by reflection high energy electron diffraction (RHEED). X-ray photoelectron spectroscopy was also employed. For the investigation of the magnetic properties, magneto-optical Kerr effect (MOKE) in the longitudinal configuration, and ferromagnetic resonance (FMR) measurements with different field orientations have been used. The obtained results indicate the formation of soft magnetic Co films with structures compatible with fcc and fct grains for depositions at 25 °C and at 200 °C. Fig. 1 shows RHEED profiles and a MOKE magnetization loop for the film deposited at 25 °C. Slightly alterations of the RHEED pattern occur during the deposition process for this sample, the distance between the streaks of the final film remain approximately the same of the substrate. For higher deposition temperatures RHEED results also indicate of the crystallites with cubic/tetragonal structure but the diffraction peaks broaden as the temperature rises, and the lattice parameters are close to values normally found in bulk fcc Co. Furthermore, sample deposited at 25 °C presents an in-plane fourth-order magnetocrystalline field with the same magnitude but with the inverse signal of what is found in bulk fcc Co and in films where the lattice parameter is similar to the bulk one (Fig. 2). This inverse signal corresponds to an in-plane easy axis distinct of what is normally observed in films of cubic/tetragonal Co, [100] instead of [110]. The distortion of the Co lattice due to the use of the MgO substrate seems to lead to a change in the easy axis direction for the magnetization of the Co films.

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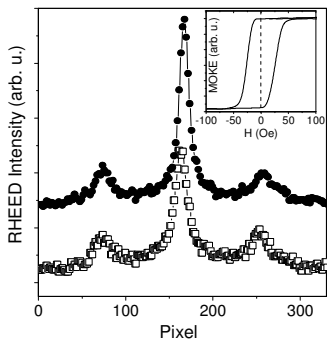

Fig. 1 - RHEED profiles before (filled) and after (open) the deposition of the Co film. Inset: MOKE hysteresis at easy axes.

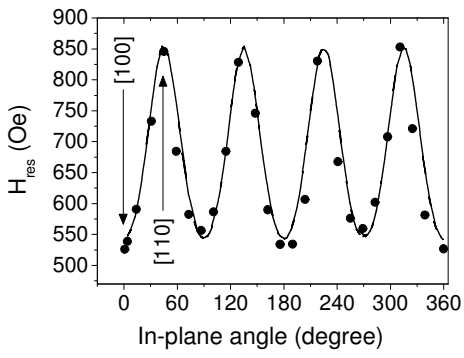

Fig. 2 - In-plane angular variation of the external field for FMR