Self-assembly of metal Nano-particles on spontaneously patterned oxide films

P. Torelli[1], E. A. Soares[2], G. Renaud[3], L. Gragnaniello[1,4], X. X. Guo[3], P. Luches[1] and S. Valeri[1,4]

[1] *INFM-CNR, National Research Centre for nanoStructures and bioSystems at Surfaces (S3), Modena, Italy.*

[2] *Depto. de Fisica, Universidade Federal de Minas Gerais, C.P. 702, 30123-970 Belo Horizonte, MG, Brazil*

[3] *CEA-Grenoble, DRFMC/SP2M/NRS, Grenoble, France*

[4] *Dipartimento di Fisica, Univeristà di Modena e Reggio Emilia, Modena, Italy.*

Self-assembled metallic nanoparticles on surfaces are of a great interest for fundamental and technological research in view of their applications in nano-magnetism and catalysis. To control the self assembly process at the initial stage of overlayer growth is possible to exploit the surface self-pattering of thin film originating from the strain field induced by the presence of misfit dislocations at the interface.

In this work, we show that it is possible to obtain an ordered array of Ni clusters of ~5 nm lateral size and 0.6 nm height on an CoO film of 5 nm of thickness grown on Ag(001). Due to the 3.25% lattice mismatch between the CoO overlayer and the Ag(001) substrate, a square dislocation network forms at the interface as observed by GIXD. The dislocation network evolves as a function of the film thickness together with the relaxation of the CoO in-plane parameter and reaches the final periodicity (of 9.2 nm) at about 5 nm of thickness. STM investigation of the CoO film surface revealed that the interfacial dislocation network creates an atomic displacement field that extends up to the CoO surface. The growth of Ni on the CoO surface has been studied as a function of the Ni thickness; it turns out that the Ni starts its growth nucleating 3D clusters at the step edges of the CoO terraces and that after the deposition of 0.2 nm the surface is completely covered by Ni particles. The grain analysis performed on this surface evidenced that the size distribution of the Ni particles is quite narrow and centered around 5 nm. The statistical analysis of the Ni clusters spatial distribution indicates a clear tendency to arrange on a squared network with borders parallel to the <110> direction of CoO and with a mean separation of about 9 nm. The relationship between the spatial arrangement of the Ni particles and of the misfit dislocation has been demonstrated by GISAXS measurement. We have observed periodic oscillations of the scattered intensity along the scattering rods of the dislocation network after the deposit of 0.2 nm of Ni; the existence of this interference demonstrates that there is a constant separation between the core of the dislocations and the positions of the Ni clusters, and thus that the clusters ordering is induced by the dislocation network.

Work supported by E.U. within the project FP6STRP “GSOMEN” under Contract No. NMP4-CT-2004-001594. E.A.S. also acknowledges financial support from CNPq and FAPEMIG.

Corresponding author: edmar@fisica.ufmg.br