SIZE CONTROLLED DEPOSITION OF PARTIALLY OXIDIZED FE AND TI NANO-CLUSTERS BY A HIGH VACUUM SPUTTERING GAS AGGREGATION TECHNIQUE.

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In the field of nanomaterials research, the common objective for different metallic and non metallic elements is to understand the evolution from atoms or molecule to materials with bulk properties. So, it is interesting the identification of various size-control parameters to allow controlled preparation of nanoclusters with tailored size and shape distribution.

Nowadays the study of magnetic granular systems, such as magnetic nanoparticles embedded in a matrix and core-shell structures, is a very intriguing area in the field of the materials science at the nanometric scale [1]. The magnetic properties are greatly determined by structural features, such as particle size. Thus, the control of the particle dimensions will allow us to 'tune', to some extent, the magnetic behaviour of the system. Nevertheless, sizes below a critical value lead to superparamagnetic behaviour, which limits the application of these materials. Exchange anisotropy between a antiferromagnetic and a ferromagnetic materials overcomes this limitation.

On the other hands, the development of new optoelectronics devices based on organics materials has promote the study among the properties of nanomaterials, the movement of electrons and holes in semiconductor nanomaterials is primarily governed by the well-known quantum confinement, and the transport properties related to phonons and photons are largely affected by the size and geometry. The high surface area brought about by small particle size is beneficial to many TiO2 based devices, as it facilitates interaction between the devices and the interacting media. Thus, the performance of TiO2 based devices is largely influenced by the sizes of the TiO2 building units at the nanometer scale [2].

In previous works, we have prepared nanocrystalline iron thin films by sputtering at very low substrate temperatures during growth. The shrink in the grain size observed by using x-ray absorption and diffraction techniques [3], while lowering the temperatures, is decisive in the interpretation of the changes of magnetic properties of the samples. Films prepared at near-room temperatures present a common thin film magnetic behaviour, whereas the films prepared at lower behaves like a granular system formed by a distribution of particle blocking temperatures [4].

Partially oxidized iron and titanium thin films were prepared by using a magnetron sputtering source placed inside a high pressure aggregation chamber. This preparation technique involves typical magnetron sputtering vaporization with aggregation in a high pressure (1e-1 mbar) gas to form cluster. After that process, channelling the clusters, through an aperture to the low pressure main deposition chamber, it is possible to fabricate films form made up by nanometric clusters (Fig. 1 shows an iron film deposited under these conditions) and even to combine it with another deposition technique or with an in situ controlled oxidation after deposition.

The distribution of the cluster size can be changed by controlling the residence time within the aggregation zone [5]. In order to study the physical and morphologic properties of the nanometric clusters, films of clusters with different sizes have been deposited after varying systematically some parameters. Such parameters are the aggregation length, distance between the aggregation chamber magnetron and aperture between chambers, the He/Ar atmosphere ratio and its pressure in the aggregation region. Clusters size distribution has been characterized by Atomic Force Microscopy as a function of different deposition parameters. Finally, a study of the nanometric clusters size dependence of optical properties, in titanium oxide, and magnetic properties, in iron oxide, has been carried out.

References

[1] F.J. Himpsel, J.E. Ortega, G.J. Mankey and R.F. Willis, Adv. Phys. 47, 511 (1998).
[2] Xiaobo Chen, Samuel S. Mao, Chem Rev 107,2891-2959 (2007)
[3] F. Jiménez-Villacorta, A. Muñoz-Martin and C. Prieto, J. Appl. Phys. 96, 6224 (2004).
[4] F. Jiménez-Villacorta, Y. Huttel, A. Muñoz-Martín, E. Román and C.Prieto, J. Appl. Phys., 101, 113914 (2007); and F. Jiménez-Villacorta and C. Prieto, J. Phys. Condens. Matter., 20, 085216 (1-10) (2008).
[5] H. Haberland, M. Karrais, M. Mall, Z. Phys. D 20, 413 (1991)

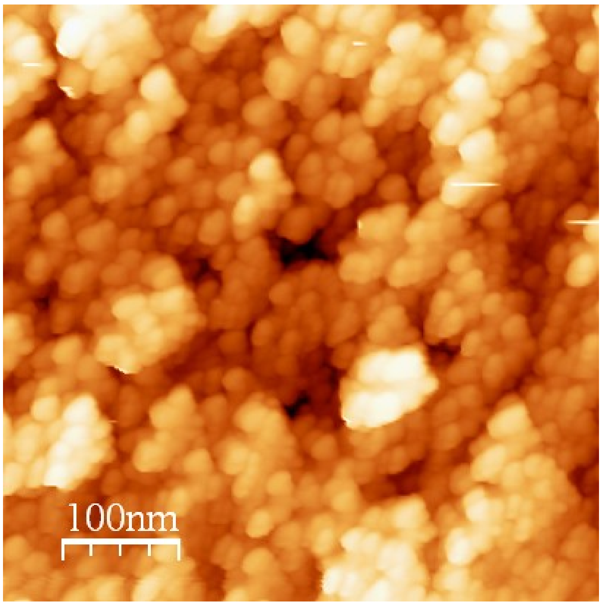

Fig 1.