CONDUCTIVE-SFM STUDY OF NANOSTRUCTURED IRON PREPARED BY SPUTTERING AT VERY LOW TEMPERATURES.

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Scanning probe microscopy (SPM) has already proven its almost unique potential for characterization and surface manipulation down to the nanometer scale. Furthermore, the ability to measure different properties by combining diverse operation modes has made SPM a unique tool in the field of nanoscience and nanotechnology: not only surface topography, but frictional, elastic, magnetic or current maps can be acquired with unprecedented resolution [1]. In this work, and by means of Conductive Scanning Force Microscopy (C-SFM), we have faced the combined study of the surface structure and the electrical characteristics of iron thin films grown on silicon. The influence of the substrate temperature during film growth on both, the surface topography and the conductivity properties, are addressed.

Iron thin films of about 6 nm have been prepared by DC magnetron sputtering on passivated Si (001) substrates. Several samples have been prepared at substrate temperatures, T_S, ranging from 300 to 200 K. As previously demonstrated, variations in this parameter may lead to significant changes in the microstructural features of Fe 100 nm-thin films [2]. Such modifications have direct influence on the obtained magnetic and transport properties [3].

As shown in figure 1 for two temperatures, noticeable differences in the surface morphology are found. For samples prepared at room temperature, (a) and (c), the coverage is uniform over the entire surface and the film consists of grains with an average diameter of 15 nm. However, samples prepared at T_S=200 K, (b) and (d), present a percolated morphology composed by grains of two different heights, which appear to be interconnected forming chains. The total covered area is ~48 %.

A typical current map obtained by means of C-SFM is presented in figure 2 with the corresponding topographic image. By exploiting the capability of SFM to measure at specific locations on the surface, differences in the electrical nature of the different grains are revealed by the respective current versus voltage (IV) curves (bottom figure 2). In particular, for films prepared at T_S=200 K, two different conductive responses are obtained: larger grains show an ohmic behaviour while smaller grains present IV curves, exhibiting a conduction gap for small voltages. These curves can be compared with the IV characteristics of the bare Si substrate.

References:

[1] J. Loos, Adv. Mater. 17 (2005) 1821.
[2] F. Jiménez-Villacorta, A. Muñoz-Martín y C. Prieto, J. Appl. Phys. 96 (2004) 6224.
[3] J. Stankiewicz, F. Jiménez-Villacorta and C. Prieto, Phys. Rev. B 73 (2006) 014429.

Figures:

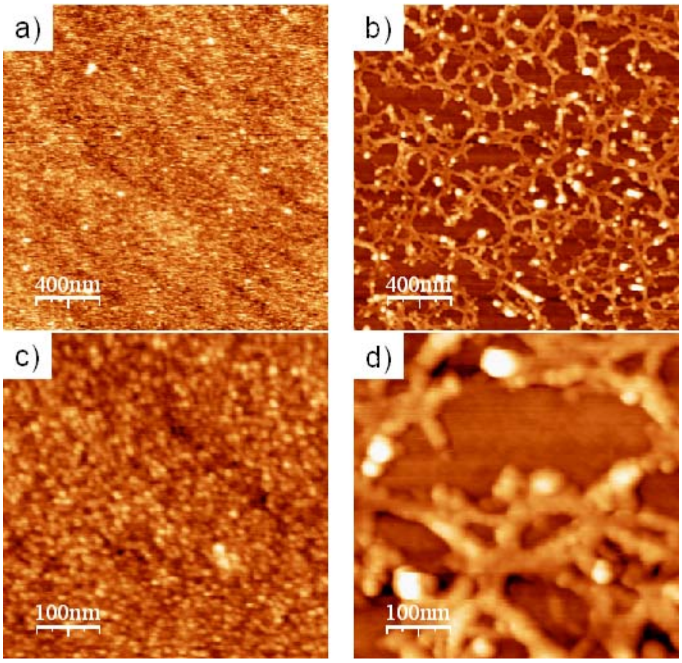

Figure 1: Topographic SFM images of 6nm of Fe on Si at (a) and (c) T_S=300K and (b) and (d) T_S=200K

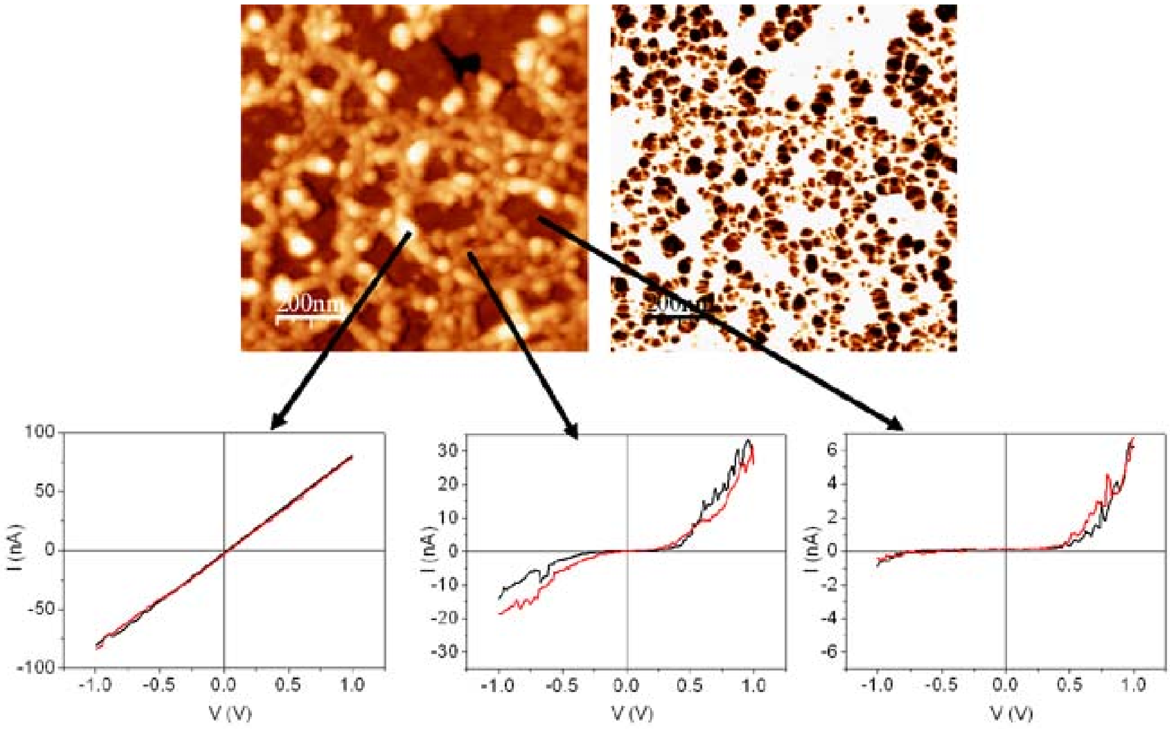

Figure 2: Top: simultaneous (a) topographic and (b) current images of ≃ 6nm of Fe on Si prepared at T_S=200K. Bottom: IV curves measured on specified locations: larger grains, smaller grains and bare Si substrate.