INFLUENCE OF SIZE AND SHAPE ON MAGNETIC PROPERTIES OF OXIDIZED IRON NANOPARTICLES GROWN BY SPUTTERING

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In recent years, the development of accurate methods to produce and characterize magnetic nanoparticles and nanostructures have shown an important development, due mainly to their special interest in technological research [1]. Differences in sizes, shapes and distributions of these structures determine qualitatively different magnetic properties, so precise techniques to control their preparation and to measure them are necessary. However, their morphological and structural studies are found to be quite difficult because of their very small dimensions.

In this work, iron thin films have been grown by DC magnetron sputtering using Si(100) wafers as substrates. Film thickness is about 50 nm, and grains forming these samples do not exceed from 20 nm. In order to control structural properties of these grains, such as size and shape, growth conditions can be varied, like magnetron power or substrate temperature during deposition, varying in the last case from 150 to 300 K. Two set of samples have been prepared: (i) “in-situ” oxidized and (ii) non-oxidized iron films. In order to prevent iron films from natural oxidation, all the samples series were covered with a gold layer.

Compositional characterization has been made using non-RBS technique, in order to obtain a depth profile of our samples. In this study, we have taken special care on situation of oxygen in the film to control oxidation.

For a better structural study, both XRD and EXAFS techniques have been used, finding out that our grains present an elongated shape, according to columnar growth observed in many films fabricated with this technique [2]. In combination with specific models for non-spherical particles [3], both techniques allows us to a precise understanding of size and shape of iron particles present in the films, as well as crystallographic properties of samples. Results show a clear decrease in grain dimensions as substrate temperature diminishes (see Fig.1).

For magnetic characterization we have made the point in the study of anisotropies present in our samples. To achieve this, we have made a detailed study of hysteresis loops (Fig.2) at different temperatures and ZFC-FC representations [4], applying both in-plane and out-of-plane configurations, using for this task a SQUID magnetometer. Results show that growth conditions and controlled oxidation of samples affect strongly their magnetic properties, such as evolution of coercive field with substrate temperature and magnetron power (see Fig.3), presence of anisotropy directions and even superparamagnetic behaviour. These effects can be explained by connecting them directly to structural properties of our samples.

References:

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Figures:

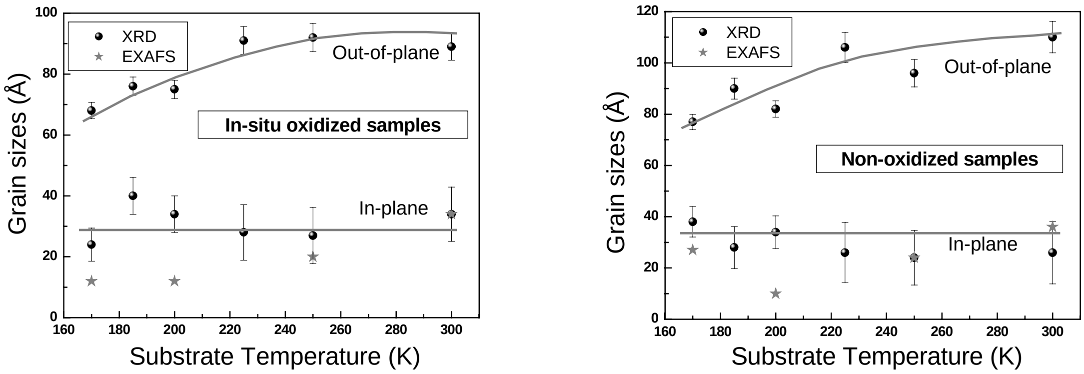

Fig. 1: Grain sizes estimated from the XRD and EXAFS results obtained by applying the spheroidal model. for "in-situ" oxidized samplesand non-oxidized samples.

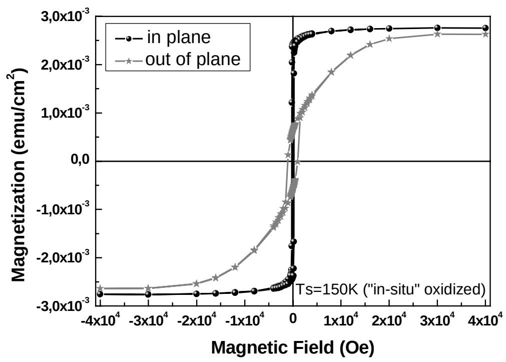

Fig. 2: Hysteresis loops of an in-situ oxidized sample. Magnetic measurements have two configurations: in-plane (with the film parallel to the plane) and out-of-plane (with the film normal to the plane).

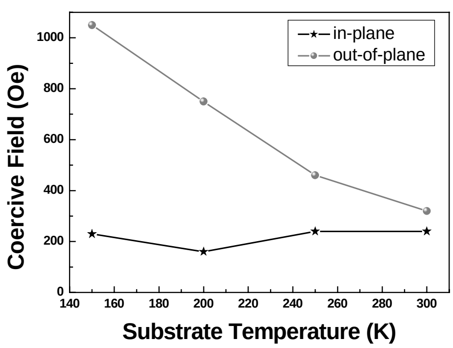

Fig 3: Influence of substrate temperature on coercive field in “in situ” oxidized samples.