HIGH MAGNETIZATION PARTICLES COATED WITH INORGANIC MAGNESIA FOR BIOMEDICINE, CATALYSIS AND SPINTRONICS APPLICATIONS

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Magnetic nanoparticles are a very active scientific arena since they offer abundant attractive possibilities in fields as diverse as catalysis, spintronics or biotechnology. But in spite of the encouraging progress in the recent years expectations have not been fully accomplished. For instance, the development of really useful magnetic nanoparticles remains challenging for applications in drug delivery or magnetic resonance imaging. Among the multiple hurdles that must be overcome, the provision of a sufficiently high magnetic response, good chemical stability and an adequate degree of biocompatibility are of major relevance. One promising solution for overcoming these problems is the development of core-shell structured nanoparticles in which the shell will provide chemical stability and biocompatibility while maintaining the magnetic properties of the core.

Here we report on a new nanostructured system, made of crystalline $Fe_{1-x}Co_x$ particles covered by a uniform 3 nm thick MgO epitaxial shell that has proved to be very promising for both biomedical and spintronic applications. Either by using the simple and scalable gas-aggregation method in a solar furnace, or by means of laser ablation techniques in liquid, spherical nanoparticles with high saturation magnetization (over 200 emu/g at room temperature) and sharp core/shell interfaces were obtained.

Studies of biocompatibility of $Fe_{1-x}Co_x$ / MgO nanoparticles performed in cell cultures derived from mouse embryo fibroblasts and embryo neocortex will be presented in parallel with the analysis of the potential performances of nanoparticles for hyperthermia applications.

Worthy, the exceptional properties of the Fe/MgO system, with its spin-filtering effect, have ensured a rapid growth of interest in this epitaxial structure for spintronic applications. We reported pioneering results on tunnelling magnetoresistance (TMR) in this system in 2001 [J. Cryst. Growth 226, 223 & Appl. Phys. Lett. 79, 1655], in a multilayered structure. Since then, TMR values have been substantially improved reaching values above 500% at room temperature [J. Phys. D: Appl. Phys. 40 (2007) R337]. Nevertheless, controlling the interfaces quality and pillar dimensions of these multilayered magnetic tunnelling junctions are key issues for technology commercialization. With these results in mind, we have investigated magnetotransport properties of both cold isostatic pressed assemblies of nanoparticles and isolated nanoparticles. On the one hand, we introduce here tunnelling conductance measurements of a single Fe island enclosed by the epitaxial MgO shell, showing clear oscillations in the I(V) curves as a function of the bias voltage that enables an accurate determination of the electronic density of states (DOS) of the iron core. In addition, magnetoresistance measurements at room temperature of assemblies of nanoparticles will be also presented.

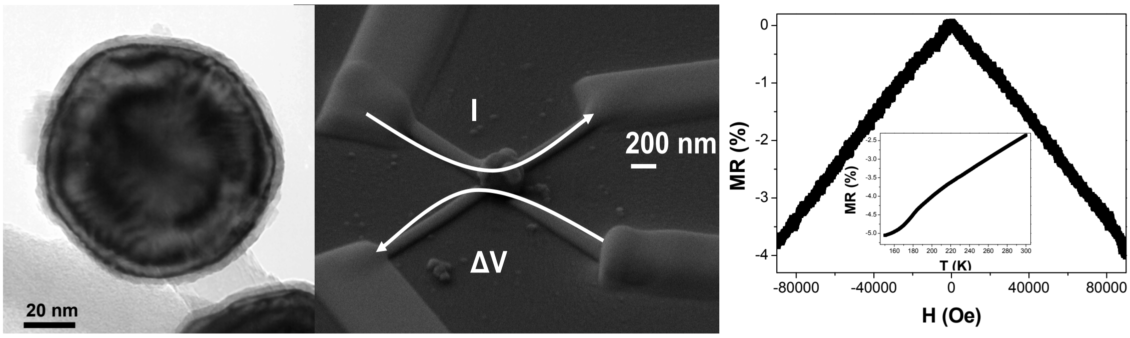

Fig. Electron microscopy images of core/shell particles and magnetotransport characterization. Left: TEM of a single Fe coated particle. Epitaxial relationship follows $[001]_{MgO}$ || $[001]_{Fe}$ and $[110]_{MgO}$ || $[100]_{Fe}$. Middle: SEM of the lead-particle-lead device used in the I-V spectroscopy measurements. Right: Magnetoresistance dependence on temperature and field.