Spatial Confined Growth Effects on the Crystalline Properties of Cylindrical Ferromagnetic Nanowires
V. M. Prida¹, E. D. Barriga-Castro², V. Vega¹, J. García¹, R. Mendoza-Reséndez³, C Luna³
¹Depto. de Física, Universidad de Oviedo, Calvo Sotelo s/n, 33007-Oviedo, Asturias, Spain. ²Centro de Investigación en Química Aplicada (CIQA), Blvd. Enrique Reyna Hermosillo No. 140, Saltillo, 25294 Coahuila, Mexico. ³Universidad Autónoma de Nuevo León (UANL), Av. Universidad S/N, San Nicolás de los Garza, Nuevo León 66450, Mexico.

Ordered assemblies of cylindrical nanowires electrochemically grown into the self-organized channels of nanoporous anodic alumina templates, are nanostructured systems exhibiting unique physical properties, which can be engineered through the controlled modification of the diameter, size, chemical composition and crystalline structure of nanowires, together with their interdistance in the nanowires arrangement. The magnetic properties of such nanomaterials are usually explained on the hypothesis of an idealized crystalline structure that is usually assumed to determine the effective magnetic anisotropy of the system, mainly attributed to the competition between the magnetocrystalline and shape anisotropies of each nanowire in the array. However, the confined growth of these nanowires into the membrane pores, forces to the atoms to be accommodated into a cylindrical volume with nanoscale dimensions, yielding to the frustrated formation of stable facets and right angles in the transverse directions of the nanowires, resulting in pseudo-monocrystalline and/or polycrystalline structures that have not been ever studied in detail until now, albeit the scientific and technological relevance of these cylindrical magnetic nanowires. Here we investigate these spatial confined effects, which have been experimentally studied by several transmission electron microscopy techniques in three different systems of magnetic nanowires (nickel, cobalt and multisegmented Co₅₈Ni₄₂/Co₈₃Ni₁₇ nanowires), suggesting the universality of these phenomena. Concretely, we report experimental evidences of the inhibited formation of some crystallographic planes and directions, and the appearance of stacking faults and crystalline deformations even in not particularly thin nanowires (diameters around of 200 nm), resulting nanowires with pseudo-monocrystalline structures that exhibit unusual electron scattering properties, including the appearance of forbidden reflections and an anomalous low-dependence of the electron diffraction patterns with the sample tilting angle. The comprehension of these effects provides a new fundamental framework to engineer the magnetic behaviors of nanowires for a wide variety of emerging technologies based on these low dimensional materials.

Keywords: alumina template, electrodeposition, nanowire

References:


Presenting author’s email: vmpp@uniovi.es