Structural and electronic characterization and spin-orbit effects on IrO_2 thin films

E. Arias-Egido[1, 2], M. A. Laguna-Marco[1, 2], P. Jiménez-Cavero[3, 2], Roberto Boada[4, 5], Sofía Díaz-Moreno[5], I. Lucas[3, 2], C. Piquer[1, 2]

[1]*Instituto de Ciencia de Materiales de Aragón, CSIC - Universidad de Zaragoza, Zaragoza 50009, Spain*
[2]*Departamento de Física de la Materia Condensada, Universidad de Zaragoza, 50009 Zaragoza, Spain*
[3]*Instituto de Nanociencia de Aragón, Universidad de Zaragoza, Zaragoza 50018, Spain*
[4]*Universitat Autònoma de Barcelona, Department of Chemistry, 08193 Bellaterra (Barcelona), Spain*
[5]*Diamond Light Source Ltd, Harwell Science and Innovation Campus, Didcot, Oxfordshire OX11 0DE, United Kingdom*
earias@unizar.es

IrO_2 has recently attracted considerable interest for spin-current detection since it exhibits a large spin Hall effect (SHE), a novel phenomenon where the spin-orbit coupling (SOC) converts a charge current into a spin current [1]. In order to make IrO_2 suitable for spintronic applications it is essential to grow it in nanostructures with controlled and optimized structure. Surprisingly enough, initial works on IrO_2 nanostructures have reported not only a good behavior in the polycrystalline state of such material, but even also a better one in the amorphous state. This is quite an unexpected result that prompts us to understand the effect of structure and low dimensionality on the electronic and magnetic properties. A particular important question to elucidate is the effect of surfaces, interfaces and microstructure in the SOC.

Aiming at this; we have grown several IrO_2 thin films by means of the sputtering and PLD techniques, obtaining thus, samples with different microstructure, crystallinity and thickness. The strength of the SOC, more specifically $\langle L \cdot S \rangle$, was determined by applying sum rule analysis to the XANES spectra [2].

By measuring the HERFD-XANES in the IrO_2 films we gained information on how the structural details (surface/bulk ratio, crystallinity, strain, etc.) affect to the strength of the spin-orbit interaction. In all the cases the XANES data showed strong "white lines" at both absorption edges with a significant SOC independently on the structural details.

Our data so far indicate that samples with a worse degree of crystallinity have a better SOC, which explains the behavior reported by Fujiwara et al. [1]. This is a remarkable result in terms of practical applications. In addition, our data suggest that the crystal orientation and the lattice parameters may be a key factor affecting the strength of the SOC.

[1] K.Fujiwara et al., Nature Communications 4, 2893 (2013)
[2] G. van der Laan and B. T. Thole, Phys. Rev. Lett. 60, 1977 (1988)

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