Structural and electronic characterization and spin-orbit effects on IrO$_2$ thin films

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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.


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