Towards more Efficient Spin/Charge Conversion at the α-Sn Topological Insulator Surface

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Classical spintronics generally uses magnetic materials to produce a spin current from a spin-polarized charge current, but it now appears that spin-orbit coupling (SOC) provides new directions to generate pure spin currents without associated charge currents. The SOC, this relativistic correction to the equations of quantum mechanics, can be significantly strong in materials containing heavy atoms. Today, it turns out that an efficient conversion can be obtained by exploiting the SOC-induced properties of a two-dimensional electron gas (2DEG) found at some surfaces and interfaces: the so-called Rashba interfaces and the surfaces or interfaces of new materials called topological insulators (TI).

Band gap opening and TI properties can be induced at room temperature in α-Sn (0 0 1) layers by strain and quantum-size effects in thin films [1–3]. Indeed, Angle-Resolved Photoemission Spectroscopy (ARPES) measurements by Ohtsubo et al. [3] performed on thin α-Sn (0 0 1) films grown in-situ by molecular beam epitaxy revealed a Dirac cone (DC) linear dispersion with helical spin polarization around the Γ point of the surface Brillouin zone. We recently reported that a very efficient spin-to-charge conversion (SCC) can be achieved at room temperature by spin pumping into this α-Sn thin films, in clear relation with the Inverse Edelstein Effect (IEE) induced by the counterclockwise helical spin configuration of the Dirac cones identified by ARPES [3,4].

We will present our recent work where we studied by ARPES the thickness dependence as well as the impact of a metallic or insulating capping layer on the α-Sn surface states. For all the thicknesses (20ML to 51ML) a linear energy dispersion of the surface states has been observed as illustrated in Figure 1 for a α-Sn sample with 51ML (6.55nm) thickness. It leads to a precise description of the states where Fermi velocity, Fermi level and density of states can be extracted. Concomitant with the ARPES experiment we performed magnetotransport experiments on samples covered by $Al_2 0_3$ which preserve the surface states as revealed during ARPES experiments. A large anisotropic magnetoresistance was observed as illustrated by Figure 2. We will discuss the origin of this anisotropic magnetoresistance including gap opening and backscattering effects on topological surface states when a magnetic field is applied perpendicular to the surface of the sample. It leads to an estimation of large g factor associated to the surface states.

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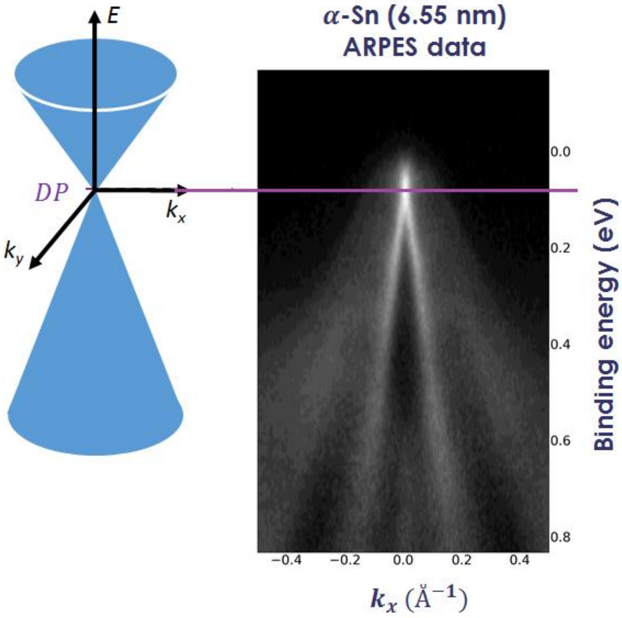

Figure 1: ARPES energy dispersion of α-Sn displaying a Dirac cone

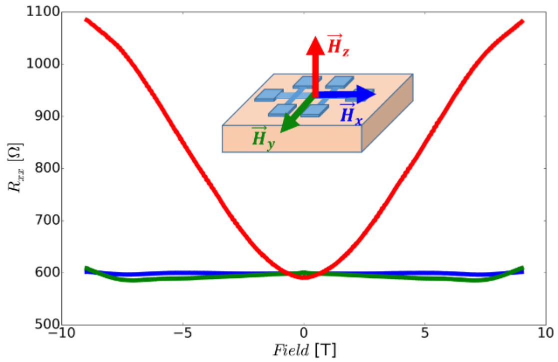

Figure 2: Magneto-transport measurement with large anisotropic magnetoresistance when the applied field is perpendicular to the plan.

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