Highly efficient spin-to-charge current conversion at room temperature in strained HgTe surface states

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Spin current manipulation in spintronic requires finding an efficient way to transform charge currents into spin currents, and vice-versa. If classical spintronics generally relies on magnetic materials, the spin manipulation can also be achieved by harnessing the Spin Orbit Coupling (SOC) in non-magnetic materials. For instance, the Spin Hall Effect permits to convert charge currents into spin currents in the bulk of heavy metals, such as Pt or Ta [1]. Yet a more efficient conversion can be obtained in two dimensional electron gas (2DEG) at surfaces and interfaces, such as at Rashba Interfaces [2] and in topological insulators.

The main interest of topological insulators lies in their surface states, which possess a linear Dirac-like dispersion, and a spin momentum locking (cf. figure 1). A flow of electric current in the 2DEG leads to a spin accumulation. The direction of the accumulated spins is parallel to the surface, and perpendicular to the electron motion direction. This effect is known as the Edelstein Effect [3], while the reverse spin-to charge-conversion effect is known as the Inverse Edelstein Effect (IEE). Recent results suggest that surfaces of topological insulators as Bi_2Se_3 [4] or strained α-Sn [5] have a strong potential for spintronics, both for the generation or detection of spin currents through direct or inverse Edelstein effects.

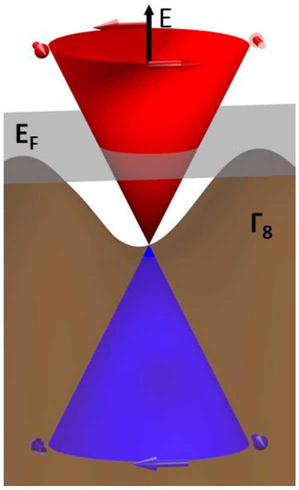

Figure 1: Schematic representation of the band structure of strained HgTe, with the Dirac dispersion cone of the surface states, and the bulk Γ8 band. The arrows represent the helical spin configuration.

Among these newly discovered class of materials, strained HgTe is a promising one, as it is an archetypal topological insulator, compatible with electronic and optoelectronic applications. Gap opening and Topological insulator properties can be induced in HgTe by applying a tensile strain that can be achieved by epitaxy of HgTe on a substrate with a larger lattice constant, such as CdTe [6].

The spin to charge current conversion has studied in strained HgTe thin films by ferromagnetic resonance spin pumping in cavity as described on figure 2. The spin to charge current conversion rate, the inverse Edelstein length [7], was measured to be up to 2 nm, one to two orders of magnitude larger than in Bi-based topological insulators [8]. Such high conversion rate can be related to the large value of the mobility [9] and mean free path of the surface states of strained HgTe and the lower bulk to surface conductivity ratio at room temperature compared to Bi_2Se_3. Moreover, the non-conventional thickness dependence of the conversion rate allows to ascribe this conversion to the topological surface states.

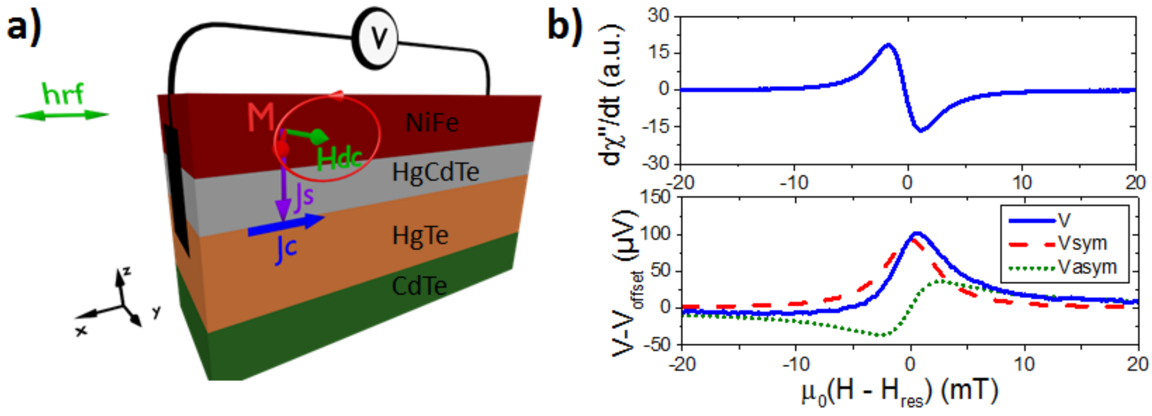

Figure 2: a) Geometry of the spin pumping by ferromagnetic resonance (FMR) measurement setup, and stack used for the measurement. b) FMR and DC voltages in a typical spin pumping FMR measurement. The symmetric (dashed line) and antisymmetric (dotted line) contributions have been extracted from the measured signal (in blue). The symmetric contribution corresponds to the inverse Edelstein Effect contribution.

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