DEPARTMENT OF PHYSICS AND ASTRONOMY

SPECIAL CONDENSED MATTER SEMINAR

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Physics Room 242, 10:00 AM

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Strained HgTe topological insulators, toward spintronic applications

First predicted in 2007 as a new class of matter, three-dimensional topological insulators (3D TI) combine an insulating bulk and conducting surfaces with a massless Dirac fermion band structure where the spin and the momentum are locked. Thanks to their unique electronic and spin properties, these materials are expected to give rise to novel electronic transport mechanisms with potential applications in quantum nanoelectronics and spintronics. With an inverted band structure, the semi-metal HgTe has been identified as a strong TI assuming the opening of a bulk gap. Quantum confinement for 2D structures or application of a tensile strain for 3D bulk ones allow to generate this gap.

Tensile strained HgTe/HgCdTe layers have been grown by molecular beam epitaxy on CdTe (100) substrates [1]. Since electronic transport occurs at HgTe/HgCdTe interfaces, a careful investigation of interface morphology, strain, and chemistry has been required to find ways of improvements to optimize our structures. With constant efforts , our strained 3D HgTe TI are now characterized with flat interfaces and very high mobility (up to 600,000 cm2/(V.s)), witnessing an excellent control in the growth and processing of HgTe.

By applying large magnetic field, our thin films of 3D HgTe TI enter in the Quantum Hall (QH) regime where plateaus of the Hall resistance are associated to vanishing longitudinal resistances. Consequently, we demonstrate direct evidences of Dirac fermions in these thin films of strained 3D HgTe TI by temperature dependent analysis of the QH effect. In particular, we highlight that the energy separation between successive Landau levels (LL) is consistent with a Dirac-like LL energy spectrum $EN = \sqrt{2e\hbar v f 2NB}$. We also demonstrate that the coupling between the top and bottom topological surface states leads to a degeneracy lifting of the LLs through a mechanism specific to these Dirac surface states.

With the demonstration of their topological nature, our 3D HgTe structures are now implemented into simple p-n junctions to realize a first spin-based logic element.
This whole study, including the material growth optimization and characterization, the magneto-transport measurements and the on-going work focusing on spintronic applications, will be presented.

**** [1] P.Ballet, C.Thomas, X.Baudry, C.Bouvier, O.Crauste, T.Meunier, G.Badano, M.Veillerot, J.P.Barnes, P.H.Jouneau and L.P.Lévy, Journ.of Elec. Mat., 43, 2955-2962, (2014).***