ARPES study of the interface states in normal/topological crystalline insulator heterostructures

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While some essential characteristics of topological interface states are dictated solely by considerations of symmetry and bulk band structure, small perturbations can still induce significant modifications. For example, the topological crystalline insulator (Pb,Sn)Se can be surface doped with rubidium atoms to achieve a rigid (i.e. $k_{||}$ independent) energy shift [1], whilst lattice distortions will open a gap [2] and changes in temperature or tin content can modify or eliminate the topological surface states [3].

A particularly interesting modification of the surface states can result from intervalley scattering. This effect requires a sharp confinement potential on a surface in which two or more inequivalent bulk valleys have the same in-plane momentum, and was heavily studied in silicon inversion layers. Among all of the currently known topological insulators, only the (100) face of (Pb,Sn)Se and (Pb,Sn)Te possess this property. The consequence is the existence of two sets of Dirac-like surface states at each $\bar{X}$ in the surface Brillouin zone, split in energy by the intervalley scattering [4].

Here we present an angle resolved photoemission study (ARPES) of the topological interface states in (100) oriented, in-situ grown PbSe/(Pb,Sn)Se heterostructures. We are able to observe the evolution of the topological surface states (TSS) as the TCI-normal interface is buried. With rising thickness of the capping layer the interevalley energy splitting of TSS oscillates and diminishes to zero for thick enough PbSe over-layer. For yet thicker cap TSS are completely buried and disappear in ARPES pictures. Instead, the oscillations of the density of states in the continuum energy regions start to be visible. Such oscillations, reported previously in the case of metallic thin films, appear due to the interference effect of electrons scattering at interface and surface of the system.

Most of the obtained effects have been qualitatively well described with the use of tight binding model. The calculated oscillatory effect, however has much lower amplitude. The similar oscillations with the width of the structure have been previously predicted in the case of electrons confined in quantum wells [5,6] but to date this has not been experimentally confirmed.

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