Oscillating valley splitting in a topological insulator heterostructure

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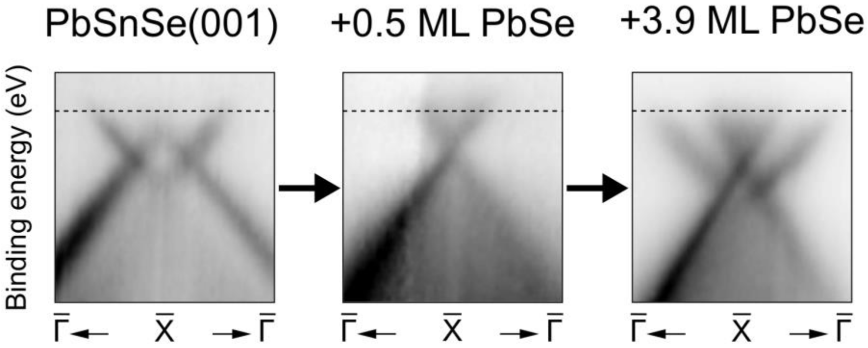

The surface states found on the (001) faces of $Pb_{1-x}Sn_xSe$ and $Pb_{1-x}Sn_xTe$ crystals feature an unique "double Dirac cone" structure, consisting of two identical Dirac cones at $\bar{X}$ which are separated by an energy splitting of approximately 80meV. Combined with the influence of mirror symmetry protection, this leads to the unusual situation of topologically protected band-crossings located away from a time reversal invariant momentum.

By tuning properties of the bulk crystal, previous experimental studies have shown that the magnitude of the splitting is correlated with the bulk band inversion strength [1-3]. However, the mechanism behind this was not clarified.

Here we demonstrate an alternative approach to studying the splitting, in which we grow heterostructures consisting of thin layers of the topologically trivial semiconductor PbSe on top of bulk crystals of the band-inverted topological crystalline insulator $Pb_{0.7}Sn_{0.3}Se$. With angle resolved photoemission spectroscopy we observe the evolution of the topological interface state as it is buried by up to 2.5nm. We demonstrate that the valley interaction that splits the two Dirac cones at each $\bar{X}$ is extremely sensitive to atomic-scale details of the surface, exhibiting non-monotonic changes as PbSe deposition proceeds. This includes an apparent total collapse of the splitting for sub-monolayer coverage. Aided by tight binding calculations and an effective mass model, we offer a full explanation of the origin of these effects [4].

References:
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