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Electric Field Control of Topological Insulator Surface States

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Electrical-field control of the carrier density of topological insulators (TIs) has greatly expanded the possible practical use of these materials. However, the combination of low-temperature local probe studies and a gate tunable TI device remains challenging. We have overcome this limitation by scanning tunneling microscopy measurements on in-situ molecular-beam epitaxy grown TI films on SrTiO3 substrates with pre-patterned electrodes. We are able to continuously tune the carrier density and observe the local electronic structure of pristine TI films. In the talk I present our recent results on back-gated Bi2Se3 and Sb2Te3 films. In Bi2Se3 films, we found that both DOS and the wavelength of the standing waves vary with gate voltage, due to the shifting of the Fermi level. In 3 nm thick Sb2Te3 film, a gap opening at Dirac point due to the coupling of top and bottom surface is observed. Moreover, the surface state band gap was found to be tunable by back gate, indicating the possibility of observing a topological phase transition in this system. Our results are well explained by an effective model of 3D topological insulator with structure inversion asymmetry, indicating that 3 nm thick Sb2Te3 films are topologically nontrivial and belong to the quantum spin Hall insulator class.