Mapping the fluctuations of Dirac point in $BiSbTeSe_2$ measured by STM/STS

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Recently discovered quaternary compound $Bi_{2-x}Sb_xTe_{3-y}Se_y$ (Fig.1) are known to exhibit ideal characteristics of 3D topological insulators (TI), such that they exhibits surface dominant transports due to its bulk insulating properties and their Dirac point energy are tunable within the bulk band gap by changing their alloy composition. These characteristics allows us to observe a hallmark of topological transport, half integer quantum Hall effect. However, spatial fluctuation of topological surface state due to alloy disorder, defect, dopant/acceptor, has been pointed out to degrade the surface transport property.

In this study, we performed spatially resolved STS experiment to evaluate spatial fluctuations of surface electronic structure of $BiSbTeSe_2$ (BSTS) and Bi_2Te_2Se using LT-STM operated at 2K. The Crystal structure of $Bi_{2-x}Sb_xTe_{3-y}Se_y$ is shown in fig.a, a hexagonal crystal structure consisting of five atomic layers along c axis. Each layer forms a binary alloy $Bi_{2-x}Sb_x$ and $Te_{3-y}Se_y$ with two-dimensional hexagonal lattices. STM image obtained on BSTS surface is shown in fig.b. Atomic scale topographic height variation arises from inhomogeneity of electronic structure due to alloy. Dirac point (DP) of topological surface state which appears as a dip of dI/dV spectrum (fig.3), were spatially mapped in in fig.4. Dirac point energy were positive in all measured area, indicating that BSTS is p-type TI. Spatial fluctuation of DP is smoother than that of the other reported Bi based TI materials, demonstrating high quality of our sample.

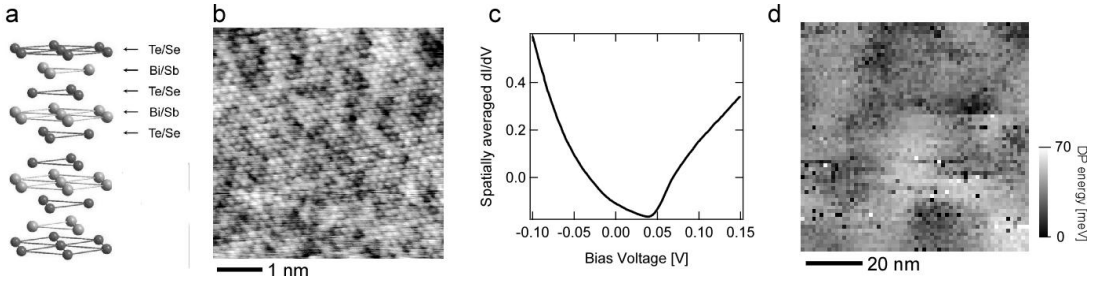

Fig.a Crystal structure of BSTS b. STM image of BSTS c. spatially averaged dI/dV spectrum d. nanoscale variation of DP energy obtained from spatially resolved STS spectrum