Supplementary Information

Demonstration of surface transport in a hybrid Bi_2Se_3/Bi_2Te_3 heterostructure

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Supplementary Information

Hall Measurements of 20 QLs Bi_2Se_3, 20 QLs Bi_2Te_3 and 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3

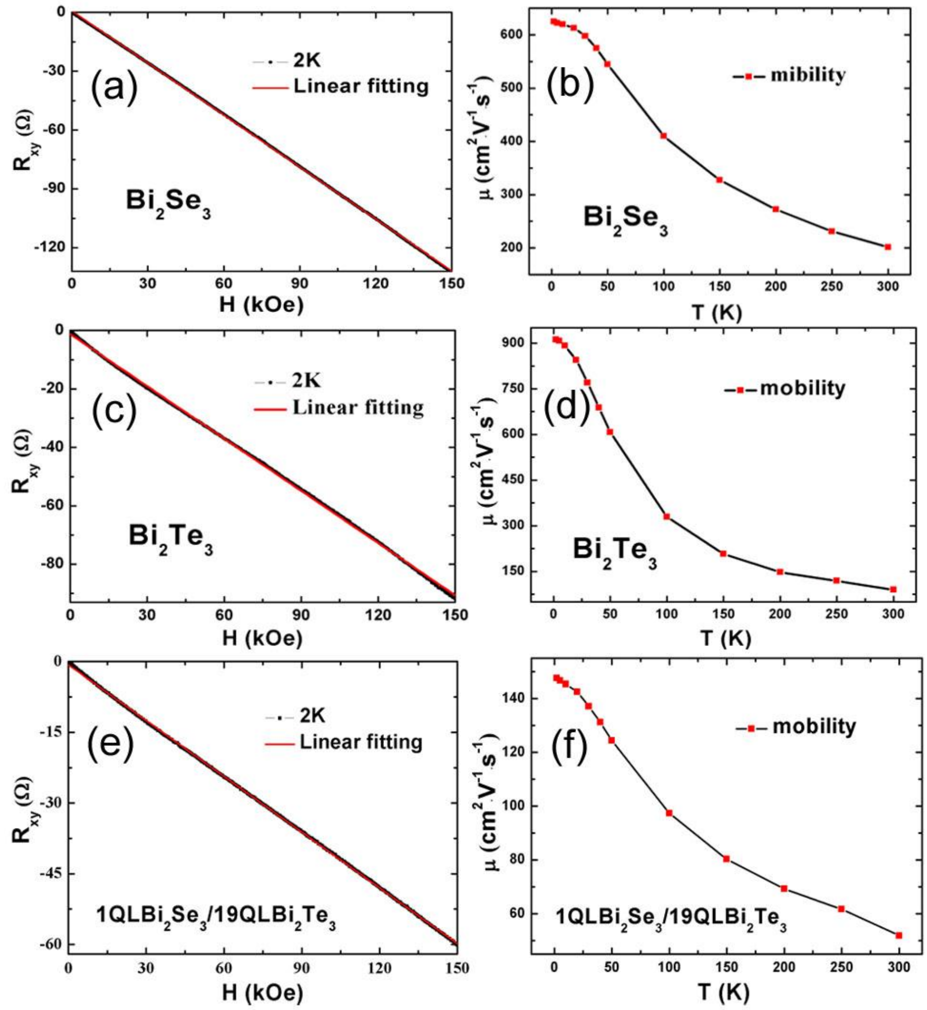

Fig. S1: Hall resistance of the 20 QLs Bi_2Se_3 film (a), 20 QLs Bi_2Te_3 film (c) and 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 thin film (e) at 2 K. Temperature dependence of mobility for three samples, (b) for 20 QLs Bi_2Se_3, (d) for 20 QLs Bi_2Te_3 and (f) for 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 thin films.

We determine the carrier density in the three samples using the Hall effect, as shown in Fig. S1. The carriers are electrons in all three samples. From the approximately linear behavior of R_{xy} at low magnetic field, we estimate a carrier density of $3.53\times10^{19}cm^{-3}$ and mobility of $650cm^2/vs$ for the 20 QLs Bi_2Se_3 film at 2

K. For the 20QLs Bi_2Te_3 film, carrier density is $4.17\times10^{19}cm^{-3}$ and mobility is $912cm^2/vs$. The carrier density of the 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film is $7.9\times10^{19}cm^{-3}$ and the mobility is $134cm^2/vs$.

Complete transport data of Fig. 3f

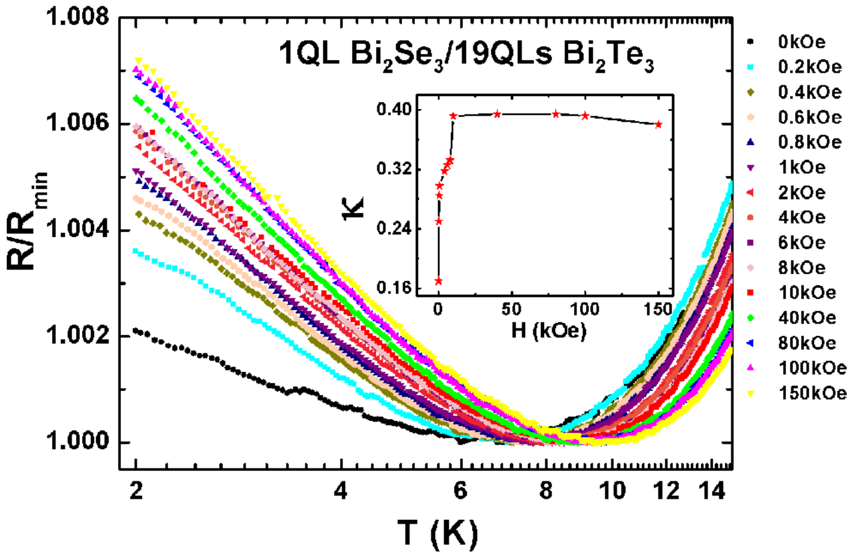

Fig. S2: The complete transport data on the 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film as a function of temperature at different magnetic field, indicates that a logarithmic increase with decreasing T. In the upper inset, the slope defined as $\kappa = (\pi h/e^2)d\sigma_{xx}/d\ln T$ is shown as a function of magnetic field. The κ increases with increasing the magnetic field and becomes a constant when the magnetic field ranges from 10 kOe to 150 kOe.

The Linear MR of the 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film at different tilt angle

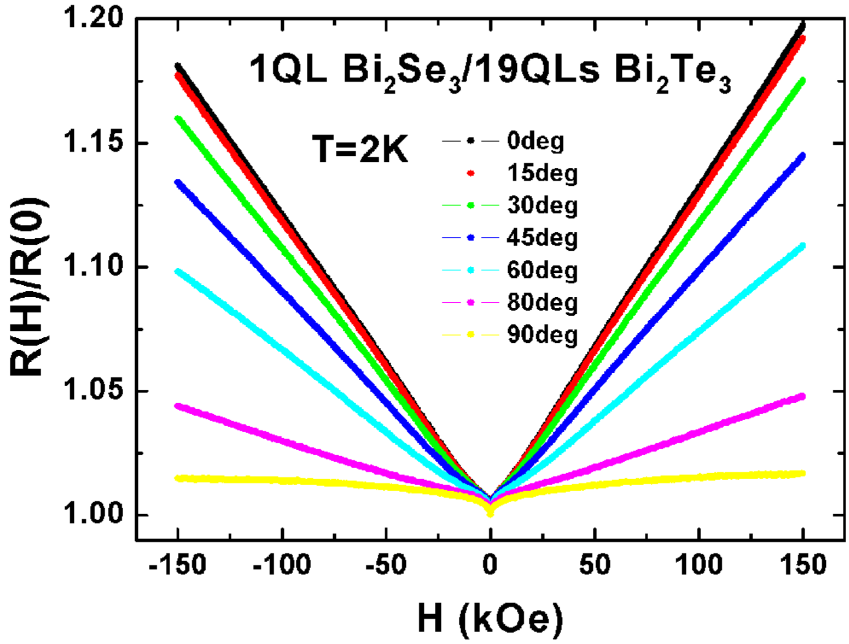

Fig. S3: Normalized MR vs magnetic field of the 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film at 2 K at different tilt angle between sample surface and the magnetic field.

In perpendicular magnetic field (θ=0deg), the sample exhibited a linear, non-saturated behavior across a wide range of magnetic field from 10 kOe to 150 kOe. The behavior gradually decreased when the sample was tilted away from the perpendicular angle and eventually became nonlinear in the parallel magnetic field (θ=90deg). It indicates that the linear MR is a 2D magneto-transport behavior.

The fitting combined weak antilocalization with e-e interaction theory of 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film in low field at *T*=4K

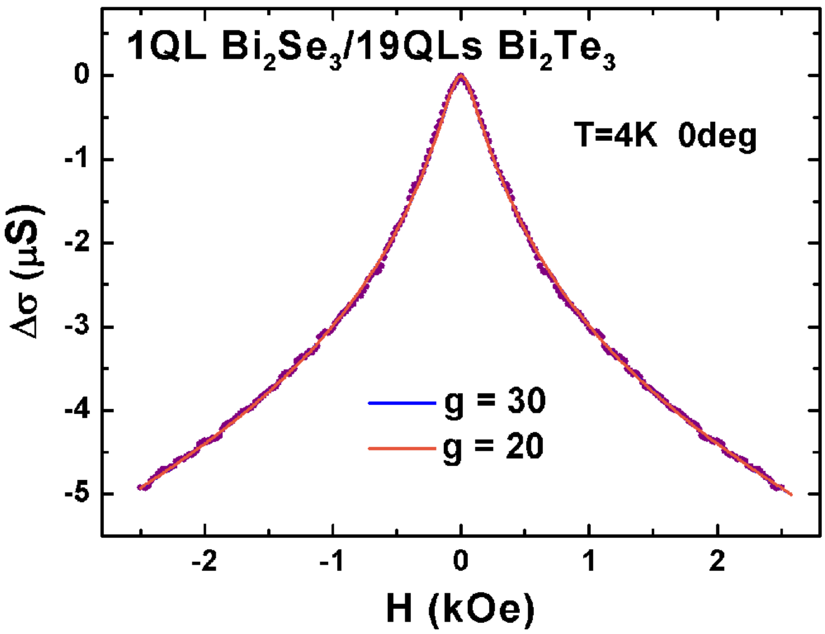

Fig. S4: Solid lines are the results of a combined WAL and EEI theory[S1]. Considering the g-factor of 1 QL Bi_2Se_3 / 19 QLs Bi_2Te_3 film is not so sure, we fixed g-factor to be 30 and 20. The fitting curves are plotted by blue and orange respectively.

The combined model [S1]: $\Delta\sigma(T,H_\perp)=\Delta\sigma_{WAL}(T,H_\perp)+\Delta\sigma_{EEI}(T,H_\perp)$

$$\Delta\sigma_{WAL}=-\frac{\alpha e^2}{2\pi^2\hbar}\left[\ln\left(\frac{\hbar}{4Bel_\phi^{\,2}}\right)-\psi\left(\frac{1}{2}+\frac{\hbar}{4Bel_\phi^{\,2}}\right)\right]$$ and $$\Delta\sigma_{EEI}=-\frac{e^2}{4\pi^2\hbar}\tilde{F}_\sigma g_2(T,H)$$

Where $g_2(T,H)=\int_0^\infty d\Omega\ln\left|1-\left(\frac{g\mu_B H/k_B T}{\Omega}\right)^2\right|\frac{d^2}{d\Omega^2}\frac{\Omega}{e^\Omega-1}$

α, $\tilde{F}_\sigma$ and l_ϕ are taken as fitting parameters.

The fitting parameters are as follows:

g-factor	α	l_ϕ	$\tilde{F}_\sigma$
30	-0.32	194nm	0.6
20	-0.25	193nm	0.93

Reference

S1. Wang, J. et al. Evidence for electron-electron interaction in topological insulator thin films. *Phys. Rev. B.* **83**, 245438 (2011).