MAR13-2012-020146

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

**Topological insulator engineering of $Bi_2Se_3$ through molecular beam epitaxy**[1]

SEONGSHIK OH, Rutgers University

Despite numerous reports proving the presence of the surface states on various topological insulator (TI) materials, all existing TI materials suffer from the bulk conductance problem at various levels. Therefore, achieving a truly insulating bulk state without degrading the surface state in their transport properties is one of the most important tasks of the TI materials research. In this talk, I will present how we address this problem by utilizing various molecular beam epitaxy (MBE) schemes with focus on $Bi_2Se_3$ family of materials. Considering that the bulk conductance problem originates mostly from the selenium vacancies in $Bi_2Se_3$, the typical MBE growth condition characterized by low growth temperature and high selenium vapor pressure is ideal for solving this bulk conductance problem. Moreover, thin films have another advantage of naturally reduced bulk effect due to the enhanced surface-to-bulk ratio. These intrinsic advantages of MBE-grown TI thin films recently led to a number of new findings. High quality $Bi_2Se_3$ thin films did show the expected dominant surface transport characters with negligible bulk conductance. However, the strong tendency toward downward band bending in undoped $Bi_2Se_3$ introduces trivial surface transport channels in addition to the topological surface states, leading to complications in the interpretations of transport results. Furthermore, even if reducing the thickness of TI samples helps reveal the surface transport channels by reducing the bulk contribution, it does not really solve the bulk conductance problem because regardless of how small it may be, the bulk state still remains metallic, shorting the top and bottom surfaces. According to the Mott-criterion of metal-insulator transition, in order to implement a truly insulating bulk state in the current generation TI materials, it is necessary to suppress the defect density below $\sim 10^{14}$ cm$^{-3}$, which might be fundamentally impossible considering the weak Van der Waals bonding character of these materials. However, we have found that it is possible to overcome this limit and achieve a bulk-insulating topological insulator with fully decoupled surface states in thin film TIs.

[1]This work is supported by National Science Foundation (NSF DMR-0845464) and Office of Naval Research (ONR N000140910749 and N000141210456).