CHAPTER 7

Summary and future perspectives

7.1 Summary

The present dissertation addresses interesting magneto-transport properties, ARPES studies and theoretical investigation of some TIs. The high-quality single crystal samples of TIs were synthesized by adhering modified Bridgman technique. The single crystalline nature of all grown samples was confirmed by XRD and Laue diffraction. Further, the extensive transport measurements, magnetic measurements, ARPES measurements and pressure dependent transport measurements have been performed. $Bi_{2-x}M_x(SeS)_3$, $Bi_2Cu_xTe_{3-x}$, $Bi_{1.5}Sb_{0.5}Te_{1.3}Se_{1.7}$, $Bi_{2-x}Fe_xSe_{3-y}S_y$ TIs materials have been chosen for present thesis work.

The magneto-transport, angle resolved photoemission spectroscopy (ARPES), magnetization of $Bi_{2-x}M_x(SeS)_3$ (with M=Fe, Mn) have been investigated. In Fe-doped $Bi_2(SeS)_3$ the presence of both the electron-mediated RKKY coupling and carrier-independent van Vleck magnetism have been demonstrated. Interestingly by varying the Fe content and temperature, the interplay between the two mechanisms for magnetic ordering has been revealed. On the other hand, in Mn doped sample hole-mediated RKKY coupling is observed. Thus, a particular mechanism can be used to induce magnetic ordering in topological insulator. Furthermore, both ARPES and magnetic studies indicate that surface magnetic ordering may or may not break the time reversal symmetry (TRS) whereas bulk magnetic ordering breaks the TRS suggesting the potentiality of these materials for spintronic application. All the investigated results are mentioned in chapter 3.

The angle resolved photo-emission spectroscopy (ARPES) study and magneto-transport properties of $Bi_2Cu_xTe_{3-x}$ have been investigated. ARPES study indicates the clear existence of surface states in the as-prepared samples. The estimated bandgap from ARPES is found to be ~5 meV and 16 meV respectively for x=0.03 and x=0.15 samples. Presence of larger Cu concentration (x=0.15) introduces magnetic ordering. Observed non-linearity in the

Hall data is due to the existence of anomalous Hall effect which can be attributed to the 2D transport. The observed magneto-transport features might be related to the surface carrier which is confirmed by ARPES study.

The magneto-transport and from angle-resolved photoelectron spectroscopy (ARPES) of the S-doped $Bi_{1.5}Sb_{0.5}Te_{1.3}Se_{1.7}$ system have been investigated. Both the positive magnetoresistance (p-MR) and negative magnetoresistance (n-MR) under perpendicular magnetic field as well as a change-over from Weak Anti Localization (WAL) to Weak Localization (WL) are observed. The interplay between p-MR and n-MR is elucidated in terms of the dephasing and spin-orbit scattering time scales. The topological surface state bands have been probed from angle-resolved photoelectron spectroscopy (ARPES).

At the lower temperature range, the interband s-d e-phonon scattering mechanism dominates over s-s e-phonon scattering mechanism in $Bi_{2-x}Fe_xSe_{3-y}S_y$. The value of β=0 and 0.5 enunciate about normal fermions and Dirac fermions, respectively. If β is near about 1/2 leads to the π Berry phase and suggests that the oscillations originate from the surface helical state. The value of α, which varies $1.61<\alpha<1.87$, which is very close to 2, suggesting that it is a perfectly compensated system. It has a tremendous power factor at 236K and 300K; therefore, we can use it at room temperature potential applications. The low value of χ (temperature coefficient) is the foremost to get a high power factor value .

7.2 Future Perspectives

The discovery of TIs has emerged as a subject of immense attraction in current era. These materials have Dirac quasi-particle, exhibit extraordinary properties from the viewpoint of both fundamental and technological enthusiasm. The focus of the present work was to observe some interesting results and to explore some new quantum phases of materials by manipulating some internal and external parameters of well-recognized TIs for the benefit of fundamental research and technological applications. Few given goals may be achieved in the future.

- To enhance the magneto-resistive properties of topological insulator at room temperature by doping of different magnetic/nonmagnetic elements.
- To enhance the thermoelectric property of topological insulators upon doping of transition metal and rare earth elements.
- To introduce superconducting property in 3D topological Insulator by creating internal chemical pressure this could be a prominent way to get the Majorana fermions.
- Thickness dependent transport study can be performed after growing the TIs thin films