Preface

Three dimensional (3D) topological insulator (TI) is a new quantum state of matter, characterized by gapless surface state (SS) and bulk gap inverted due to strong spin orbit coupling. In 3D topological insulator, surface states have an odd number of massless Dirac cone. In which spin of an electron locked perpendicular to its momentum in chiral spin structure where electron with opposite momenta have opposite spins. The topological surface states have revealed many interesting quantum phenomena associated with transport studies of topological insulators (TIs) such as weak antilocalization (WAL).

Among the various discovered Topological Insulating (TIs) materials, Bi_2Se_3 is one of the most popular candidates as it has a single Dirac cone in the Brillouin zone and relatively large bulk energy gap of 0.3eV, sufficient for room temperature applications. Topological insulators also are of interest for spintronic materials as the Dirac states can be used to carry the spin current with small heat dissipation. Moreover, accessing the topological surface states (TSS) in transport is hindered by a large residual carrier density in the bulk. Though the bulk and surface charge carriers can be distinguished by Shubnikov–de Haas (SdH) oscillations, even then their analysis and interpretation remains controversial. As a matter of fact, it is a difficult task to distinguish between the bulk and TSS. Apart from the TSS, the electronic bulk states in Bi_2Se_3 are of particular interest as their spin splitting is found to be twice the cyclotron energy observed in quantum oscillation. Another very interesting property observed in Bi_2Se_3 and other 3D TIs is the linear positive magnetoresistance (MR) that persists up to room temperature. The observed positive linear MR is dependent on the thickness and mobility of the TIs. Furthermore, at low temperature and high magnetic field, Shubnikov–de Haas (SdH) oscillation usually superpose on the positive MR background and the π Berry phase can be extracted, which shows the transport properties of 2D Dirac fermions.

The present thesis is focused on the thermo-electric, magnetic, electrical resistivity, magneto-resistance, Hall-measurement and angle resolved photoemission spectroscopy of pure Bi_2Se_3 and doped (with Co, S and Fe) Bi_2Se_3 topological insulator. In order to give systematic discussion, this thesis has been organized into five chapters. Summary of each chapter is given below:

In **Chapter 1**, the physics of TIs has been discussed in detail. The QHE was the first state, not to involve symmetry breaking with a topological classification of the edge currents and TSS was revealed to be similar to the QH state. The key physical properties of TIs like spin momentum locking, absence of backscattering and the first experimental realization of TIs are discussed. The chapter also deals with other issues like spin orbit coupling, weak anti localization time reversal symmetry etc. which are significant in the study of topological insulators. A brief literature survey has been included in the chapter.

In **Chapter 2,** synthesis process and basic principle and design of different characterization techniques used in the thesis have been discussed. We incorporate different characterization techniques such as, X-ray diffraction (XRD) for phase and structure identification, Hall measurement for detecting type of carrier and electrical transport measurement. The detail of super conducting interference device (SQUID) for magnetic measurement at low temperature has been discussed. We have also included the basic principle of angle resolve photo emission spectroscopy (ARPES) in the chapter.

In **Chapter 3,** the study of magnetoresistance (MR), thermoelectric power, magnetization and Hall effect measurements are presented, which have been performed on Co-doped Bi_2Se_3 topological insulators. Magnetization behavior indicates the establishment of ferromagnetic ordering with Co doping. Hall effect data also supports the establishment of ferromagnetic ordering in Co-doped Bi_2Se_3 samples by showing the anomalous Hall effect. Furthermore, when spectral weight suppression (SWS) is insignificant, the Bi_2Se_3 behaves as dilute magnetic semiconductor. Moreover, the maximum power factor is observed when time reversal symmetry (TRS) is maintained. As the TRS is broken, the power factor value is decreased which indicates that with the rise of Dirac cone above the Fermi level the anomalous Hall effect and linearity in MR increase and Power factor decreases.

Chapter 4 deals with the magneto-transport properties of $Bi_2Se_{3-y}S_y$. Magnetoresistance (MR) decreases with increase of S content and finally for 7% (i.e. $y = 0.21$) S doping the magnetoresistance becomes negative. This negative MR is unusual as it is observed when magnetic field is applied in the perpendicular direction to the plane of the sample. The magneto-transport behavior shows the Shubnikov-de Hass (SdH) oscillation indicating the coexistence of both surface and bulk states. The negative MR has been attributed to the non-trivial bulk conduction.

In **Chapter 5** deals with magnetic, magneto-transport and ARPES studies of $Bi_{2-x}Fe_xSe_{3-x}S_x$. In this chapter we systematically observe the effects of bulk doping of magnetic (Fe) and non-magnetic (S) atoms on the topological properties of the parent compound Bi_2Se_3. The magneto-resistance (MR) was found to evolve from positive to negative and again positive with increasing doping concentration with the most important observation being a giant negative MR at 9% doping which persists even at room temperature. The negative MR is found to be correlated to the observed ferromagnetism in them. ARPES results indicate a complete disappearance of the topologically protected surface state at higher doping which corroborates well with the conclusions of the magneto-transport data.

Chapter 6 presents the conclusions of whole work presented in the thesis with plans for future research.