ABSTRACT

Topological insulators (TIs) are a class of quantum materials that have insulating bulk and conducting surface states. The gapless surface states are protected by time-reversal symmetry (TRS), making them robust against backscattering from non-magnetic impurities and disorder. Breaking the TRS leads to creation of a gap in the surface states, thus providing potential applications of TIs in spin based electronics and quantum computers. The TRS is reported to be broken only by magnetic impurities. It is also predicted theoretically to be broken by a strong disorder. Lattice disorders like vacancies and anti-site defects are further known to induce magnetism in conventionally non-magnetic materials such as TIs. In addition, a strong disorder is predicted to convert the weak anti-localization (WAL) process, akin to TIs, to weak localization (WL). It is, therefore, intriguing to investigate different behaviours of strongly disordered TIs. Nanostructures are known to be a rich host of defects, apart from providing a large surface-to-volume ratio that could enable to explore surface dominated properties. Further, a large amount of disorder can be retained in nanostructures prepared by chemical methods by deliberately not subjecting them to annealing that could remove the defects. Gapped TI nanostructures may also find applications as photodetectors by blending these with plasmonic nanoparticles. This thesis is aimed at investigating (i) magnetic and transport properties of disordered undoped and magnetically doped Bi_2Se_3 nanostructures, and (ii) plasmonic properties of Ag-blended Bi_2Se_3 nanostructures. Bi_2Se_3 has been chosen as the TI for this study because it is one of the best-known TIs.

The study has been performed in three parts. **Part 1** constitutes the study of defect induced macroscopic and local magnetic behaviours of unannealed Bi_2Se_3 nanoplates prepared using a chemical method (and hence supposedly strongly disordered), and the alteration in the behaviours on magnetic Co impurity doping. Muon spin rotation spectroscopy has been used to investigate the local magnetism. Co has been taken as the dopant here because Co-impurity studies in ordered and weakly disordered Bi_2Se_3 exist, and hence it would be easy to see the differences. It is found that the nanoplates comprise of a mixture of ferromagnetic (FM) zones with static fields and paramagnetic (PM) zones with fluctuating moments. Density functional theory (DFT) computations reveal that the moments are possessed by Bi vacancies and Bi_{Se} anti-site defects. A comparison with bulk magnetism suggests that the defect concentration is very high ($\sim10^{20}$ defects/cm^3), as desired. Co doping is then seen to strengthen the magnetic order in the system. Having established the fact that a strong disorder in Bi_2Se_3 nanoplates results in magnetism, the next task in **Part 2** has been to study the electronic transport and magneto-transport behaviours of such strongly disordered Bi_2Se_3 nanoplates, apart from the magnetic properties, and then the effect of doping with an unexplored magnetic impurity Dy. From magnetization studies and DFT computations, the defects in this system have been found to be an order of magnitude less. In this case, both the samples are found to be PM, with larger average magnetic moment for Dy doping. Transport properties of both the samples show characteristics disordered semiconducting behaviour. The quantum transport features WL behaviour, which turns to WAL on annealing out the defects. In **Part 3**, photoresponse properties of plasmonic Ag-nanoparticles-decorated Bi_2Se_3 (AGBS) nanosheets have been studied. The plasmonic peak of Ag nanoparticles is found to be shifted in the presence of Bi_2Se_3 due to the modified dielectric environment. Further, AGBS/p-Si heterojunction shows an excellent photoresponse properties.

Keywords: Topological Insulators, Disorder, Magnetic doping, Plasmons, Photoresponse.