

---

# *CONTENTS*

---

<b>Certificate</b>	<b>i</b>
<b>Declaration by the Candidate</b>	<b>ii</b>
<b>Copyright Transfer Certificate</b>	<b>iii</b>
<b>Acknowledgements</b>	<b>iv</b>
<b>Preface</b>	<b>vi</b>
<b>Contents</b>	<b>x</b>
<b>List of Figures</b>	<b>xxiii</b>
<b>List of Tables</b>	<b>xxiv</b>
<b>Abbreviations</b>	<b>xxv</b>
<b>Chapter 1: Introduction and Literature Review</b>	<b>1-50</b>
1.1 Introduction	1
1.1.1 Band Theory of Solids	2
1.1.2 What is topology?	3
1.1.3 Interesting features of Topological Insulators	6
1.1.4 Time Reversal Symmetry	6
1.2 Effect of Magnetic Field in Different Type of Systems	8
1.2.1 Hall Effect	8
1.2.2 Effect of Magnetic System in 3D system	11
1.2.2.1 Effect of Magnetic Field on Density of States in 3D System	13
1.2.3 Effect of magnetic field in 2D systems	14
1.2.3.1 Effect of Magnetic Field on Density of States in 2D System	14
1.2.4 Quantum Hall Effects (QHE)	15
1.2.4.1 Edge Sates	16
1.2.5 Quantum Spin Hall Effect (QSHE)	18
1.2.5.1 Spin Orbit Coupling (SOC)	21
1.2.6 Quantum Anomalous Hall Effect (QAHE)	21
1.2.7 Weak Antilocalization	23
1.2.8 Shubnikov-de Hass Oscillation (SdH) Oscillation	24
1.3 Types of Topological Insulators	25
1.3.1 2D Topological Insulators	25
1.3.1.1 Graphene	25
1.3.1.2 CdTe/HgTe/CdTe System	27
1.3.1.3 InAs/ GaSb System	29
1.3.2 3D Topological Insulators	30
1.3.2.1 Weak Topological Insulators	31
1.3.2.2 Strong Topological Insulator	32
1.3.2.2.1 The First 3D Topological Insulator $\text{Bi}_{1-x}\text{Sb}_x$	32
1.3.2.2.2 New Materials $\text{Bi}_2\text{Te}_3$ , $\text{Bi}_2\text{Se}_3$ and $\text{Sb}_2\text{Te}_3$	36
1.3.2.2.2.1 Crystal Structure and Symmetry Properties	37
1.3.2.2.2.2 Band Inversion in $\text{Bi}_2\text{Se}_3$ System	39

1.3.2.2.2.3 ARPES Study	41
1.3.2.2.2.4 Magnetic and Transport Properties	45
<b>Chapter 2: Experimental: Synthesis Procedure and Characterization Details</b>	<b>51-68</b>
2.1 Sample synthesis	51
2.2 Experimental Tools & Their Working Principle	52
2.2.1 X-ray diffraction pattern	52
2.2.2 Resistivity Measurement	54
2.2.3 Hall Measurement	55
2.2.4 Thermoelectric Measurement	57
2.2.5 X-ray Photoelectron Spectroscopy	58
2.2.6 Magnetic property measurement System (MPMS)	60
2.2.6.1 Theory of Vibrating Sample Magnetometer (VSM) Measurement	60
2.2.6.2 Theory of Superconducting Quantum Interference Device	62
2.2.7 Scanning Electron Microscopy (SEM)	63
2.2.8 Atomic Force Microscopy	66
<b>Chapter 3: Magnetic and Magneto-Transport Study of <math>\text{Bi}_2\text{Cu}_x\text{Te}_{3-x}</math> (<math>x=0, 0.03, 0.09</math>) Topological Insulators</b>	<b>69-87</b>
3.1 Introduction	69
3.2 Results and Discussion	70
3.2.1 X-Ray Diffraction Analysis	70
3.2.2 Electrical Resistivity	72
3.2.3 Hall Analysis	74
3.2.4 Magnetoresistance Analysis	76
3.2.5 Magnetic Analysis	84
3.3 Conclusion	87
<b>Chapter 4: Tuning of Carrier type, Enhancement of Magnetoresistance and Room Temperature Ferromagnetism in Cu doped <math>\text{Bi}_2\text{Te}_3</math> Topological Insulators</b>	<b>89-108</b>
4.1 Introduction	89
4.2 Results and Discussion	90
4.2.1 X-Ray Diffraction Analysis	90
4.2.2 Angle Integrated Photo electron Spectroscopy (AIPES) study	92
4.2.3 Transport Property Analysis	94
4.2.4 Study of Magnetic Property	103
4.2.5 X-ray photoemission spectroscopy (XPS) analysis	105
4.3 Conclusion	107
<b>Chapter 5: Enhancement in power factor due to anti-correlation between Electrical Conductivity and Thermoelectric power and Induced Magnetic Ordering in high mobility Zn doped <math>\text{Bi}_2\text{Te}_3</math> Topological Insulator</b>	<b>109-123</b>
5.1 Introduction	109
5.2 Results and Discussion	111
5.2.1 X-Ray Diffraction Analysis	111
5.2.2 Electrical resistivity Analysis	112

5.2.3 Magnetic Property Analysis	113
5.2.4 Thermo-electric Analysis	114
5.2.5 Hall Analysis	116
5.2.6 Study of Magnetoresistance	117
5.3 Conclusion	122
<b>Chapter 6: Distinguishing Bulk State from Surface State by Simultaneous SdH and dHvA Oscillations in Sb<sub>1.90</sub>Cu<sub>0.10</sub>Te<sub>3</sub> Topological Insulator</b>	<b>125-135</b>
6.1 Introduction	125
6.2 Results and Discussion	126
6.2.1 Hall Analysis	126
6.2.2 Analysis of Shubnikov–de Haas (SdH) Oscillation	128
6.2.3 Analysis of The de-Haas van Alphen (dHvA) oscillation	131
6.3 Conclusion	134
<b>Chapter 7: Presence of Anti-Ferromagnetic Ordering at Room Temperature in Low Concentration co-doped Sb<sub>2</sub>Te<sub>3</sub> Topological Insulators</b>	<b>137-148</b>
7.1 Introduction	137
7.2 Results and Discussion	138
7.2.1 X-Ray Diffraction Analysis	138
7.2.2 Elemental and Surface Analysis	141
7.2.3 XPS Analysis	143
7.2.4 Study of Magnetic Properties	145
7.3 Conclusion	148
<b>Chapter 8: Conclusions and Future Scope</b>	<b>149-151</b>
8.1 General conclusion of the Thesis Work	149
8.2 Future Perspectives	150
<b>References</b>	<b>153-169</b>
<b>List of Publications/References</b>	<b>171-175</b>