

	page
Abstract	I
Acknowledgements	iii
Contents	v
List of Figures	vii
List of Tables	xi
List of Symbols	xiii
List of Abbreviations	xiv
<b>Chapter 1: Introduction</b>	<b>1</b>
1.1 LAYERED 2D MATERIALS	1
1.2 GRAPHENE	4
1.3 2D MATERIALS BEYOND GRAPHENE	9
1.4 MOLYBDENUM DISULFIDE (MoS <sub>2</sub> )	12
1.5 HETEROJUNCTIONS	18
1.6 APPLICATIONS OF HETEROSTRUCTURES	20
1.6.1 Applications of 0D/2D heterostructures	20
1.6.2 Applications of 1D/2D heterostructures	24
1.6.3 Applications of 2D/2D heterostructures	27
1.6.4 Applications of 2D/3D heterostructures	29
1.7 MOTIVATION	33
1.8 OBJECTIVES OF THIS WORK	34
1.9 ORGANIZATION OF THIS THESIS	35
<b>Chapter 2: Synthesis and Characterization Techniques of MoS<sub>2</sub></b>	<b>37</b>
2.1 SYNTHESIS OF MoS <sub>2</sub>	37
2.1.1 Mechanical exfoliation	37
2.1.2 Chemical vapor deposition (CVD)	38
2.1.3 Sputtering coupled with sulfurization	39
2.2 CHARACTERIZATION TECHNIQUE	42
2.2.1 Scanning electron microscopy (SEM)	42
2.2.2 Atomic force microscopy (AFM)	45
2.2.3 Raman Spectroscopy	46
2.2.4 Ultraviolet-visible spectroscopy	48
2.2.5 X-ray Powder Diffraction (XRD)	49
2.2.6 X-ray photoelectron spectroscopy (XPS)	50
2.2.7 Ultraviolet photoelectron spectroscopy (UPS)	52
2.3 CONTACTS PADS FORMATION	53
2.3.1 Thermal evaporator	53
2.3.2 Photolithography	54
2.4 MEASUREMENTS	56
2.4.1 Electrical measurements	56
2.4.2 Gas sensing measurements	56
<b>Chapter 3: Determination of Band Alignment at 2D/3D Heterointerfaces</b>	<b>59</b>
3.1 INTRODUCTION	59
3.2 BAND OFFSETS AT FEW-LAYER MoS <sub>2</sub> /Si HETEROJUNCTION	60
3.2.1 Fabrication and characterization of MoS <sub>2</sub> /Si heterojunction	60
3.2.2 Calculation of VBO through XPS measurement	62
3.2.3 Calculation of CBO through UPS measurement	63
3.3 BAND OFFSETS AT FEW-LAYER MoS <sub>2</sub> /GaN HETEROJUNCTION	64
3.3.1 Fabrication of MoS <sub>2</sub> /GaN heterojunction	65
3.3.1.1 The growth of GaN film	65
3.3.1.2 Fabrication of MoS <sub>2</sub> /GaN heterojunction	65
3.3.1.3 Characterization	65
3.3.2 Calculation of VBO through XPS measurement	67
3.3.3 Calculation of CBO through UPS measurement	70

3.4	COMPARISON OF INTERFACIAL ELECTRONIC MOVEMENT AT MoS <sub>2</sub> /Si AND MoS <sub>2</sub> /GaN HETEROINTERFACES	71
3.5	CHAPTER SUMMARY	72
<b>Chapter 4: Enhanced Carrier Density in a MoS<sub>2</sub>/Si Heterojunction-based Photodetector by Inverse Auger Process</b>		<b>73</b>
4.1	INTRODUCTION	73
4.2	FABRICATION AND CHARACTERIZATION OF MoS <sub>2</sub> /Si HETEROJUNCTION	74
	4.2.1 <i>Fabrication of MoS<sub>2</sub>/Si heterojunction</i>	74
	4.2.2 <i>Characterization of MoS<sub>2</sub>/Si heterojunction</i>	74
4.3	PERFORMANCE OF THE FABRICATED PHOTODETECTOR	76
4.4	AUGER AND INVERSE AUGER RELAXATION PROCESSES	78
4.5	CALCULATION OF BARRIER HEIGHT AT THE HETEROINTERFACE	79
4.6	TRANSIENT RESPONSE AT MoS <sub>2</sub> /Si HETEROINTERFACE	81
4.7	CARRIER TRANSPORT ACROSS THE MoS <sub>2</sub> /Si HETEROINTERFACE	81
4.8	CHAPTER SUMMARY	82
<b>Chapter 5: Wafer-Scale Synthesis of a Uniform Film of Few-Layer MoS<sub>2</sub> on GaN for 2D Heterojunction Ultraviolet Photodetector</b>		<b>83</b>
5.1	INTRODUCTION	83
5.2	THE GROWTH AND CHARACTERIZATION OF MoS <sub>2</sub> /GaN HETEROJUNCTION	84
	5.2.1 <i>Fabrication of MoS<sub>2</sub>/GaN heterojunction</i>	84
	5.2.2 <i>Microscopic and spectroscopic characterizations</i>	84
	5.2.3 <i>Electrical characterization</i>	86
5.3	PHOTODETECTING PERFORMANCE OF MoS <sub>2</sub> /GaN HETEROJUNCTION	87
5.4	FIGURES OF MERIT OF MoS <sub>2</sub> /GaN PHOTODETECTOR	88
5.5	CHARGE TRANSPORT MECHANISM AT MoS <sub>2</sub> /GaN HETEROINTERFACE	89
5.6	CALCULATION OF BARRIER HEIGHT AT THE MoS <sub>2</sub> /GaN HETEROINTERFACE	90
5.7	CHAPTER SUMMARY	92
<b>Chapter 6: High-performance Hydrogen Sensor Based on Reverse-biased MoS<sub>2</sub>/GaN Heterojunction</b>		<b>93</b>
6.1	INTRODUCTION	93
6.2	EXPERIMENTAL DETAILS	94
	6.2.1 <i>Fabrication of MoS<sub>2</sub>/GaN heterojunction</i>	94
	6.2.2 <i>Gas sensing measurement</i>	95
	6.2.3 <i>Characterization of MoS<sub>2</sub>/GaN heterojunction</i>	95
6.3	SENSING PERFORMANCE OF MoS <sub>2</sub> /GaN HETEROJUNCTION	96
6.4	SENSING PERFORMANCE OF INDIVIDUAL MoS <sub>2</sub> AND GaN FILMS	98
6.5	SENSING MECHANISM AT MoS <sub>2</sub> /GaN HETEROINTERFACE	99
6.6	CARRIER TRANSPORT ACROSS THE MoS <sub>2</sub> /GaN HETEROINTERFACE	100
6.7	CHAPTER SUMMARY	101
<b>Chapter 7: Temperature Dependent Transport Studies at 2D/3D Heterointerfaces</b>		<b>103</b>
7.1	INTRODUCTION	103
7.2	TEMPERATURE DEPENDANT BEHAVIOR OF MoS <sub>2</sub> /Si HETEROJUNCTION	103
	7.2.1 <i>Fabrication and characterization of MoS<sub>2</sub>/Si heterojunction</i>	103
	7.2.2 <i>Tunable rectifier behavior at MoS<sub>2</sub>/Si heterojunction</i>	103
7.3	TEMPERATURE DEPENDANT BEHAVIOR OF MoS <sub>2</sub> /GaN HETEROJUNCTION	106
	7.3.1 <i>Fabrication and characterization of MoS<sub>2</sub>/GaN heterojunction</i>	106
	7.3.2 <i>Tunable rectifier behavior at MoS<sub>2</sub>/GaN heterojunction</i>	106
7.4	CHAPTER SUMMARY	109
<b>Chapter 8: Conclusions, Challenges and Future Work</b>		<b>111</b>
8.1	Conclusions	111
8.2	Challenges and Future Work	112
	8.2.1 <i>The specific objectives of the future work</i>	113
	8.2.2 <i>Suggested action plan to achieve the future objectives</i>	114
<b>Publications</b>		<b>115</b>
<b>References</b>		