

Contents

<i>Acknowledgements</i>	vii
<i>Contents</i>	ix
<i>List of Figures</i>	xiii
<i>List of Tables</i>	xix
<i>Abbreviations</i>	xxi
<i>PREFACE</i>	xxv
Chapter 1 Introduction and Literatures Review	1
1.1 Structure of HfO ₂	4
1.1.1 Phases of HfO ₂ at Ambient Pressure	5
1.1.2 High Pressure Driven Phases of HfO ₂	7
1.1.3 Stabilization of the High Temperature Tetragonal/Cubic Phase of HfO ₂ at Room Temperature	8
1.2 Magnetic Properties of HfO ₂	14
1.3 Optical Properties of HfO ₂	18
1.4 Resistive Random Access Memory Application of HfO ₂	23
1.5 Objectives.....	27
Chapter 2 Experimental	31
2.1 Introduction	31
2.2 Powder Synthesis Method.....	31
2.3 Thin Film Deposition	33
2.4 Device Fabrication for RRAM.....	36
2.4.1 Cleaning of p ⁺⁺ -Si	36
2.4.2 Fabrication of Metal-Insulator-Metal (MIM) Test Structures	36
2.5 Characterization Techniques	37
2.5.1 X-ray Diffraction (XRD) for Powder Samples.....	37
2.5.2 Grazing Incidence X-ray diffraction (GIXRD) for Thin Films	39
2.5.3 X-ray reflectivity (XRR).....	40
2.5.4 Electron Probe Micro Analysis (EPMA)	40

2.5.5	Transmission Electron Microscopy (TEM)	41
2.5.6	Scanning Electron Microscopy (SEM)	42
2.5.7	X-ray Photoelectron Spectroscopy (XPS)	43
2.5.8	Magnetic Measurements	45
2.5.9	Photoluminescence (PL) Measurements.....	47
2.5.10	Current-voltage (<i>I</i> - <i>V</i>) Measurements	50
Chapter 3 Structural Transformation along with Magnetic and Photoluminescence Properties of Dy doped HfO₂ Nanoparticles	.....	51
3.1	Introduction	51
3.2	Results and Discussion.....	51
3.2.1	Elemental Analysis	51
3.2.2	Structural Analysis and Phase Transformation.....	53
3.2.3	Microstructural Analysis.....	58
3.2.4	Mechanism for Monoclinic to Cubic Phase Transformation.....	60
3.2.5	X-ray Photoelectron Spectroscopy (XPS)	62
3.2.6	Magnetic Properties	64
3.2.7	Origin of Room Temperature Ferromagnetism	70
3.2.8	Photoluminescence Properties	72
3.2.9	Energy Band Diagram.....	77
3.3	Conclusions	78
Chapter 4 Effect of Sm Dopant on Structure and Photoluminescence Properties of HfO₂ Nanoparticles	.....	81
4.1	Introduction	81
4.2	Results and Discussion.....	81
4.2.1	Structure and Phase Transformation	81
4.2.2	Microstructural Analysis.....	86
4.2.3	Mechanism for Monoclinic to Cubic Phase Transformation	88
4.2.4	Photoluminescence Properties	90
4.2.5	Energy Band Diagram.....	97
4.3	Conclusions	99
Chapter 5 Structure and Luminescence Properties of Dy and Sm Codoped HfO₂ Nanophosphors: Application in Latent Fingerprint Imaging	.....	101

5.1	Introduction.....	101
5.2	Results and Discussion.....	101
5.2.1	Phase and Structural Transformation of Dy and Sm:HfO ₂	101
5.2.2	Microstructural Analysis.....	106
5.2.3	Photoluminescence properties	109
5.2.4	Time Resolved Decay Curves.....	113
5.2.5	Energy Band Diagram	119
5.2.6	Application in Latent Fingerprint Imaging	121
5.3	Conclusions	127
Chapter 6 Structure and Electrical Properties of Sm and Dy Doped HfO₂ Thin Films: Application as RRAM	.....	129
6.1	Introduction.....	129
6.2	Results and Discussion.....	129
6.2.1	X-ray Reflectivity and Phase transformation.....	129
6.2.2	X-ray Photoelectron Spectroscopy	132
6.2.3	Current-voltage (<i>I-V</i>) characteristics	134
6.3	Conclusions	139
Chapter 7 Conclusions and Future Outlook	.....	141
7.1	Stabilization of the High Temperature Cubic Phase at Room Temperature	141
7.2	Room Temperature Ferromagnetism and its Origin	143
7.3	Excellent Luminescence Properties	143
7.4	Latent Fingerprint Imaging for Forensic Science	144
7.5	Stabilization of Cubic Phase at Room Temperature and RRAM Device Application.....	145
7.6	Future Outlook	146
References	.....	147
List of Publications	.....	163

