

CONTENTS

CHAPTER 1: GENERAL INTRODUCTION AND MOTIVATION	Page Nos.
1.1 Nanotechnology - “There is Plenty of Room at the Bottom”	1
1.1.1 Quantum Size Effect	3
1.1.2 Surface Effects	4
1.2 Thin Film	5
1.3 Methods of Preparation of Thin Films	5
1.4 Merits of Chemical Bath Deposition (CBD) Method	7
1.5 Basics of Chemical Bath Deposition	7
1.5.1 Solubility Product and Ionic Product	8
1.5.2 Nucleations in CBD	9
1.5.3 Crystal Growth	10
1.5.4 Mechanisms of CBD	11
1.6 Lead Sulfide- PbS	15
1.7 A Brief Review of PbS thin film deposited by CBD Method	18
1.8 Aims and Objectives of the Present Work	30
1.9 Motivation for the Present Work	31
1.10 Safety Considerations of PbS	32
CHAPTER 2: PREPARATION OF THE FILMS AND MEASUREMENT OF PROPERTIES	
2.1 Introduction	33
2.2 Preparation of the films	33
2.2.1 Selection of substrates	33

2.2.2	Cleaning of substrates	33
2.2.3	Materials used for depositions	34
2.2.4	Formation of films by CBD method	35
2.3	X-ray diffraction (XRD)	35
2.3.1	Basic Principle	35
2.3.2	Determination of crystallite size from broadening of the diffraction peaks	36
2.3.3	Microstrain	36
2.3.4	Nelson-Riley plot	38
2.3.5	Corrections for instrumental broadening	39
2.3.6	Indexing of the diffraction pattern and identification of phases	40
2.3.7	Textured Coefficient	40
2.3.8	Standard XRD peaks of bulk PbS	41
2.4	Scanning Electron Microscope (SEM)	42
2.5	Transmission Electron Microscope (TEM)	43
2.6	Raman Spectroscopy	44
2.7	Optical Absorption	45
2.8	Transmittance, Reflectance and Absorbance of a thin film	48
2.9	Urbach Energy	48
2.10	Direct and indirect band gap	49
2.11	Complex refractive index	50
2.12	Photoluminescence (PL)	51

2.13 Conductivity of the films	52
2.14 Thickness measurement	53
CHAPTER 3: STUDY OF THE STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF PbS NANOCRYSTALLINE FILMS PREPARED UNDER VARIOUS (i) DEPOSITION TEMPERATURES, (ii) CONCENTRATIONS OF LEAD ACETATE AND (iii) pH	
3.1 Introduction	54
3.2 Study of Structural, Optical and Electrical Properties of PbS Nanocrystalline Films Prepared under Various Deposition Temperatures	55
3.2.1 Experimental Details	55
3.2.2 Results and Discussions	
3.2.2.1 Structural Properties by XRD	56
3.2.2.2 Surface Morphology by SEM	61
3.2.2.3 Optical Properties by UV-Visible Spectrophotometer	64
3.2.2.4 Current-voltage characteristics	69
3.3 Study of Structural, Optical and Electrical Properties of PbS Nanocrystalline Films Prepared under Various Concentrations of Lead Acetate	72
3.3.1 Experimental Details	72
3.3.2 Results and Discussion	
3.3.2.1 Structural Properties by XRD	73
3.3.2.2 Surface Morphology by SEM	79
3.3.2.3 Optical properties of the Films by UV-Visible Spectrophotometer	81

3.3.2.4 Current-voltage characteristics of the Films	88
3.4 Study of Structural, Optical and Electrical Properties of PbS Nanocrystalline Films Prepared under Various pH	91
3.4.1 Experimental Details	91
3.4.2 Results and Discussion	
3.4.2.1 Structural Properties of the films by XRD	92
3.4.2.2 Surface Morphology	97
3.4.2.3 Optical Properties of the Films by UV-Visible Spectrophotometer	99
3.4.2.4 Current Voltage Characteristics	105
3.5 Conclusions	108
 CHAPTER 4: STUDY OF THE STRUCTURAL AND OPTICAL PROPERTIES OF THE PbS NANOCRYSTALLINE FILMS PREPARED UNDER THE EFFECT OF Fe AND Zn IMPURITIES	
4.1 Introduction	110
4.2 Experimental Details	111
4.3 Results and Discussion	
4.3.1 Surface Morphology	113
4.3.2 Elemental Analysis by EDX	117
4.3.3 Structural Properties	120
4.3.4 Optical Properties by UV-Vis. Spectrophotometer	127
4.3.5 Photoluminescence Spectra	135
4.4 Conclusion	137

**CHAPTER 5: EFFECT OF TRIETHANOLAMINE (TEA) ON THE
STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF
PbS NANOCRYSTALLINE FILMS**

5.1 Introduction	138
5.2 Effect of Deposition Time on the Structural, Optical and Electrical Properties of Nanocrystalline Films of PbS Prepared in Two Different Baths- One containing TEA and the other without TEA	
5.2.1 Experimental Details	139
5.2.2 Results and Discussion	
5.2.2.1 Structural Characterization by XRD	141
5.2.2.2 Variation of thickness of the films with deposition time	150
5.2.2.3 Surface Morphology by SEM	151
5.2.2.4 HRTEM Analysis	152
5.2.2.5 UV-Visible Absorption, Transmission and Reflection Study	156
5.2.2.6 Photoluminescence Spectra of the films	164
5.2.2.7 Current-Voltage Characteristics	166
5.3 Effect of TEA on the Structural, Optical and Electrical Properties of the Nanocrystalline Films of PbS prepared in Lead Acetate Bath at room temperature	
5.3.1 Experimental Details	168
5.3.2 Results and Discussion	

5.3.2.1 Structural Characterization by XRD	169
5.3.2.2 Elemental Analysis by EDX	171
5.3.2.3 Surface Morphology by SEM	173
5.3.2.4 Optical Properties	174
5.3.2.5 Current-Voltage Characteristics	179
5.4 Effect of concentration of TEA on the Structural, Optical and Electrical properties of the films of PbS prepared in Lead Nitrate Bath	
5.4.1 Experimental Details	181
5.4.2 Results and Discussions	
5.4.2.1 Structural Properties by XRD	183
5.4.2.2 Raman Spectra	186
5.4.2.3 Surface Morphology by SEM	187
5.4.2.4 Elemental Analysis by EDX	189
5.4.2.5 Optical Properties by UV-Visible-NIR spectrophotometer	192
5.4.2.6 Photoluminescence Properties	202
5.4.2.7 Electrical Properties	203
5.5 Conclusions	205
CHAPTER 6: POSSIBLE APPLICATIONS OF PREPARED FILMS IN OPTOELECTRONICS: SOME SUGGESTIONS	
6.1 Principle of solar cell	208
6.2 Prepared Films Applicable as Absorber in Solar Cell	209
6.3 Conclusion	215

CHAPTER 7: GENERAL CONCLUSIONS AND SCOPE FOR FUTURE RESEARCH	
7.1 General Conclusions	216
7.2 Limitations of the thesis	218
7.3 Scope for future research	219
REFERENCES	220
LIST OF PUBLICATIONS AND CONFERENCE PAPERS	230