## List of Figures

Figure No.	Figure Caption	Page No.
Figure 1.1	The low dimensional materials (a) Nanoparticles (0-D) (b)	
	Nanorod (1-D) (c) Thin film (2-D) (d) 3D materials	2
Figure 1.2	(a) Magnetic semiconductor (b) Non-magnetic semiconductor	
	(c) Diluted magnetic semiconductor	4
Figure 1.3	Direct and indirect band gap semiconductor	5
Figure 1.4	Electron transition from valence band to conduction band in an	
	indirect band gap semiconductor.	6
Figure 1.5	Excitation-relaxation process of photoluminescence	7
Figure 1.6	An overview of ZnO material properties	10
Figure 1.7	ZnO wurtzite structure	12
Figure 1.8	(a) Band structure of ZnO (b) Typical ultra violet-visible (UV-	
	Vis) spectrum of ZnO nanoparticles	13
Figure 1.9	Deconvoluted Photoluminescence emission spectra of pure	
	ZnO at $\lambda_{ext}$ =320 nm	14
Figure 1.10	Diagram of ZnO versatile applications	20
Figure 2.1	Flow chart of nanoparticles preparation	28
Figure 2.2	Flow chart of thin film preparation	29
Figure 2.3	(a) spin coater (b) deposition technique (c) prepared thin film	
	on glass substrate	29
Figure 2.4	TGA-DSC set up	30
Figure 2.5	(a) Schematic diagram of X-ray diffraction (b) XRD set up	32
Figure 2.6	HR-XRD set up	33
Figure 2.7	SEM- EDS set up	34

Figure 2.9	(a) Renishaw Micro Raman spectroscope (b) Energy level	
	diagram showing states involved in Raman signal. The line	
	thickness is roughly proportional to the signal strength from the	
	different transitions	40
Figure 2.10	(a) Schematic diagram of a Michelson interferometer,	
	configured for FTIR (b) Fourier transmission infrared	
	spectrometer (JASCO FT/IR-4600)	41
Figure 2.11	X-ray photoelectron spectroscopy setup (Amicus)	43
Figure 2.12	UV-Vis setup	44
Figure 2.13	(a) Schematic diagram of a Photoluminescence	
	spectrophotometer (b) set of Photoluminescence	
	spectrophotometer	45
Figure 2.14	MPMS3 setup	47
Figure 2.15	Atomic Force Microscope	48
Figure 2.16	MProbe thickness measurement set up	49
Figure 3.1	XRD pattern of Zn <sub>1-x</sub> Co <sub>x</sub> O nanoparticles	56
Figure 3.2	(a) TEM image, (b) SAED pattern (c) EDS spectra (d) particle	
	size distribution of ZnO nanoparticles	58
Figure 3.3	(a) TEM image, (b) SAED pattern (c) EDS spectra	
	(d) particle size distribution of Co2% doped ZnO nanoparticles	
	(e) SEAD pattern of single particles of Co 2% doped ZnO	58
Figure 3.4	FTIR spectra of $Zn_{1-x}Co_xO$ nanopowder	60
Figure 3.5	Absorption Spectra of Zn <sub>1-x</sub> Co <sub>x</sub> O nanoparticles	62
Figure 3.6	(a) $(\alpha hv)^2$ versus photon energy of ZnO nanoparticles	62

Figure 3.6	(b) Energy band gap versus Co concentration of $Zn_{1-x}Co_xO$	63
Figure 3.7	(a) Photoluminescence spectra of $Zn_{1-x}Co_xO$ nanoparticles	64
Figure 3.7	( <b>b</b> ) CIE diagram of Zn <sub>1-x</sub> Co <sub>x</sub> O nanoparticles	64
Figure 3.8	M-H curve of pure and Co doped ZnO nanoparticles at 300 K	67
Figure 3.9	(a) M-H curve of pure ZnO nanopowder at 300 K	67
Figure 3.9	(b) Susceptibility curve (ZFC-FC) of pure ZnO	68
Figure 3.10	Susceptibility curve of Co doped ZnO	68
Figure 4.1	XRD of Zn <sub>1-x</sub> Mn <sub>x</sub> O sintered at 1000°C	76
Figure 4.2	(a), (b) and (c) shows peak position of (100), (002) and (101)	
	planes respectively	77
Figure 4.3	The variation of lattice parameters ratio (c/a) with Mn	
	Concentration	77
Figure 4.4	Variation of APF with Mn concentration	78
Figure 4.5	Change in crystallite size with Mn concentration	78
Figure 4.6	SEM image of (a) ZnO, (b) $Zn_{.98}Mn_{.02}O$ , (c) $Zn_{.96}Mn_{.04}O$ and	
	(d) Zn <sub>.94</sub> Mn <sub>.06</sub> O nanoparticles respectively	80
Figure 4.7	EDS spectra of pure and Mn doped ZnO nanopowder	81
Figure 4.8	Absorption Spectra of $Zn_{1-x}Mn_x O$ nanopowder	83
Figure 4.9	$(\alpha h\nu)^2$ versus photon energy of (a) ZnO, (b) Zn <sub>.98</sub> Mn <sub>.02</sub> O, (c)	
	$Zn_{.96}$ Mn_{.04}O and (d) $Zn_{.94}$ Mn_{.06}O nanopowder	85
Figure 4.10	Energy band gap versus Mn concentration of $Zn_{1-x}Mn_xO$	
	nanopowder	85
Figure 4.11	Raman spectra of $Zn_{1-x}Mn_xO$ nanopowder at room temperature	87
Figure 4.12	FTIR spectra of Zn <sub>1-x</sub> Mn <sub>x</sub> O nanopowder	89
Figure 4.13	M-H curve of pure and Mn doped ZnO nanopowder at 300 K	91

Figure 4.14	M-H curve of pure ZnO nanopowder at 300 K	92
Figure 4.15	Susceptibility curve of Mn doped ZnO. Inset shows	
	susceptibility curve of pure ZnO	92
Figure 5.1	TGA- DSC of ZnO:Eu(1%) nanoparticles	100
Figure 5.2	(a) Rietveld refine XRD patterns of pure and doped zinc oxide	
	Nanoparticles	102
Figure 5.2	(b) The variation of lattice parameters (a and c) with	
	compositions. Inset shows change in crystallite size	103
Figure 5.3	TEM image and particle size distribution of (a) ZnO (b)	
	ZnO:Eu(1%) (c) ZnO:Eu(1%):Li(1%) nanoparticles. (d) SAED	
	pattern of zinc oxide nanoparticles	105
Figure 5.4	EDS spectra, elemental mapping of ZnO:Eu and atomic	
	percentage distribution of ZnO and ZnO:Eu nanoparticles	105
Figure 5.5	(a) Raman spectra of pure and doped zinc oxide	106
Figure 5.5	(b) Intensity variation of $E_2$ Low in Raman spectra of pure and	
	doped ZnO	107
Figure 5.6	FTIR spectra of pure and doped zinc oxide nanoparticles	108
Figure 5.7	(a) XPS survey of ZnO, ZnO:Eu(1%),	
	ZnO:Eu(1%):Li(1%) nanoparticles	110
Figure 5.7	(b) Zn 2p core level XPS spectra	110
Figure 5.8	XPS spectra oxygen core level 1s of (a) ZnO (b) ZnO:Eu, (c)	
	ZnO:Eu:Li(1%) and (d) XPS spectra of Li	111
Figure 5.9	(a) Normalised XANES spectra of Eu and Li co-doped ZnO	
	measured at Zn K-edge	112

Figure 5.9	(b) Normalised XANES spectra of Eu and Li co-doped ZnO	
	measured at Eu L3-edge	112
Figure 5.10	(a) Normalised EXAFS spectra of Eu and Li co-doped ZnO	
	measured at Zn K-edge	116
Figure 5.10	(b) Normalised EXAFS spectra of Eu and Li co-doped ZnO	
	measured at Eu L3-edge	116
Figure 5.10	(c) Fourier transformed EXAFS spectra of Eu and Li co-doped	
	ZnO samples measured at Zn K-edge (Scatter points)	
	alongwith the theoretical fit (Solid line): (a) ZnO, (b)	
	ZnO:Eu(1%), (c)ZnO:Eu:Li(0.25%) and (d) ZnO:Eu:Li(1.0%)	117
Figure 5.10	(d) Variation of (top to bottom) bond length and disorder	
	obtained from EXAFS fitting at Zn K edge	117
Figure 5.10	(e) Fourier transformed EXAFS spectra of Eu and Li co-doped	
	ZnO samples measured at Eu L3-edge (Scatter points) along	
	with the theoretical fit (Solid line): (a) ZnO:Eu(1%), (b)	
	ZnO:Eu:Li(0.25%) and (c) ZnO:Eu:Li(1.0%)	118
Figure 5.10	(f) Variation of (top to bottom) bond length, coordination	
	number and disorder obtained from EXAFS fitting at Eu L3	
	edge	118
Figure 5.11	Absorption Spectra of pure and doped zinc oxide nanoparticles	
	inset (a) Tauc plot of zinc oxide, (b) variation of energy band	
	gap with composition	120
Figure 5.12	(a) Photoluminescence emission spectra of samples at $\lambda_{ex}$ =320	
	nm	122

Figure 5.12	(b) Photoluminescence excitation spectra of doped ZnO	122
	at $\lambda_{em} = 610 \text{ nm}$	
Figure5.12	(c) Photoluminescence emission spectra of samples at $\lambda_{ex}$ =464	123
	nm	
Figure 5.13	(a) M-H curve of pure and doped ZnO nanoparticles at 300 K	126
Figure 5.13	(b) M-H curve of pure ZnO nanoparticles at 300 K	126
Figure 5.13	(c) Susceptibility curve of pure and doped ZnO nanoparticles	127
Figure 6.1	TGA- DSC of ZnO:Tb(1%) nanoparticles	134
Figure 6.2	Rietveld refine XRD patterns of pure and doped zinc oxide	
	nanoparticles	136
Figure 6.3	TEM image and particle size distribution of (a) ZnO	
	<b>(b)</b> ZnO:Tb(1%) <b>(c)</b> ZnO:Tb(1%):Li(1%) nanoparticles	
	(d) SAED pattern of ZnO:Tb(1%) nanoparticles	138
Figure 6.4	EDS spectra, elemental mapping of ZnO:Tb and atomic	
	percentage distribution of ZnO and ZnO:Tb nanoparticles	138
Figure 6.5	FTIR spectra of pure and doped zinc oxide nanoparticles	140
Figure 6.6	(a) Raman spectra of pure and doped zinc oxide	141
Figure 6.6	(b) Intensity variation of $E_2$ Low in Raman spectra of pure and	
	doped ZnO	142
Figure 6.7	(a) XPS survey scan spectra of ZnO, Tb1 and Li1.0	144
	nanoparticles	
Figure 6.7	XPS Core level spectra of (b) $Zn (2p) (c) Tb (4d) (d) O (1s)$	
	(e) Li (1s)	144
Figure 6.8	Normalised XANES spectra of Tb and Li co-doped ZnO	
	measured at Zn K-edge	145

Figure 6.9	Normalised XANES spectra of Tb and Li co-doped ZnO	
	measured at Tb L3-edge	146
Figure 6.10	Normalised EXAFS spectra of Tb and Li co-doped ZnO	
	measured at Zn K-edge	148
Figure 6.11	Normalised EXAFS spectra of Tb and Li co-doped ZnO	
	measured at Tb L3-edge	148
Figure 6.12	Fourier transformed EXAFS spectra of Tb and Li co-doped	
	ZnO samples measured at Zn K-edge (Scatter points) along	
	with the theoretical fit (Solid line): (a) ZnO, (b) Tb1 (c) Li	149
Figure 6.13	0.25 (d) Li1.0 Variation of (top to bottom) bond length and disorder obtained	
	from EXAFS fitting at Zn K edge	149
Figure 6.14	Fourier transformed EXAFS spectra of Tb and Li co-doped	
	ZnO samples measured at Tb L3-edge (Scatter points) along	
	with the theoretical fit (Solid line): (a) Tb1, (b) Li0.25 and (c)	150
	Li1.0	
Figure 6.15	Variation of (top to bottom) bond length, coordination number	
	and disorder obtained from EXAFS fitting at Tb L3 edge	150
Figure 6.16	Absorption Spectra of pure and doped zinc oxide nanoparticles	152
Figure 6.17	Tauc plot of (a) ZnO (b)Tb1 (c)Li0.25 (d)Li0.5 (e)Li1.0	
	(f) variation of energy band gap with composition	152
Figure 6.18	(a)Photoluminescence emission spectra of pure and doped zinc	
	oxide at $\lambda_{ex}$ =320 nm	155
Figure 6.18	(b) Deconvoluted Photoluminescence emission spectra of pure	
	zinc oxide at $\lambda_{ex}$ =320 nm	155

Figure 6.19	Photoluminescence excitation spectra of Tb doped ZnO	
	at $\lambda_{em}$ =540 nm	156
Figure 6.20	Photoluminescence emission spectra of pure and doped zinc	
	oxide at $\lambda_{ex}$ =397 nm	156
Figure 6.21	M-H curve of pure and doped ZnO nanoparticles at 300 K	160
Figure 6.22	(a) M-H curve of pure ZnO nanoparticles at 300 K	161
Figure 6.22	(b) M-H curve of doped ZnO nanoparticles near origin	161
Figure 6.23	Susceptibility curve of pure and doped ZnO nanoparticles	162
Figure 7.1	HR-XRD spectra of pure and Dy doped ZnO thin film	170
Figure 7.2	(a) 2D AFM image of ZnO thin film. The inset shows grain	171
	size distribution	1/1
Figure 7.2	(b) 2D AFM image of ZnO: Dy(1%) thin film. The inset shows	
	grain size distribution	172
Figure 7.3	Absorption spectra of pure and doped ZnO thin film. The inset	
	shows Tauc plot of ZnO thin film	173
Figure 7.4	Device structure fabricated on glass substrate	176
Figure 7.5	(a) Current-Voltage curve of ZnO	176
Figure 7.5	(b) Current-Voltage curve of Dy doped ZnO	177
Figure 7.5	(c) Current-Time curve of ZnO	177
Figure 7.5	(d) Current-Time curve of Dy doped ZnO	178
Figure 7.6	XRD spectra of pure and Co doped ZnO thin films	180
Figure 7.7	(a) 2D AFM image of ZnO thin film	181
Figure 7.7	(b)3D AFM image of ZnO thin film	181
Figure 7.8	2D AFM image of Co doped ZnO thin film with grain	
	boundaries	182

Figure 7.9	Absorption spectra of pure and Co doped ZnO thin films. Inset	
	shows close inspection in the visible region	183
Figure 7.10	(a) Tauc plot of ZnO thin film	184
Figure 7.10	(b) Tauc plot of Co doped ZnO thin film	184
Figure 7.11	Photoluminescence spectra of pure and Co doped ZnO thin	
	films	185