

Magnetic Ordering In Nanostructured Materials

A thesis submitted to
the Calcutta University
in partial fulfilment of
the requirements for the degree
DOCTOR OF PHILOSOPHY (SCIENCE).

by
Indranil Sarkar

Contents

1	Introduction	1
1.1	Motivation and Aim	1
1.2	Magnetic States	4
1.3	Basic idea of Magnetism in nanoparticles	6
1.4	Stoner Criterion of Itinerant Ferromagnetism : Enhanced Paramagnets	9
1.5	Dilute Magnetic Semiconductors	12
1.5.1	Exchange interactions in DMS	14
1.5.2	Effect of disorder in DMS: Bound Magnetic Polaron theory . .	18
1.6	Excitons in semiconductors	20
1.7	Magnetization relaxation in low dimensional molecular magnets . . .	22
1.8	Thesis overview	24
2	Experimental Techniques and Instruments	26
2.1	Transmission Electron Microscope	26
2.2	X-ray Diffraction	30
2.2.1	The Instrument	32
2.3	Scanning Electron Microscopy and Energy Dispersive Analysis of X-ray	33
2.4	Super Conducting Quantum Interference Device (SQUID)	35
2.4.1	The basic principle	35
2.4.2	Detection coils	38
2.4.3	Instrument for magnetization measurement:MPMS-7T	40

2.5	Photoluminescence	46
2.5.1	PL spectroscopy	47
2.5.2	PL measurement at room temperature	49
2.5.3	PL at low temperature in presence of ultra high magnetic field	49
2.5.4	Spin polarized PLE	50
2.6	X-ray and Neutron scattering techniques	52
2.6.1	Basic formalism of X-ray and Neutron reflectivity	54
2.6.2	The X-ray reflectivity Instrument	61
2.6.3	The neutron reflectivity instrument	65
2.6.4	Polarized neutron reflectivity	66
3	Intrinsic Ferromagnetism in Manganese doped Zinc Sulfide nanocrystals	71
3.1	Introduction	71
3.2	Advantages of Mn doped Zinc Sulfide DMS	73
3.3	Sample Preparation	73
3.4	Experimental Procedures	74
3.4.1	Physical Characterization	74
3.4.2	Magnetization Measurements: SQUID Magnetometry	78
3.4.3	Spin polarized photoluminescence excitation	89
3.5	Results and Discussions	91
3.6	Magnetization model based on Bound magnetic polaron theory	91
3.7	Conclusion	93
4	Suppression of Mn photoluminescence in the ferromagnetic state of Mn doped ZnS nanocrystals	94
4.1	Introduction	94
4.2	Experimental Procedures	98
4.3	Results and Discussions	99

4.3.1	Field dependence study of PL intensities	99
4.3.2	Theory of Auger mechanism of energy transfer in presence of magnetic field and its limitations	101
4.3.3	Thermal dependence of zero-field PL intensity	103
4.3.4	Magnetic ordering induced spin selective energy transfer model	105
4.4	Conclusion	110
5	Magnetization Relaxation studies on Layered Nickel alkanethiolates	111
5.1	Introduction	111
5.2	Sample Preparation and Characterization	114
5.2.1	X-Ray Diffraction	114
5.2.2	DC Magnetization Susceptibility	114
5.3	Magnetization Relaxation Measurements	116
5.3.1	Protocols	116
5.3.2	Results and Discussion	117
5.4	Explanation of magnetization evolution	122
5.5	Conclusion	123
6	Magnetic proximity effect in core-shell nanoparticles having a Palladium core and Nickel shell	124
6.1	Introduction	124
6.2	Sample Preparation and Characterization	126
6.3	X-Ray and Polarized Neutron Reflectivity measurement	128
6.3.1	Analysis	128
6.3.2	Result	134
6.4	Conclusion	138
Bibliography		139