

PHASE TRANSITIONS IN ULTRA-THIN ORGANIC FILMS

THESIS SUBMITTED TO
THE UNIVERSITY OF CALCUTTA
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY (SCIENCE)

By
MRINMAY KUMAR MUKHOPADHYAY

May 2005

TABLE OF CONTENTS

	Page
Chapters:	
1. Introduction	1
1.1 Phase transitions in low-dimensional systems	2
1.2 Two-dimensional melting: experimental observations	6
1.2.1 Studies on liquid-crystal films	7
1.2.2 Studies on rare gases adsorbed on graphite substrate	9
1.2.3 Studies on electrons on the surface of liquid helium	11
1.2.4 Studies on charged sub-micron sized spheres	12
1.3 Two-dimensional melting: theoretical understanding	12
1.3.1 Order parameters, symmetries and correlation	13
1.3.2 Topological defects	15
1.3.3 Vortex unbinding transition: KT theory	19
1.3.4 Dislocation mediated melting: KTHNY theory	20
1.3.5 Analogy with magnetism	22
1.4 Two-dimensional magnetization: experimental observations	23
1.5 Two-dimensional magnetism: theoretical understanding	26
1.5.1 General theory of ferromagnetism and spin waves	26
1.5.2 Absence of long-range ordering: Mermin-Wagner theorem	30
1.5.3 Long-range magnetic order in presence of dipolar interaction	32
1.5.4 Magneto-crystalline anisotropic interaction	33
1.5.5 Spin-waves in presence of exchange, dipole and magneto-crystalline anisotropic interactions	34
1.5.6 Stripe domain formation in 2D magnetic layers	36
1.6 Outline of the present work	37
2. Experimental Techniques	40
2.1 Langmuir-Blodgett deposition technique	41
2.1.1 Preparation of Langmuir monolayer	41

2.1.2	Deposition of LB films	46
2.2	X-ray and Neutron scattering techniques	50
2.2.1	X-ray and Neutron reflectivity basic formalism	52
2.2.2	Instrument for X-ray reflectivity study	60
2.2.3	Instrument for Neutron reflectivity study	62
2.2.4	X-ray grazing incidence diffraction	66
2.2.5	Polarized neutron reflectivity	70
2.3	Instrument for magnetization measurements	74
3.	Structure and growth mechanism of Langmuir-Blodgett films	79
3.1	Introduction	80
3.2	Experimental details	85
3.3	Analysis scheme	87
3.4	Experimental results	89
3.4.1	Structure of divalent fatty acid salt LB films	89
3.4.2	Structure of preformed trivalent fatty acid salt LB films	94
3.5	Conclusions	103
4.	Two-dimensionaal to three dimensional melting transition in Langmuir-Blodgett Films	105
4.1	Introduction	106
4.2	Experimental details	110
4.2.1	The sample cell	111
4.2.2	X-ray Reflectivity studies	112
4.2.3	Grazing incidence diffraction studies	113
4.3	Data analysis	114
4.3.1	Energy dispersive reflectivity	114
4.3.2	Grazing incidence diffraction	118
4.4	Model and interpretation	123
4.5	Conclusions	126
5.	Two-dimensional magnetic ordering in Langmuir-Blodgett films	127
5.1	Introduction	128
5.2	Experimental details	131
5.2.1	Sample preparation and characterization	131
5.2.2	Magnetization measurements	132
5.3	Structure characterization of GdSt LB films	133
5.4	Short-range ferromagnetic ordering: results of VSM measurements	134
5.5	Magnetic structure of LB films: Neutron reflectivity study	139

5.6	Anisotropic interactions in ferromagnetic ordering: results of sub-Kelvin magnetization measurements	143
5.7	Conclusions	146
	Bibliography	147