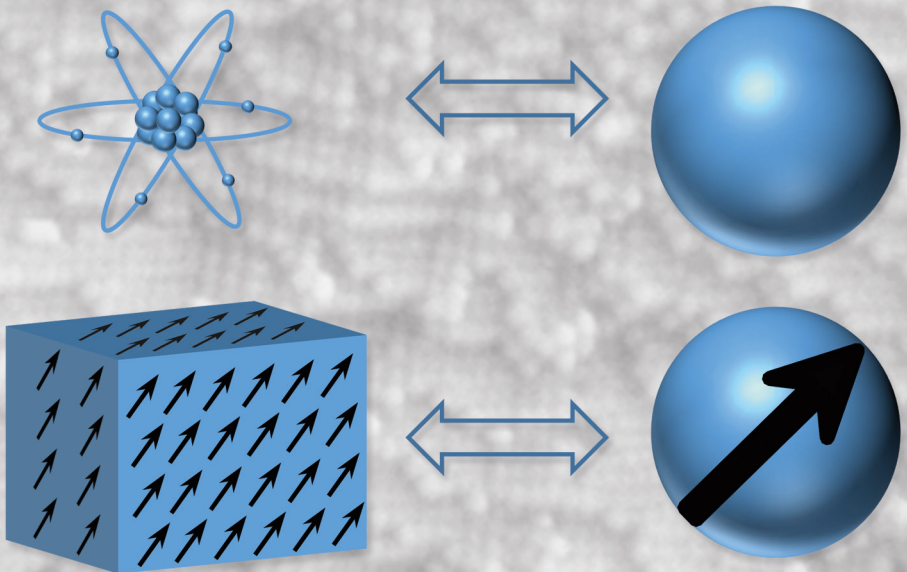


Magnetic Proximity Effects in Nanoparticle Composite Systems and Macrocrystals

Genevieve Wilbs



Schlüsseltechnologien /
Key Technologies
Band / Volume 142
ISBN 978-3-95806-233-7

Forschungszentrum Jülich GmbH
Peter Grünberg Institute (PGI)
Scattering Methods (PGI-4 / JCNS-2)

Magnetic Proximity Effects in Nanoparticle Composite Systems and Macrocrystals

Genevieve Wilbs

Schriften des Forschungszentrums Jülich
Reihe Schlüsseltechnologien / Key Technologies

Band / Volume 142

ISSN 1866-1807

ISBN 978-3-95806-233-7

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Concept	1
1.3	Current State of Research	2
2	Theoretical Background	3
2.1	The Iron Oxides	3
2.1.1	Magnetite	3
2.1.2	Maghemite	4
2.1.3	Wustite	4
2.2	Basics of Solid State Magnetism	5
2.2.1	Magnetic Moment	5
2.2.2	Magnetic Interactions	6
2.2.3	Anisotropy	10
2.2.4	Classification of Magnetic Materials	11
2.2.5	Nanomagnetism	17
2.3	Self-Assembly	21
2.3.1	Van der Waals Interaction	21
2.3.2	Magnetic Interaction in Nanoparticle Systems	22
2.3.3	Steric Repulsion	23
2.3.4	Capillary Forces	23
2.3.5	Attractive Depletion Force	24
2.3.6	Entropy	25
2.3.7	Other Forces	26
2.4	Scattering	26
2.4.1	Reciprocal Space	26
2.4.2	Diffraction	27
2.4.3	X-ray and Synchrotron Radiation	31
2.5	Electrical Transport	32
2.5.1	Models of Electrical Conduction	32
2.5.2	Thin Film Conductivity	33
2.5.3	Magnetoresistance	33
3	Experimental Methods and Instruments	37
3.1	Magnetometry	37
3.1.1	Vibrating Sample Magnetometer	37
3.1.2	Superconducting Quantum Interference Device	38
3.1.3	Measurement Procedures	39
3.2	Magneto Optical Kerr Effect	41

3.3	First Order Reversal Curves	42
3.3.1	The Preisach Model	42
3.3.2	Measurement procedure	43
3.3.3	Data Evaluation	43
3.4	Resistivity	45
3.5	X-Ray Powder Diffraction	46
3.6	Small Angle X-Ray Scattering	47
3.7	Grazing Incidence Small Angle X-ray Scattering	50
3.8	X-ray Absorption Spectroscopy	52
3.8.1	EXAFS	53
3.8.2	XANES	53
3.9	X-ray Magnetic Circular Dichroism	53
3.9.1	Transition Probabilities	54
3.9.2	Sum Rules	55
3.9.3	Experimental Setup	55
3.9.4	Data Treatment	56
3.10	Scanning Electron Microscopy	58
3.11	Coating	59
3.12	Plasma Etching	60
4	Two Dimensional Systems	61
4.1	Sample Description	61
4.1.1	Self-assembly	62
4.1.2	Magnetic Properties	64
4.2	Sub-monolayer Fabrication	66
4.3	Plasma Treatment	68
4.3.1	Reference Sample	68
4.3.2	Oleic Acid Removal	70
4.3.3	Phase Transformation	70
4.4	Polarization Effects	75
4.5	Magnetoresistance Effects	82
4.5.1	Measurements in van der Pauw Geometry	82
4.5.2	Measurements on Hall Bar Structures	85
4.5.3	Influence of Nanoparticle Size	87
4.6	Conclusion	89
5	Three Dimensional Systems	93
5.1	Nanoparticle Description	93
5.2	Macrocrystal Preparation	99
5.3	Macrocrystal Morphology	101
5.3.1	Batch O1	101
5.3.2	Batch O2	109
5.4	Nanoparticle Arrangement	113
5.4.1	Influence of Size Distribution	113
5.4.2	Influence of Centrifugation Parameters	115
5.4.3	Influence of Surfactants	126
5.5	Magnetic Properties	129
5.6	Polarization and Magnetoresistance Effects	131

5.7 Conclusion	135
6 Summary and Outlook	137
A Nanoparticle Data Sheet Ocean NanoTech	139
B Sample List 2D	141
C Magnetometry	143
D SEM Images of Macrocrystals	145
List of Figures	199
List of Tables	209
List of Acronyms	211
List of Symbols	213
Bibliography	221
Acknowledgement	231

**Schlüsseltechnologien /
Key Technologies
Band / Volume 142
ISBN 978-3-95806-233-7**

