

# Contents

<b>1</b>	<b>Introduction</b> . . . . .	1
1.1	Layered Magnetic Structures . . . . .	1
1.1.1	Magnetoresistive Devices . . . . .	1
1.1.2	Spintronics . . . . .	5
1.1.3	Ferromagnetic–Antiferromagnetic Heterostructures. . . . .	6
1.1.4	Need for Layer-Resolved Information . . . . .	8
1.1.5	Need for Time Resolution . . . . .	9
1.2	Approaches to Layer-Resolved Magnetic Imaging . . . . .	13
1.2.1	Interference-Based Approach . . . . .	13
1.2.2	Electronic Properties-Based Approach . . . . .	15
<b>2</b>	<b>Magneto-Optical Effects</b> . . . . .	19
2.1	Overview . . . . .	19
2.2	Optical Basics of Conventional Effects . . . . .	23
2.2.1	Wave Equation . . . . .	23
2.2.2	Polarized Light . . . . .	30
2.2.3	Birefringence, Dichroism, and Optical Activity . . . . .	36
2.2.4	The Compensator . . . . .	40
2.2.5	Reflection and Transmission of Polarized Light. . . . .	44
2.3	Electromagnetic Basics of Conventional Effects. . . . .	49
2.3.1	The Dielectric Permittivity Tensor. . . . .	49
2.3.2	Solutions . . . . .	50
2.4	Faraday and Kerr Effect . . . . .	54
2.4.1	Phenomenological Description . . . . .	54
2.4.2	Geometry of the Rotation Effects . . . . .	63
2.4.3	Kerr Contrast and Signal . . . . .	68
2.4.4	Microscopic Origin of the Kerr Effect . . . . .	73
2.5	Voigt Effect . . . . .	75
2.6	Gradient Effect . . . . .	81

2.7	X-Ray Magnetic Dichroism . . . . .	86
2.7.1	X-Ray Magnetic Linear Dichroism . . . . .	86
2.7.2	Circularly Polarized X-rays. . . . .	91
2.7.3	X-Ray Magnetic Circular Dichroism . . . . .	92
<b>3</b>	<b>Depth-Sensitive Conventional Magneto-Optical Microscopy . . . . .</b>	<b>97</b>
3.1	Magneto-Optical Microscopy and Magnetometry . . . . .	97
3.1.1	Wide-Field Microscopy . . . . .	98
3.1.2	Laser-Scanning Microscopy . . . . .	103
3.1.3	Magneto-Optical Magnetometry and Ellipsometry . . . . .	105
3.2	Depth Sensitivity of Conventional Magneto-Optics. . . . .	107
3.2.1	Experimental Proof of Depth Sensitivity. . . . .	108
3.2.2	Theoretical Approaches to Depth Sensitivity in Magneto-Optics. . . . .	109
3.2.3	Depth Sensitivity Function . . . . .	115
3.2.4	Depth Sensitivity in Magnetic Films . . . . .	119
3.2.5	Depth Sensitivity in Magnetic Multilayers . . . . .	124
3.2.6	Depth Selectivity in Magnetic Multilayers . . . . .	127
3.3	Depth-Selective Kerr Microscopy. . . . .	130
3.4	Voigt- and Gradient Microscopy . . . . .	137
<b>4</b>	<b>Depth-Sensitive Photoelectron Emission Microscopy. . . . .</b>	<b>141</b>
4.1	Photoelectron Emission Microscopy . . . . .	141
4.2	Electron Yield Detection of Absorption from Buried Layers . . . . .	142
4.3	Imaging Ferromagnetic Materials by X-ray Magnetic Circular Dichroism. . . . .	150
4.3.1	NiFe/Cu/Co Trilayers. . . . .	151
4.3.2	Co/Cu/Ni Trilayers . . . . .	153
4.3.3	NiFe/Al <sub>2</sub> O <sub>3</sub> /Co Trilayers . . . . .	161
4.3.4	Ni/Fe/Co Trilayers. . . . .	163
4.3.5	Ni/FeMn/Co Trilayers . . . . .	166
4.4	Imaging Antiferromagnetic Materials by X-ray Magnetic Linear Dichroism. . . . .	169
4.4.1	Magnetic Linear Dichroism as Contrast Mechanism for Layer-Resolved Magnetic Imaging Using PEEM. . . . .	170
4.4.2	Exchange Coupling at the Interface of NiO and a Ferromagnetic Metal . . . . .	172
4.4.3	CoO/NiO Heterostructures . . . . .	176
4.4.4	Co/LaFeO <sub>3</sub> Heterostructures . . . . .	178
4.5	Time- and Layer-Resolved Magnetic Imaging by XMCD-PEEM . . . . .	180

- 5 Magnetic Transmission Soft X-Ray Microscopy** . . . . . 189
  - 5.1 Introduction . . . . . 189
  - 5.2 Absorption of X Rays in Transmission Experiments. . . . . 190
  - 5.3 Basic Elements in Magnetic Transmission Soft X-Ray Microscopy . . . . . 197
    - 5.3.1 Fresnel Zone Plates as Optical Elements. . . . . 197
    - 5.3.2 Experimental Set-Up . . . . . 199
    - 5.3.3 Sample Properties . . . . . 202
    - 5.3.4 Sensitivity to Thin Layers . . . . . 203
  - 5.4 Imaging Layered Magnetic Microstructures . . . . . 204
    - 5.4.1 Elemental Specificity . . . . . 204
    - 5.4.2 Magnetization Reversal Processes in Nanostructured Elements . . . . . 205
    - 5.4.3 Domain Structures in Multilayered Systems . . . . . 210
  - 5.5 Time and Layer-Resolved Magnetic Imaging by M-TXM. . . . . 216
  - 5.6 Future Perspectives . . . . . 220
  
- References**. . . . . 221
  
- Index** . . . . . 241



<http://www.springer.com/978-3-662-44531-0>

Magnetic Microscopy of Layered Structures

Kuch, W.; Schäfer, R.; Fischer, P.; Hillebrecht, F.U.

2015, XI, 246 p. 112 illus., 6 illus. in color., Hardcover

ISBN: 978-3-662-44531-0