

Contents

1	An Introduction to Microscopy	1
1.1	Limitations of the Human Eye	1
1.2	The Light-Optical Microscope	5
1.3	The X-ray Microscope	8
1.4	The Transmission Electron Microscope	9
1.5	The Scanning Electron Microscope	15
1.6	Scanning Transmission Electron Microscope	16
1.7	Analytical Electron Microscopy	19
1.8	Low-Energy and Photoelectron Microscopes	19
1.9	Field-Emission and Atom-Probe Microscopy	20
1.10	Scanning-Probe Microscopes	22
1.11	Further Reading	25
2	Electron Optics	27
2.1	Properties of an Ideal Image	27
2.2	Imaging in Light Optics	29
2.3	Imaging with Electrons	32
2.4	Focusing Properties of a Thin Magnetic Lens	38
2.5	Comparison of Magnetic and Electrostatic Lenses	41
2.6	Defects of Electron Lenses	42
2.7	Aberration Correctors and Monochromators	51
2.8	Further Reading	53
3	The Transmission Electron Microscope	55
3.1	The Electron Gun	56
3.1.1	Thermionic Emission	56
3.1.2	Schottky Emission	59
3.1.3	Field Emission	60
3.1.4	Comparison of Electron Sources; Source Brightness	61
3.2	Electron Acceleration	63

3.3	Condenser-Lens System	67
3.3.1	Condenser Aperture	69
3.3.2	Condenser Stigmator	70
3.3.3	Illumination Shift and Tilt Controls	71
3.4	The Specimen Stage.	71
3.5	TEM Imaging System	74
3.5.1	Objective Lens	74
3.5.2	Objective Aperture.	75
3.5.3	Objective Stigmator	78
3.5.4	Selected-Area Aperture.	78
3.5.5	Intermediate Lens	79
3.5.6	Projector Lens.	79
3.5.7	TEM Screen and Camera System.	80
3.5.8	Depth of Focus and Depth of Field	81
3.6	Scanning Transmission Systems.	83
3.7	Vacuum System	84
3.8	Further Reading.	88
4	TEM Specimens and Images	89
4.1	Kinematics of Scattering by an Atomic Nucleus	90
4.2	Electron-Electron Scattering	92
4.3	The Dynamics of Scattering	93
4.4	Scattering Contrast from Amorphous Specimens	96
4.5	Diffraction Contrast from Polycrystalline Specimens.	101
4.6	Dark-Field Images	103
4.7	Electron-Diffraction Patterns	103
4.8	Diffraction Contrast from a Single Crystal.	107
4.9	Phase Contrast in the TEM.	110
4.10	STEM Images	114
4.11	TEM Specimen Preparation.	115
4.12	Further Reading.	119
5	The Scanning Electron Microscope.	121
5.1	Operating Principle of the SEM.	121
5.2	Penetration of Electrons into a Solid	124
5.3	Secondary-Electron Images	126
5.4	Backscattered-Electron Images.	131
5.5	Other SEM Imaging Modes	134
5.6	SEM Operating Conditions	138
5.7	SEM Specimen Preparation.	142
5.8	The Environmental SEM	143
5.9	Electron-Beam Lithography.	145
5.10	Further Reading.	147

6 Analytical Electron Microscopy	149
6.1 The Bohr Model of the Atom	149
6.2 X-Ray Emission	152
6.3 X-Ray Energy-Dispersive Spectroscopy	155
6.4 Quantitative Analysis in the TEM	159
6.5 Quantitative Analysis in the SEM	160
6.6 X-Ray Wavelength-Dispersive Spectroscopy	161
6.7 Comparison of XEDS and XWDS Analysis	163
6.8 Auger-Electron Spectroscopy.	164
6.9 Electron Energy-Loss Spectroscopy	165
6.10 Further Reading.	169
7 Special Topics	171
7.1 Environmental TEM.	171
7.2 Radiation Damage	173
7.3 Electron Tomography.	176
7.4 Electron Holography	177
7.5 Time-Resolved Microscopy.	181
7.6 Further Reading.	184
Appendix: Mathematical Derivations.	185
Index	191

<http://www.springer.com/978-3-319-39876-1>

Physical Principles of Electron Microscopy

An Introduction to TEM, SEM, and AEM

Egerton, R.F.

2016, XI, 196 p. 124 illus., 15 illus. in color., Hardcover

ISBN: 978-3-319-39876-1