

# Contents

---

## Part I. Experimental Realization

---

<b>1. Basic Elements of the Equipment</b> .....	<b>3</b>
1.1 X-Ray Sources .....	3
1.2 Monochromators and Collimators .....	6
1.3 Detectors .....	12
<b>2. Diffractometers and Reflectometers</b> .....	<b>17</b>
2.1 X-Ray Reflectometers .....	18
2.2 High-Resolution Diffractometer .....	21
2.3 Limits on the Use of Powder Diffractometers .....	23
2.4 Craying-Incidence Diffraction .....	24
<b>3. Scans and Resolution</b>	
<b>in Angular and Reciprocal Space</b> .....	<b>27</b>
3.1 Coherence of Radiation at the Sample Position .....	28
3.2 Scans Across Reciprocal Space .....	30
3.3 Resolution Elements in Reciprocal Space .....	33
<b>References: Part I</b> .....	<b>39</b>

---

## Part II. Theory

---

<b>4. Basic Principles</b> .....	<b>43</b>
4.1 Description of the X-Ray Wavefield .....	43
4.2 Translational Symmetry of the Sample .....	48
4.3 Direction of the Scattered Waves .....	50
4.4 Randomly Disturbed Samples .....	55
4.5 Classification of Scattering Theories .....	56
<b>5. Kinematical Scattering Theory</b> .....	<b>59</b>
5.1 Scattering from a Single Atom .....	59
5.2 Perfect Layers .....	62
5.3 Refraction and Absorption Corrections .....	67

5.4	Deformed Samples .....	69
5.5	Multilayers .....	72
5.6	Randomly Deformed Samples .....	76
<b>6.</b>	<b>Dynamical Scattering Theory.</b> .....	<b>81</b>
6.1	The Wave Equation. ....	81
6.2	Boundary Conditions .....	83
6.3	X-Ray Reflection .....	86
6.4	Two-Beam Diffraction .....	89
6.5	Layered Samples .....	94
6.5.1	Multilayers: X-Ray Reflection .....	97
6.5.2	Multilayers: Conventional X-Ray Diffraction .....	99
6.6	The Takagi-Taupin Equation .....	100
6.7	The Kinematical Limit of the Takagi-Taupin Equation .....	102
6.8	The Takagi-Taupin Equation in the One-Beam Case .....	105
6.9	Distorted-Wave Born Approximation (DWBA) .....	106
	<b>References:PartII</b> .....	<b>113</b>

---

**Part III. Solution of Selected Experimental Problems**

---

<b>7.</b>	<b>Layer Thicknesses of Single Layers and Multilayers</b> .....	<b>119</b>
7.1	X-Ray Reflection by Single Layers .....	120
7.2	X-Ray Reflection by Periodic Multilayers .....	128
7.3	Coplanar X-Ray Diffraction by Single Layers. ....	134
7.4	Coplanar X-Ray Diffraction by Periodic Superlattices .....	137
7.5	X-Ray Grazing-Incidence Diffraction .....	143
7.6	Buried Layers .....	145
7.6.1	High-Resolution X-Ray Diffraction .....	145
7.6.2	X-Ray Reflection .....	148
7.6.3	Grazing-Incidence Diffraction .....	149
<b>8.</b>	<b>Lattice Parameters and Lattice Strains in Single Epitaxial Layers.</b> .....	<b>151</b>
8.1	Conventional Coplanar Diffraction .....	151
8.2	Coplanar Extremely Asymmetric Diffraction .....	160
8.3	Grazing-Incidence Diffraction .....	164
<b>9.</b>	<b>Volume Defects in Layers</b> .....	<b>169</b>
9.1	Diffuse Scattering from Weak Defects .....	170
9.2	Diffuse X-Ray Reflection from Layers Containing Small-Volume Defects. ....	180
9.3	Diffraction from Relaxed Epitaxial Layers .....	182

<b>10. X-Ray Reflection by Rough Multilayers</b> .....	191
10.1 Introduction .....	191
10.2 Interface Roughness: The Scattering Potential and its Statistical Properties .....	192
10.2.1 The Scattering Potential of a Multilayer with Rough Interfaces .....	192
10.3 Specular X-Ray Reflection .....	195
10.3.1 Theoretical Description .....	195
10.3.2 Examples .....	198
10.4 Non-Specular X-Ray Reflection .....	207
10.4.1 Theoretical Description .....	208
10.4.2 Examples .....	211
<b>11. X-Ray Scattering by Gratings and Dots</b> .....	<b>221</b>
11.1 Scattering by Surface Gratings: General Considerations .....	221
11.1.1 Scattering Potential .....	221
11.1.2 Diffraction by a Surface Grating .....	224
11.2 Coplanar X-Ray Diffraction .....	225
11.2.1 Determination of the Grating Period and the Etching Depth .....	225
11.2.2 Reciprocal-Space Mapping .....	226
11.2.3 Diffraction by Superlattice Surface Gratings .....	231
11.3 Grazing-Incidence Diffraction .....	232
11.3.1 Investigation of the Shape and Strain .....	232
11.4 Diffraction by Buried Gratings .....	236
11.5 Lateral Strain-Induced Patterning .....	238
11.6 Quantum Dots .....	240
<b>References: Part III</b> .....	<b>243</b>
<b>A. Wave Vectors and Amplitudes   of the Internal Wavefields   in a Dynamically Scattering Crystal</b> .....	<b>247</b>
A.1 Coplanar Diffraction .....	247
A.2 Grazing-Incidence Diffraction .....	250
A.3 X-Ray Reflection .....	251
<b>Index</b> .....	<b>253</b>