

Contents

1 Basic Principles of the Interaction of X-Rays with Matter:	
Quantum Electrodynamical Analysis	1
1.1 Equations of X-Ray Optics	1
1.2 Average Current Density and X-Ray Polarizability	10
1.3 Scattering Factors	18
1.4 Numerical Calculation of Debye–Waller Factor	34
References	50
2 The Theory of X-Ray Scattering from Macroscopical Objects	53
2.1 The Stationary and Temporal Approaches to X-Ray Scattering Process	53
2.2 Approximate Methods for the Solution of Stationary Scattering Problem	63
References	69
3 X-Ray Reflectivity	71
3.1 Experiment Geometry and Basic Parameters of XRR	71
3.2 Reflection of X-Ray Radiation from Rough Surface	81
3.3 X-Ray Reflectivity from Multilayered Structures	101
3.4 Characterization of Samples Using Experimental XRR Data	113
References	117
4 X-Ray Diffraction in Ideal Crystals	119
4.1 Kinematical X-Ray Diffraction Theory	120
4.2 Basics of Two-Wave Dynamical Diffraction	125
4.2.1 Amplitude Ratio	134
4.2.2 Anomalous Absorption and Extinction	137
4.2.3 Group Velocity	140
4.3 Dynamical Diffraction in Multilayers and Superlattices	141
4.4 Grazing Incidence and Extremely Asymmetric Diffraction	154
4.5 X-Ray Diffraction from Lateral Nanostructures	160
References	167

5	Diffuse X-Ray Scattering from Imperfect Surfaces and Interfaces	171
5.1	Statistical Approach for X-Ray Scattering from Imperfect Structures	172
5.2	Diffuse Scattering from Roughness in XRR Geometry	179
5.3	X-Ray Diffuse Scattering from Rough Interfaces in Multilayered Structures	195
5.4	Grazing-Incidence Small Angle X-Ray Scattering	203
	References	215
6	X-Ray Diffraction from Crystals with Defects	217
6.1	X-Ray Polarizability of Crystal with Defects	218
6.2	Dynamical X-Ray Diffraction in a Crystal with Defects	223
6.3	Effective Potential and Applicability of Kinematical Theory	231
6.4	One-Dimensional Defects (Dislocations)	236
6.4.1	Parallel Edge Dislocations at Interfaces	237
6.4.2	Parallel Edge Dislocations in Graded Layers	245
6.4.3	Parallel Dislocations Lines Perpendicular to Sample Surface	251
6.5	Two-Dimensional Defects (Stacking Faults)	256
	References	260
7	X-Ray Diffraction Residual Stress Analysis in Polycrystals	265
7.1	X-Ray Stress Measurements	266
7.2	Grain-Interaction Models	272
7.2.1	Voigt Model	274
7.2.2	Reuss Model	275
7.2.3	Hashin-Shtrikman Boundaries for Rigidity Modulus	276
7.2.4	Self-Consistent Model of Eshelby-Kröner	282
7.2.5	Grain Interaction in Thin Film. Vook-Witt and Inverse Vook-Witt Models	285
7.3	Residual Stress Analysis as a Particular Case of Powder Diffractometry	288
7.4	Residual Stress in Macroscopically Isotropic Materials. X-Ray Elastic Constants	294
7.4.1	Voigt Model	299
7.4.2	Reuss Model	300
7.4.3	Eshelby-Kröner Model	300
7.5	Residual Stress in Macroscopically Anisotropic Materials. X-Ray Stress Factors	303
7.5.1	Voigt Model	303
7.5.2	Reuss Model	304

7.5.3	Eshelby-Kröner Model.	306
7.5.4	Vook-Witt and Inverse Vook-Witt Models.	307
References	309
Index	313