D. Shindo · K. Hiraga

dandelon.com
© 2008 AGI-Information Management Consultants
May be used for personal purposes only or by
libraries associated to dandelon.com network.

High-Resolution Electron Microscopy for Materials Science

With 203 Figures

Springer

Contents

Preface V
List of specimens observed by high-resolution electron microscopy IX
List of electron microscopes (EMs) used IX

1. Basis of High-Resolution Electron Microscopy

1.1 Principles of Transmission Electron Microscopy 1
1.2 Electron Scattering and Fourier Transform 3
1.3 Formation of High-Resolution Images 4
1.3.1 High-Resolution Images of Thin Crystals 4
1.3.2 Resolution of Electron Microscopes 8
1.3.3 High-Resolution Images of Thick Crystals 9
1.4 Computer Simulation of High-Resolution Images 11
1.4.1 Simulation Program and Input Parameters 11
1.4.2 Generalization of Image Simulation 13
1.4.3 Checking Programs 14
References 15

2. Practice of High-Resolution Electron Microscopy

2.1 Classification of High-Resolution Images 17
2.1.1 Lattice Fringes 17
2.1.2 One-Dimensional Structure Images 20
2.1.3 Two-Dimensional Lattice Images 21
2.1.4 Two-Dimensional Structure Images 25
2.1.5 Special Images 29
2.2 Practice in Observing High-Resolution Images 31
2.2.1 Points to Note Before Observation 31
2.2.2 Points to Note During Observation 33
2.2.3 Selection of Good Images 36
2.2.4 Points to Note in the Interpretation of Images 38
2.2.5 Training for the Observation of High-Resolution Images 39
References 39

3. Application of High-Resolution Electron Microscopy

3.1 High-Resolution Images of Various Defects 41
3.1.1 Dislocations 41
3.1.2 Grain Boundaries and Interfaces Between Different Phases 54
3.1.3 Surfaces 69
3.1.4 Other Structural Defects 75
3.2 High-Resolution Images of Various Materials 83
3.2.1 Ceramics 83

3.2.2 Superconducting Oxides 91
3.2.3 Ordered Alloys 99
3.2.4 Quasicrystals 113
References 127

4. Peripheral Instruments and Techniques for High-Resolution Electron Microscopy

4.1 Image Processing 129
4.1.1 Input and Output of High-Resolution Images 129
4.1.2 Practice in Processing High-Resolution Images 131
4.2 Quantitative Analysis 138
4.2.1 Principles of New Recording Systems 138
4.2.2 Characteristics of New Recording Systems 139
4.2.3 Quantitative High-Resolution Electron Microscopy 142
4.3 Electron Diffraction 147
4.3.1 Basis of Electron Diffraction 147
4.3.2 Practice of Electron Diffraction 149
4.3.3 Electron Diffraction Patterns of Various Structures 152
4.4 Weak-Beam Method 156
4.4.1 Principles of the Weak-Beam Method 156
4.4.2 Weak-Beam Method in Practice 158
4.5 Evaluation of the Performance of Electron Microscopes 159
4.5.1 Evaluation of Basic Parameters in Electron Microscopes 159
4.5.2 Evaluation of the Resolution of Electron Microscopes 163
4.6 Specimen Preparation Techniques 164
4.6.1 Crushing 164
4.6.2 Electropolishing 164
4.6.3 Chemical Polishing 165
4.6.4 Ultramicrotomy 165
4.6.5 Ion Milling 166
4.6.6 Focused Ion Beam (FIB) 167
4.6.7 Vacuum Evaporation 167
References 168

Appendixes

Appendix A. Physical Constants, Conversion Factors and Electron Wavelength 169
Appendix B. Geometry of Crystal Lattice 170
Appendix C. Typical Structures in Materials and Their Electron Diffraction Patterns 172
Appendix D. Properties of Fourier Transform 181
Appendix E. Sign Conventions 185

Subject Index 187