

Contents

1. MBE-Grown Semiconductor Interfaces	1
1.1 Molecular-Beam Epitaxy	1
1.2 Interface Formation	3
1.3 GaAs/AlAs Surfaces	7
2. Reflection High-Energy Electron Diffraction (RHEED) ...	13
2.1 Geometry and Experimental Conditions	13
2.2 Instrumentation and Miscellaneous RHEED Techniques	17
2.3 Theoretical Models	19
2.3.1 Kinematical Scattering	20
2.3.2 Dynamical Scattering	25
3. RHEED Oscillations	27
3.1 Current Experimental Status	27
3.2 Theoretical Models	35
3.2.1 Birth–Death Models	35
3.2.2 Kinematical Model	38
3.2.3 Edge-Scattering Model	38
3.2.4 Dynamical Approaches	39
3.2.5 Top-Layer Interference Model	39
4. Semikinematical Simulations of RHEED Patterns.....	43
4.1 Different Models for the Surface Reconstruction of GaAs (113)A	44
4.2 Misoriented GaAs (113)A.....	51
4.3 (001) GaAs (2×4)/c(2×8)	54
4.3.1 Depth Modulation	56
4.3.2 Shadowing and Average Layer Potential	58
4.3.3 Relaxation, Doyle–Turner and Debye–Waller Corrections	61
4.3.4 The [110] Azimuth	63
4.4 Domains	64

VIII Contents

5. Kikuchi Lines	75
5.1 A Simple Scheme for the Geometrical Construction of Kikuchi Patterns	75
5.1.1 Three-Dimensional Lines	75
5.1.2 Extension to Fewer Than Three Dimensions	79
5.2 Determination of Average Crystal Potential and Misorientation	82
5.3 Where do Kikuchi Lines Originate?	87
6. RHEED with Rotating Substrates	91
6.1 Gated Detection	92
6.2 Azimuthal Scans	93
6.3 RHEED Oscillations	99
7. Reconstruction-Induced Phase Shifts of RHEED Oscillations	109
7.1 Phase Shifts at GaAs/AlAs Heterointerfaces	110
7.1.1 Variation of As ₄ Pressure	111
7.1.2 Variation of Substrate Temperature	112
7.1.3 Variation of the Growth Rate	117
7.1.4 Variation of Diffraction Conditions	118
7.2 Experimental Results	118
7.2.1 Sampling Depth of RHEED	119
7.2.2 Phase Shifts and Surface Reconstructions	121
7.2.3 Phase Shift Variation Along a Streak	127
7.2.4 Decoupling of Phase on Different Streaks	129
8. Energy Loss Spectroscopy During Growth	133
8.1 Electron Loss Spectroscopy on Static Surfaces	136
8.2 ELS-RHEED Intensity Oscillations	142
9. Phase Shifts: Models	145
9.1 Growth-Induced Phase Shifts	145
9.2 Diffraction-Induced Phase Shifts: The Top-Layer Interference Model	148
9.2.1 A Basic Model	148
9.2.2 Comparison With Experiments	154
9.2.3 Phase Shifts at Interfaces	161
10. Applications of Reconstruction-Induced Phase Shifts	165
10.1 Ga Segregation at AlAs/GaAs Interfaces	165
10.1.1 (001) Interfaces	165
10.1.2 (113)A Interfaces	174
10.2 Modifying the Surface Reconstruction: Tin Doping	179
10.3 Modifying the Surface Morphology: Carbon Doping	182

Contents IX

10.4 Silicon Doping	185
10.4.1 Dependence of the Phase Shift on Si Concentration ..	185
10.4.2 Si-Induced Kinks	188
10.4.3 Si Segregation	189
10.4.4 GaAs/AlAs (001) Revisited	194
11. Closing Remarks	197
References	201
Index	211
Color Plates	217