Contents

Acronyms . . . 1
Symbols . . . 4

1 Introduction 7
1.1 The Semiconductor Industry . . . 7
1.2 Dopant Profiling Requirements . . . 10

2 Review of Dopant Profiling Techniques 13
2.1 1D Dopant Profiling Techniques . . . 15
2.1.1 Spreading Resistance Profiling . . . 15
2.1.2 Secondary Ion Mass Spectroscopy . . . 20
2.1.3 Electrochemical C-V Profiling . . . 23
2.2 2D Dopant Mapping Techniques . . . 25
2.2.1 Chemical Staining/Etching . . . 25
2.2.2 Secondary Electron Dopant Contrast . . . 26
2.2.3 Scanning Probe Techniques in General . . . 27
2.2.4 Scanning Capacitance Microscopy . . . 30
2.3 Other Dopant Analysis Techniques . . . 33

3 SSRM Methodology 35
3.1 SSRM as a Secondary AFM Imaging Mode . . . 35
3.1.1 Measurement Setup . . . 37
3.1.2 Nano-Electric Point Contact . . . 40
3.1.3 Back Contact . . . 48
3.1.4 Logarithmic Current Amplifier . . . 51
3.2 Sample Preparation . . . 52
3.2.1 Cleaving . . . 54
3.2.2 Mechanical Grinding and Polishing . . . 56
3.2.3 Focused Ion Beam . . . 59
3.3 Probes . . . 64
3.3.1 Diamond coated Probes . . . 64
3.3.2 Pyramidal moulded Diamond Probes . . . 66
3.4 Data Calibration . . . 66

4 Application of SSRM for Technology Development 73
4.1 Photovoltaic 73
4.1.1 Laser Doped Selective Emitter 74
4.1.2 Other Selective Emitter Concepts 78
4.2 Integrated Silicon Devices 79
4.2.1 Resist Lift Off 79
4.2.2 Gate Depletion 84
4.3 Power Devices 100
4.3.1 Super Junction MOSFET 101
4.3.2 Silicon Carbide Power Devices 106

5 Active Device Characterization by SSRM 113
5.1 Motivation 114
5.1.1 Dynamic Voltage 114
5.1.2 Active Devices 115
5.2 Test Devices 117
5.2.1 Sample Preparation 118
5.2.2 Influence of Preparation on IV-characteristics 120
5.3 Existing Methods for Active Device Characterization 122
5.3.1 Standard SSRM 122
5.3.2 Lock-in Amplifier based SDSRM 126
5.3.3 Scanning Voltage Microscopy 133
5.4 Scanning Dynamic Voltage Spreading Resistance Microscopy 138
5.4.1 Measurement Principle 138
5.4.2 Experimental Setup 140
5.4.3 Results 144
5.4.4 Summary 148

6 Summary and Outlook 149
6.1 General Summary 149
6.2 Outlook 150

Bibliography 153

Scientific contributions 171