

# Contents

<b>Acknowledgements</b> .....	<b>i</b>
<b>Abstract</b> .....	<b>iii</b>
<b>Contents</b> .....	<b>v</b>
<b>List of Figures</b> .....	<b>vii</b>
<b>List of Tables</b> .....	<b>xv</b>
<b>Chapter 1 Introduction</b> .....	<b>1</b>
1.1 Advantages of GaN for efficient power conversion .....	1
1.2 Cost-effective GaN-on-Si platform.....	4
1.3 Current GaN-on-Si power device technologies .....	7
1.4 Major challenges .....	10
1.5 Thesis outline .....	12
<b>Chapter 2 Tri-gate technologies for GaN devices</b> .....	<b>13</b>
2.1 Introduction.....	13
2.2 Impact of fin width on transfer characteristics.....	15
2.3 Dependence of threshold voltage on the fin width.....	17
2.3.1 Effect of the increased gate capacitance .....	18
2.3.2 Effect of the strain relaxation and sidewall depletion .....	19
2.4 Eliminating degradation in on-resistance and output current .....	21
2.4.1 Effect of the fin width.....	21
2.4.2 Effect of the fin length.....	22
2.4.3 Effect of the filling factor .....	22
2.5 Additional trench-conduction channels.....	24
2.5.1 Trench conduction in normally-on devices .....	25
2.5.2 Trench conduction in normally-off devices.....	27
2.6 Improving thermal performance .....	29
2.7 Reducing gate charge .....	30
2.8 Conclusion.....	31

<b>Chapter 3 Novel tri-gate field plates for high-voltage applications.....</b>	<b>33</b>
3.1 Introduction.....	33
3.2 Principle and Concept.....	34
3.3 High-voltage tri-gate GaN-on-Si MOSHEMTs.....	35
3.4 High-performance slanted tri-gate GaN-on-Si power MOSHEMTs.....	40
3.5 Conclusion.....	42
<b>Chapter 4 Tri-gate technologies for high-voltage and low-leakage SBDs.....</b>	<b>45</b>
4.1 Introduction.....	45
4.2 High-voltage tri-anode GaN-on-Si SBDs with low leakage current.....	46
4.3 Field plate design for low leakage current in lateral GaN SBDs.....	50
4.4 2000 V slanted tri-gate SBDs with ultra-low leakage current.....	55
4.5 650 V reverse-blocking MOSHEMTs with slanted tri-gate Schottky drain.....	60
4.6 Conclusion.....	66
<b>Chapter 5 Multi-channel tri-gate technologies for ultra-low on-resistance.....</b>	<b>69</b>
5.1 Introduction.....	69
5.2 High-voltage normally-on/off multi-channel tri-gate GaN MOSHEMTs.....	71
5.3 High-performance multi-channel tri-gate GaN power SBDs.....	78
5.4 Multi-channel tri-gate GaN devices with ultra-low on-resistance.....	84
5.5 Conclusion.....	89
<b>Chapter 6 Conclusion.....</b>	<b>90</b>
6.1 Achieved results.....	90
6.2 Future development.....	91
<b>Reference.....</b>	<b>93</b>
<b>Curriculum Vitae.....</b>	<b>105</b>
<b>Appendix-1: the growth recipe for the 10x-channel GaN heterostructure.....</b>	<b>111</b>
<b>Appendix-2: the code for the ATLAS simulation of SBDs.....</b>	<b>135</b>
<b>Appendix-3: the process flow of tri-gate GaN devices.....</b>	<b>141</b>