

## Contents

<b>Abstract</b>	i-ii
<b>Declaration</b>	iii
<b>Certificate</b>	iv
<b>Certificate of the External Examiner</b>	v
<b>Acknowledgement</b>	vi-vii
<b>Contents</b>	ix-xiii
<b>List of Figures</b>	xiv-xviii
<b>List of Tables</b>	xix
<b>Nomenclature</b>	xx-xxiv

## Chapter 1: Introduction

1.1	Field Effect Transistors .....	2
1.2	Transistor Scaling .....	4
1.3	Short Channel Effects (SCEs).....	5
1.3.1	Channel Length Modulation.....	6
1.3.2	Drain Induced Barrier Lowering (DIBL).....	7
1.3.3	Threshold Voltage Roll-off.....	7
1.3.4	Velocity Saturation.....	8
1.3.5	Hot Carrier Effects.....	8
1.4	Advance Semiconductor Devices.....	9
1.4.1	Laterally Diffused Metal-Oxide-Semiconductor Device (LDMOS).....	10
1.4.2	Double Gate Silicon Carbide JLT (DG-SiCJLT).....	12
1.4.3	Junctionless Tunnel Field Effect Transistor (JL-TFET).....	13

1.5	TCAD Simulation Methodology.....	15
1.6	Reliability of Semiconductor Devices.....	17
1.7	Radiation Effect on Semiconductor Devices.....	18
1.8	Research Objectives.....	19
1.9	Thesis Organization.....	20

## Bibliography

### **Chapter 2: Reliability Assessment and Circuit Applications of LDMOS**

#### **Transistor in Harsh Environments**

2.1	Introduction.....	28
2.2	Laterally Diffused Metal-Oxide-Semiconductor (LDMOS) Device Structure and Operation.....	29
2.3	Reliability Concern of LDMOS Transistor.....	30
2.4	Calibration of LDMOS Transistor with Experimental data and Simulation Setup.....	33
2.5	Parametric Investigation of LDMOS Transistor at High Temperature and High Radiation Environment.....	38
2.5.1	$N_{it}$ , $N_{ot}$ and $V_{TH}$ shift with TID.....	38
2.5.2	Output resistance ( $R_0$ ) shift with TID.....	42
2.5.3	Unity gain cut-off frequency ( $f_T$ ) shift with TID.....	43
2.5.4	High-Temperature Performance of LDMOS Transistor at Radiation Environment.....	45
2.6	Low-Frequency (1/f) Noise Calculation of LDMOS Transistor with Total Ionizing Dose (TID).....	48

2.7	Threshold Voltage Modulation in Presence of TID.....	52
2.7.1	With Channel Doping Concentration.....	53
2.7.2	With Channel/Drift Length Variation.....	54
2.7.3	With Oxide Thickness Variation.....	54
2.7.4	Inserting a P <sup>+</sup> pocket in The Channel Region.....	54
2.8	Analog Circuit Performance of LDMOS Transistor.....	55
2.9	Summary.....	58
	Bibliography	

### **Chapter 3: Double Gate Junctionless FET with SiC substrate**

3.1	Introduction.....	66
3.2	Why Junctionless FET?.....	67
3.3	Silicon Carbide (SiC) as Substrate for High-Power Applications.....	69
3.4	DG-SiCJLT: A Symbiosis of Material Excellence and Device Innovation.....	70
3.5	Literature Review on DG-SiCJLT.....	70
3.6	Device Architectures and Simulation Set-up.....	72
3.7	Results and Discussions.....	76
3.7.1	Threshold Voltage Engineering.....	78
3.7.2	Lower Output Current.....	80
3.8	High-Temperature Performance of DG-SiCJLT and P <sup>+</sup> -SiCJLT.....	81
3.8.1	Drain Current at High-Temperature.....	81
3.8.2	Unity-gain Cut-Off Frequency at High Temperature.....	85

3.9	Comparison with Devices Featuring Embedded Pockets in Substrate near Source/Drain Contact.....	86
3.10	Fabrication Steps for The Proposed P <sup>+</sup> -SiCJLT.....	88
3.11	Summary.....	89
	Bibliography	

## **Chapter 4: Reliability of JL-TFET in Harsh Environment**

4.1	Introduction.....	96
4.2	Structure and Operating Principle of JL-TFET.....	97
4.3	Traps in JL-TFET.....	100
4.4	Device Simulation and Calibration.....	103
4.5	DC and Analog/RF Performance of JL-TFET.....	106
4.6	High-temperature Performance of JL-TFET.....	108
4.7	Improvement of Ambipolar Behavior in a JL-TFET.....	112
4.8	Reliability Issues in JL-TFET.....	114
4.8.1	Hot Carrier Injection (HCI).....	114
4.8.2	Negative Bias Temperature Instability (NBTI).....	116
4.8.3	Radiation Effects.....	118
4.8.4	Role of Interface Traps on JL-TFET at High-Temperature.....	122
4.8.5	Effect of Traps Due to Variation in Gaussian Peak Location.....	126
4.9	Summary.....	127
	Bibliography	

## **Chapter 5: Conclusions and Future Direction of Research**

5.1	Summary of Contribution.....	138
5.2	A Few Directions for Future Works.....	140

List of Publication