# Table of Contents

**Abstract**

iv

**Acknowledgements**

v

**Table of Contents**

v

**List of Tables**

ix

**List of Figures**

x

**List of Symbols**

xvi

**List of Abbreviations**

xvii

**List of Publications**

xx

## Chapter

1 **Introduction**

1.1 Motivation  
1.2 Contributions  
1.3 Thesis Organization

2 **Background and Previous Work**

2.1 Introduction  
2.2 Trends and Limitations of Technology Scaling  
2.2.1 Technology Scaling Theory  
2.2.2 Technology Scaling in Deep Nanometer Era  
2.3 Sources of Power Consumption in CMOS  
2.3.1 Dynamic Power Consumption  
2.3.2 Static Power Consumption  
2.4 Subthreshold Region of Operation  
2.4.1 Modeling of Subthreshold Leakage Current  
2.4.2 Capacitances in Subthreshold Regime  
2.4.3 Subthreshold Slope in Subthreshold Regime  
2.4.4 Energy-Delay Tradeoff for Subthreshold Circuits
5.2.3 Mixed CNT bundle 77
5.3 Related Work 79
5.4 Performance Analysis of CNT Interconnects 80
5.5 Mixed CNT Bundle for ULP Global Interconnects 87
  5.5.1 Optimization of Mixed CNT Bundle Process Parameters 87
  5.5.2 Effect of Aspect Ratio Scaling on Interconnect Performance 91
  5.5.3 Effect of Crosstalk on Interconnect Performances 92
5.6 Summary 95

6 ULTRA - LOW POWER SIGNALING FOR GLOBAL INTERCONNECTS
  6.1 Introduction 96
  6.2 Performance Analysis of Global Interconnects for Subthreshold Circuits 98
    6.2.1 Conventional Interconnects Techniques 98
    6.2.2 Proposed Subthreshold Interconnect Techniques 103
    6.2.3 Dynamic Threshold MOS (DTMOS) Technique 110
  6.3 Effect of Process and Temperature Variations on Interconnect Performances 111
    6.3.1 Effect of Threshold Voltage Variations 111
    6.3.2 Effect of Temperature Variations 114
  6.4 Effect of Crosstalk on Subthreshold Interconnect Performance 116
  6.5 Summary 119

7 PERFORMANCE EVALUATION OF EMERGING DEVICES
  7.1 Introduction 120
  7.2 Carbon Nanotube Field Effect Transistor 121
    7.2.1 Carbon Nanotubes 121
    7.2.2 CNFET Model Overview 123
    7.2.3 CNFET I-V Characteristics 124
  7.3 Structure of DG FinFET Device 126
  7.4 Optimisation of CNFET Under Subthreshold Conditions 128
  7.5 Performance Comparison of CNFET and FinFET 130
8. Subthreshold Device Design and Characterization

8.1 Introduction
8.2 Calibration of a MOS Device
8.3 Effect of Oxide Thickness and Channel Length under Subthreshold Conditions
8.4 Effect of Doping Profile Under Subthreshold Conditions
8.5 Subthreshold Device Characterization
8.6 Summary

9. Summary and Conclusion

9.1 Introduction
9.2 Summary
9.3 Conclusions
9.4 Achievements
9.5 Future Work

REFERENCES