

Contents

- 1 Introduction 1**
 - 1.1 Motivation 1
 - 1.2 Scaling Fundamentals 3
 - 1.2.1 New Materials: High-k Gate Dielectrics 5
 - 1.2.2 New Device Architectures: Multi-Gate MOSFETs 6
 - 1.2.3 New Device Concepts: Tunneling FETs 8
 - 1.3 Variability from Analog and Mixed-Signal Perspective 9
 - 1.3.1 Systematic Static Variations 9
 - 1.3.2 Static Random Variations—Mismatch 11
 - 1.3.3 Transient Random Variations—Noise 12
 - 1.3.4 Transient Systematic Variations 13
- 2 Analog Properties of Multi-Gate MOSFETs 15**
 - 2.1 Introduction to Recent FinFET Technology 15
 - 2.2 DC Characteristics 16
 - 2.3 Analog and RF Characteristics 18
 - 2.3.1 Small Signal Parameters 19
 - 2.3.2 Noise Performance 21
 - 2.4 Matching Behavior 23
 - 2.5 Charge-Trapping 26
 - 2.6 Self-Heating 29
- 3 High-k Related Design Issues 33**
 - 3.1 Flicker Noise 33
 - 3.1.1 Linear Analog Circuits and Converters 33
 - 3.1.2 Voltage Controlled Oscillator 34
 - 3.1.3 Flicker Noise Reduction Techniques 35
 - 3.2 Transient V_T Variations and Hysteresis Effects 37
 - 3.2.1 Linear and Continuous Time Building Blocks 37
 - 3.2.2 Non-Linear and Discrete Time Building Blocks 39
 - 3.2.3 Flash ADC 46
 - 3.2.4 Successive Approximation ADC 47
 - 3.2.5 $\Sigma\Delta$ ADC 53
 - 3.2.6 Conclusions on Transient V_T Shift 55

4	Multi-Gate Related Design Aspects	57
4.1	Biasing Circuits	57
4.1.1	Matching Optimized Current Mirrors	57
4.1.2	Current Reference Circuits	60
4.2	Operational Amplifiers	64
4.2.1	Gain-Bandwidth-Power Trade-off	65
4.2.2	Design Example	67
4.2.3	Common Mode and Power Supply Rejection Ratio	68
4.3	Bandgap Reference Circuits	69
4.3.1	Gated p-i-n Diodes	70
4.3.2	Low Voltage Bandgap Reference	72
4.3.3	Design Considerations	74
4.3.4	Measurement Results	77
4.4	D/A Converter	79
4.4.1	Design Considerations	80
4.4.2	Measurement Results	81
4.5	Phase-Locked-Loop Circuit	84
4.5.1	Design Considerations	84
4.5.2	Measurement Results	86
4.6	RF Building Blocks	88
4.6.1	LC-VCO	88
4.6.2	LNA	90
4.7	Self-Heating	91
4.7.1	Thermal Coupling	92
4.7.2	Transient Thermal Mismatch	93
4.7.3	Linear and Continuous Time Circuits	93
4.7.4	Non-Linear and Discrete Time Circuits	94
4.8	Selective Fin Width Tuning	95
4.8.1	Self Cascode	96
4.8.2	VIP3 Enhancement	97
5	Multi-Gate Tunneling FETs	99
5.1	Principle of Operation and Implementation of MuGTFETs	99
5.2	Measurement Results	100
5.2.1	I - V Characteristics	100
5.2.2	Digital and Analog Performance	102
5.2.3	Temperature Characteristics	103
5.2.4	Variations	104
5.3	Device Simulation	105
5.4	MuGTFET Reference Circuit	107
6	Conclusions and Outlook	111
	Symbols and Abbreviations	115
	References	119

Variation Aware Analog and Mixed-Signal Circuit Design
in Emerging Multi-Gate CMOS Technologies

Fulde, M.

2010, X, 127 p., Hardcover

ISBN: 978-90-481-3279-9