

Advanced Gate Stacks for High-Mobility Semiconductors

Bearbeitet von
Athanasios Dimoulas, Evgeni Gusev, Paul C McIntyre, Marc Heyns

1. Auflage 2007. Buch. xxii, 384 S. Hardcover

ISBN 978 3 540 71490 3

Format (B x L): 15,5 x 23,5 cm

Gewicht: 1650 g

[Weitere Fachgebiete > Technik > Elektronik > Mikroprozessoren](#)

Zu [Leseprobe](#)

schnell und portofrei erhältlich bei


DIE FACHBUCHHANDLUNG

Die Online-Fachbuchhandlung beck-shop.de ist spezialisiert auf Fachbücher, insbesondere Recht, Steuern und Wirtschaft. Im Sortiment finden Sie alle Medien (Bücher, Zeitschriften, CDs, eBooks, etc.) aller Verlage. Ergänzt wird das Programm durch Services wie Neuerscheinungsdienst oder Zusammenstellungen von Büchern zu Sonderpreisen. Der Shop führt mehr als 8 Millionen Produkte.

Contents

Preface	V
Contributors	XVII
1 Strained-Si CMOS Technology	
<i>S. Takagi</i>	1
1.1 Introduction	1
1.2 Impact of Mobility Enhancement on Current Drive of Short-Channel MOSFETs	2
1.3 Physical Mechanism of Mobility Enhancement in Strained-Si n- and p-Channel MOSFETs	3
1.3.1 Physical Origin of Mobility Enhancement in n-Channel MOSFETs	3
1.3.2 Physical Origin of Mobility Enhancement in p-Channel MOSFETs	7
1.4 Implementation of Strain into MOSFETs	11
1.4.1 Global Strain Technology	11
1.4.2 Local Strain Technology	13
1.5 Conclusions	14
References	15
2 High Current Drivability MOSFET Fabricated on Si(110) Surface	
<i>A. Teramoto, T. Ohmi</i>	21
2.1 Introduction	21
2.2 Experimental	22
2.3 Results and Discussions	24
2.3.1 MOSFET Characteristics on the Si(110) Surface	24
2.3.2 Suppression of Surface Micro-roughness	29
2.4 Conclusions	38
References	39

3 Advanced High-Mobility Semiconductor-on-Insulator**Materials**

<i>B. Ghyselen, I. Cayrefourcq, M. Kennard, F. Letertre,</i>	
<i>T. Akatsu, G. Celler, C. Mazure</i>	43
3.1 Introduction	43
3.2 Crystalline Orientation Effects	44
3.2.1 Silicon Crystalline Orientations for Bulk Substrates	44
3.2.2 Silicon Crystalline Orientations for SOI Substrates	45
3.2.3 Perspectives for Crystalline Orientations in SOI Substrates	47
3.3 Strained Si on Insulator Wafers	48
3.3.1 Introduction to Strained Si on Insulator Wafers	48
3.3.2 “Local Strain”	48
3.3.3 “Global Strain”	49
3.3.4 Two Main Approaches to “Global Strain On Insulator”: SGOI Vs. sSOI	51
3.3.5 Different Routes Towards SGOI	52
3.3.6 SGOI Material Concept Validation Through Device Demonstrations	55
3.3.7 sSOI Substrates: Ge-free Strained Si On Insulator Substrates	57
3.3.8 Thick sSOI Substrates	59
3.3.9 Device Results on sSOI	60
3.4 Germanium On Insulator Substrates	60
3.4.1 Introduction to GeOI Substrates	60
3.4.2 GeOI Substrates Manufacturing Routes	61
3.4.3 Examples of GeOI Substrates Validations at Device Level	64
3.5 Long Term Perspectives	65
3.6 Conclusions	66
References	67

4 Passivation and Characterization of Germanium Surfaces

<i>S.R. Amy, Y.J. Chabal</i>	73
4.1 Introduction	73
4.2 Experimental Methodology	74
4.2.1 X-ray and UV Photoemission Spectroscopy	74
4.2.2 Fourier Transform Infrared Spectroscopy	75
4.2.3 Scanning Tunneling Microscopy	76
4.3 Clean Ge Surfaces	76
4.4 Oxidation of Ge Surfaces	76
4.5 Hydrogenation of Germanium Surfaces	83
4.5.1 Hydrogenation in Ultra High Vacuum	83
4.5.2 Wet Chemical Treatment of Flat Single Crystal Germanium Surfaces	83

4.5.3 Electrochemistry on Flat Single Crystal Germanium Surfaces	89
4.5.4 Electrochemistry on Porous Germanium Substrate	91
4.6 Nitridation and Oxynitridation of Germanium Surfaces	93
4.7 Sulfur Passivation of Germanium Surfaces	97
4.8 Chlorine Passivation of Germanium Surfaces	99
4.9 Organic Molecules as Passivating Agent of Germanium Surfaces	101
4.10 Conclusions	104
References	111

5 Interface Engineering for High- k Ge MOSFETs

<i>S.J. Lee, C. Zhu, D.L. Kwong</i>	115
5.1 Introduction	115
5.2 Germanium Oxide and High- k /Ge Interface	116
5.3 Surface Nitridation	122
5.3.1 Physical Characterization	124
5.3.2 MOS Capacitor Characteristics	126
5.3.3 MOSFET Performance	127
5.4 Surface Silicon Passivation	128
5.4.1 Physical Characterization	128
5.4.2 MOS Capacitors and Thermal Stability	130
5.4.3 MOSFET Performance	132
5.4.4 BTI and Charge Trapping	133
5.5 Plasma-PH ₃ and AlN Surface Passivation	135
5.6 Conclusion	137
References	137

6 Effect of Surface Nitridation on the Electrical Characteristics of Germanium High- κ /Metal Gate Metal-Oxide-Semiconductor Devices

<i>D.Q. Kelly, J.J.-H. Chen, S. Guha, S.K. Banerjee</i>	139
6.1 Introduction	139
6.2 Germanium Surface Cleaning	141
6.3 Surface Pretreatment with NH ₃ (Surface Nitridation)	144
6.4 Effect of Surface Nitridation on the Electrical Characteristics of Germanium MOS Capacitors	147
6.4.1 Al ₂ O ₃ /Ge and HfO ₂ /Ge Capacitor Fabrication	149
6.4.2 Electrical Characterization of Al/Al ₂ O ₃ /Ge Capacitors	152
6.4.3 Electrical Characterization of Al/HfO ₂ /Ge and W/HfO ₂ /Ge Capacitors	155
6.5 Conclusions	159
References	160

7 Modeling of Growth of High- k Oxides on Semiconductors

<i>C.J. Först, C.A. Ashman, K. Schwarz, P.E. Blöchl</i>	165
7.1 Introduction	165
7.2 Computational Approach	166
7.3 The Chemistry of the Substrate	167
7.4 Metal Adsorption on Si(001)	168
7.5 Interface of SrTiO ₃ and Si(001)	174
7.6 Band Offset Engineering	175
7.7 Conclusions	178
References	178

8 Physical, Chemical, and Electrical Characterization of High- κ Dielectrics on Ge and GaAs

<i>S. Spiga, C. Wiemer, G. Scarel, G. Seguini, M. Fanciulli, A. Zenkevich, Yu. Lebedinskii</i>	181
8.1 Introduction	181
8.2 Experimental Methodology: ALD Deposition and Characterization Techniques	183
8.3 Structural and Chemical Properties	186
8.3.1 HfO ₂ Films Deposited by ALD on Ge and GaAs Using Various Precursor Combinations	186
8.3.2 Local Epitaxy of HfO ₂ Films Grown by ALD on Ge(001) and GaAs(001)	189
8.3.3 Lu ₂ O ₃ Films Deposited by ALD on Ge and GaAs	192
8.4 Electrical Properties of High- κ Dielectrics on Ge and GaAs	194
8.4.1 Electrical Properties of High- κ Dielectrics Deposited on Ge: HfO ₂ , Al ₂ O ₃ , and Lu ₂ O ₃	194
8.4.2 Electrical Properties of High- κ Dielectrics Deposited on GaAs	197
8.5 Band Offset of High- κ Dielectrics Deposited on Ge and GaAs	198
8.6 Conclusions	201
References	202

9 Point Defects in Stacks of High- κ Metal Oxides on Ge: Contrast with the Si Case

<i>A. Stesmans, V.V. Afanas'ev</i>	211
9.1 Introduction	211
9.1.1 Previous ESR Results	215
9.2 Experimental Methodology and Samples	216
9.2.1 ESR Spectroscopy	216
9.2.2 Electrical Analysis	217
9.2.3 Samples	217

9.3	Experimental Results	217
9.3.1	Electrical Analysis	217
9.3.2	ESR Measurements	220
9.4	Discussion	223
9.5	Conclusions	225
	References	226
 10 High κ Gate Dielectrics for Compound Semiconductors		
	<i>J. Kwo, M. Hong</i>	229
10.1	Introduction	229
10.2	High κ Gate Dielectrics for GaAs and its Related Compounds: Ga ₂ O ₃ (Gd ₂ O ₃) Approach	232
10.3	Thermodynamic Stability of Ga ₂ O ₃ (Gd ₂ O ₃)/GaAs Interface at High Temperatures [26]	236
10.4	Single Crystal Gd ₂ O ₃ on GaAs and Interfaces	239
10.5	GaAs MOSFETs	242
10.5.1	Enhancement-Mode with Inversion	242
10.5.2	Depletion-Mode MOSFET and Power Devices	243
10.6	High κ Gate Dielectrics for GaAs and its Related Compounds: ALD Al ₂ O ₃ Approach and its Mechanism of Unpinning the Fermi Level [31]	246
10.7	GaN Passivation	250
10.8	Conclusion	253
	References	254
 11 Interface Properties of High-k Dielectrics on Germanium		
	<i>A. Toriumi, K. Kita, M. Toyama, H. Nomura</i>	257
11.1	Introduction	257
11.2	Experimental	258
11.3	Results and Discussion	259
11.3.1	Effect of Hf Metal Pre-deposition Prior to HfO ₂ Deposition [5]	259
11.3.2	Effects of Ge Surface Orientation	261
11.3.3	Y ₂ O ₃ and HfO ₂ on (100) Ge [9,10]	262
11.4	Conclusion	266
	References	267
 12 A Theoretical View on the Dielectric Properties of Crystalline and Amorphous High-κ Materials and Films		
	<i>V. Fiorentini, P. Delugas, A. Filippetti</i>	269
12.1	Introduction	269
12.1.1	Linear Response Theory and Dielectric Properties	270
12.2	A Crystal Selection: Dioxides, Sesquioxides, Aluminates	273
12.2.1	Multiphase and Epitaxial Transition-Metal Dioxides	273

XIV Contents

12.2.2 Sesquioxides: Lutetia, Lanthana, and the Hex–Bix Difference.....	274
12.2.3 Rare-Earth and Transition-Metal Aluminates	277
12.3 Amorphous and Alloyed Systems: Silica, Aluminates, Silicates	280
12.3.1 A Pioneering Study of Silica	280
12.3.2 Amorphous Zirconia	281
12.3.3 Conservation of Permittivity in Amorphous Lanthanide Aluminates?	283
12.3.4 Dielectric Enhancement in Aluminate Alloys	285
12.3.5 Models vs. Ab Initio Predictions in Transition-Metal Silicates	286
12.4 Local Microscopic Screening in Ultrathin Films.....	287
12.5 Conclusions.....	289
References	290
13 Germanium Nanodevices and Technology	
<i>C.O. Chui, K.C. Saraswat</i>	293
13.1 Introduction	293
13.2 Challenges to Scaling Conventional CMOS.....	293
13.3 Why High Mobility Channel?	295
13.4 Which High Mobility Channel Material?	295
13.5 Heteroepitaxial Ge Growth on Si	297
13.6 Nanoscale Gate Stacks on Germanium	300
13.6.1 Grown Germanium Oxynitride Dielectrics	300
13.6.2 Deposited High-Permittivity Dielectrics	300
13.7 Shallow Source–Drain Junctions	303
13.7.1 Ion Implantation Doping	304
13.7.2 Solid Source Diffusion Doping.....	305
13.8 Metal-Gated Germanium MOSFET Processes	306
13.8.1 The Sub-400°C Conventional P-MOSFET Process	306
13.8.2 The Simple Self-Aligned Gate-Last n-MOSFET Process	307
13.9 Conclusions.....	310
References	311
14 Opportunities and Challenges of Germanium Channel MOSFETs	
<i>H. Shang, E.P. Gusev, M.M. Frank, J.O. Chu, S. Bedell, M. Gribelyuk, J.A. Ott, X. Wang K.W. Guarini, M. Jeong</i>	315
14.1 Introduction	315
14.2 Ge Surface Channel MOSFETs	316
14.2.1 Gate Dielectric.....	316
14.2.2 Ge Surface Preparation	316
14.2.3 Dopant Diffusion and Junction Leakage	317

14.3 Strained Ge Buried Channel MOSFETs	319
14.3.1 Device Design and Scaling Prospect for Strained Ge Buried Channel Devices	320
14.3.2 Material Growth and Thermal Stability	321
14.3.3 Gate Stack for s-Ge MOSFETs	322
14.3.4 Integration of s-Ge Channel MOSFETs	323
14.4 Conclusions	329
References	330
 15 Germanium Deep-Submicron p-FET and n-FET Devices, Fabricated on Germanium-On-Insulator Substrates	
<i>M. Meuris, B. De Jaeger, J. Van Steenberghe, R. Bonzom, M. Caymax, M. Houssa, B. Kaczer, F. Leys, K. Martens, K. Opsomer, A.M. Pourghaderi, A. Satta, E. Simoen, V. Terzieva, E. Van Moorhem, G. Winderickx, R. Loo, T. Clarysse, T. Conard, A. Delabie, D. Hellin, T. Janssens, B. Onsia, S. Sioncke, P.W. Mertens, J. Snow, S. Van Elshocht, W. Vandervorst, P. Zimmerman, D. Brunco, G. Raskin, F. Letertre, T. Akatsu, T. Billon, M. Heyns</i>	333
15.1 Introduction	333
15.2 Ge Gate Stack Capacitor	334
15.3 Dopant Activation in Germanium	336
15.4 GeOI Substrates	337
15.5 Conclusions	338
References	339
 16 Processing and Characterization of III–V Compound Semiconductor MOSFETs Using Atomic Layer Deposited Gate Dielectrics	
<i>P.D. Ye, G.D. Wilk, M.M. Frank</i>	341
16.1 Introduction	341
16.2 Materials Structure and Composition	343
16.3 Electrical Characterization of ALD Al ₂ O ₃ on GaAs	346
16.4 GaAs MOSFET Fabrication and Characterization	349
16.5 InGaAs MOSFET Fabrication and Characterization	352
16.6 GaN MOS-HEMT Fabrication and Characterization	353
16.7 Conclusions	356
References	358
 17 Fabrication of MBE High-κ Mosfets in a Standard CMOS Flow	
<i>L. Pantisano, T. Conard, T. Scram, W. Deweerdt, S. De Gendt, M. Heyns, Z.M. Rittersma, C. Marchiori, M. Sousa, J. Fompeyrine, J.-P. Locquet</i>	363
17.1 Introduction	363
17.2 Device Fabrication	364
17.2.1 TEM Pictures and Salient Features	364

17.3 Device Characterization	365
17.3.1 Large Area Capacitors	366
17.3.2 Low Leakage in LHO Devices	366
17.3.3 Long-Channel MOSFET with HfO_2 as Gate Dielectric	367
17.3.4 Long-Channel MOSFET with LHO as Gate Dielectric	369
17.3.5 Performance Comparison of MBE Materials With ALD in the ASAP Flow	371
17.3.6 Threshold Voltage Instability	372
17.4 Conclusions	372
References	374
Index	375