

Table of Contents

Preface, Committees, Sponsors

Chapter 1: SiC Growth

1.1 Bulk Growth

Bulk Growth of Large Area SiC Crystals

A.R. Powell, J.J. Sumakeris, Y. Khlebnikov, M.J. Paisley, R.T. Leonard, E. Deyneka, S. Gangwal, J. Ambati, V. Tsevtkov, J. Seaman, A. McClure, C. Horton, O. Kramarenko, V. Sakhalkar, M. O'Loughlin, A.A. Burk, J.Q. Guo, M. Dudley and E. Balkas 5

Large Area 4H SiC Products for Power Electronic Devices

I. Manning, J. Zhang, B. Thomas, E. Sanchez, D. Hansen, D. Adams, G.Y. Chung, K. Moeggenborg, C. Parfeniuk, J. Quast, V. Torres and C. Whiteley 11

Using Ray Tracing Simulations for Direct Determination of Burgers Vectors of Threading Mixed Dislocations in 4H-SiC c-Plane Wafers Grown by PVT Method

J.Q. Guo, Y. Yang, F.Z. Wu, J.J. Sumakeris, R.T. Leonard, O. Goue, B. Raghathamachar and M. Dudley 15

Trials of Solution Growth of Dislocation-Free 4H-SiC Bulk Crystals

K. Danno, S. Yamaguchi, H. Kimoto, K. Sato and T. Bessho 19

Developing Technologies of SiC Gas Source Growth Method

J. Kojima, Y. Tokuda, E. Makino, N. Sugiyama, N. Hoshino, I. Kamata and H. Tsuchida 23

Limitations in Very Fast Growth of 4H-SiC Crystals by High-Temperature Gas Source Method

N. Hoshino, I. Kamata, Y. Tokuda, E. Makino, N. Sugiyama, J. Kojima and H. Tsuchida 29

High Temperature Solution Growth of SiC by the Vertical Bridgman Method Using a Metal Free Si-C-Melt at 2300 °C

L. Fahlbusch, M. Schöler, P. Mattle, S. Schnitzer, H. Khodamoradi, N. Iwamoto, B.G. Svensson and P.J. Wellmann 33

Effect of Aluminum during the High Temperature Solution Growth of Si-Face 4H-SiC

D. Chaussende, L. Parent-Bert, Y.J. Shin, T. Ouisse and T. Yoshikawa 37

150 mm 4H-SiC Substrate with Low Defect Density

Y.Q. Gao, H.Y. Zhang, Y.M. Zong, H.H. Wang, J.Q. Guo, B. Raghathamachar, M. Dudley and X.J. Wang 41

A Competitive Lattice Model Monte Carlo Method for Simulation of Competitive Growth of Different Polytypes in SiC Single Crystal

W. Huang, H.J. Guo, X. Liu, X.C. Liu, Y.Q. Zheng, J.H. Yang and E.W. Shi 45

Application of *In Situ* 3D Computed Tomography during PVT Growth of 4H-SiC for the Study of Source Material Consumption under Varying Growth Conditions

P.J. Wellmann, L. Fahlbusch, M. Salamon and N. Uhlmann 49

Characterization of Lattice Plane Bending and Stress Distribution in Physical Vapor Transport-Grown 4H-SiC Crystals

Y. Teramoto, Y. Tabuchi, D. Fukunaga, K. Ohtomo, N. Ohtani, M. Katsuno, T. Fujimoto, S. Sato, H. Tsuge and T. Yano 53

Spatial Distribution of Carrier Concentration in 4H-SiC Crystal Grown by Solution Method

Z.J. Wang, T. Kawaguchi, K. Murayama, K. Aoyagi, S. Harada, M. Tagawa, T. Sakai, T. Kato and T. Ujihara 57

Doping Fluctuation and Defect Formation in Fast 4H-SiC Crystal Growth Using a High-Temperature Gas Source Method

I. Kamata, N. Hoshino, Y. Tokuda, E. Makino, N. Sugiyama, J. Kojima and H. Tsuchida 61

Effect of Solution Drift on Crystalline Morphology in the Solution Growth of Off-Axis 4H-SiC Crystals

T. Kato, K. Kusunoki, K. Seki, N. Okada and K. Kamei 65

Effects of Hydrogen Concentration on the Growth of High Purity 4H-SiC Single Crystal Grown by Sublimation Method	69
Y.M. Wang, R.S. Wei, L.Z. Wang, K.L. Mao, B. Li and X. Dai	
Evolution of Threading Edge Dislocations at Earlier Stages of PVT Growth for 4H-SiC Single Crystals	73
K. Tani, T. Fujimoto, K. Kamei, K. Kusunoki, K. Seki and T. Yano	
Growth of Low Resistivity p-Type 4H-SiC Crystals by Sublimation with Using Aluminum and Nitrogen Co-Doping	77
K. Eto, H. Suo, T. Kato and H. Okumura	
Experimental Investigation of the Seeding Stage during SiC Solution Growth Using Si and Al-Si Solvents	81
Y.J. Shin, K. Ariyawong, B. Doisneau, J.M. Dedulle, P. Brosselard and D. Chaussende	
Influence of Impurities in SiC Powder on High Quality SiC Crystal Growth	85
S. Heo, H.R. Son, B.S. Kim, M.S. Kim, J.E. Han, D.H. Lee, K.S. Min, S.I. Kim, S. Ha and D.G. Shin	
Physical Vapor Growth of Double Position Boundary Free, Quasi-Bulk 3C-SiC on High Quality 3C-SiC on Si CVD Templates	89
P. Schuh, P. Vecera, A. Hirsch, M. Syväjärvi, G. Litrico, F. La Via, M. Mauceri and P.J. Wellmann	
Stress in SiC Single Crystal Caused by the Difference of CTE of SiC Seed and Graphite Holder and Role of the Elastic Moduli	93
A. Fadeev, A. Lebedev and Y. Tairov	
Structural Transformation from TSDs to Frank-Type Stacking Faults by Giant Bunched Steps in PVT-Grown 4H-SiC Single Crystals	97
S. Sato, T. Fujimoto, H. Tsuge, M. Katsuno, M. Nakabayashi, S. Ushio, K. Tani and T. Yano	
Sublimation Growth of 4 and 6 Inch 4H-SiC Low Defect Bulk Crystals in Ta (TaC) Crucibles	101
Y. Makarov, D. Litvin, A. Vasiliev and S. Nagalyuk	
Synchrotron X-Ray Topography Analysis of Double Shockley Stacking Faults in 4H-SiC Wafers	105
Y. Yang, J.Q. Guo, O. Goue, B. Raghothamachar, M. Dudley, G.Y. Chung, E. Sanchez, J. Quast, I. Manning and D. Hansen	
Temperature Dependent Stability of Stacking Fault in Highly Nitrogen-Doped 4H-SiC Crystals	109
C. Taniguchi, A. Ichimura, N. Ohtani, M. Katsuno, T. Fujimoto, S. Sato, H. Tsuge and T. Yano	
The Role of Porous Graphite Plate for High Quality SiC Crystal Growth by PVT Method	113
H.W. Shin, H.J. Lee, H.J. Kim, D.H. Lee, M.S. Park, Y.S. Jang, W.J. Lee, I.G. Yeo, M.C. Chun, S.H. Lee and J.G. Kim	

1.2 Epitaxial and Thin Films Growth

Advances in Fast Epitaxial Growth of 4H-SiC and Defect Reduction	119
H. Tsuchida, I. Kamata, M. Ito, T. Miyazawa, H. Uehigashi, K. Fukada, H. Fujibayashi, M. Naitou, K. Hara, H. Osawa, T. Sugiura and T. Kozawa	
Long Charge Carrier Lifetime in As-Grown 4H-SiC Epilayer	125
R. Karhu, I. Booker, I.G. Ivanov, E. Janzén and J. Hassan	
Homoepitaxial Chemical Vapor Deposition of up to 150 µm Thick 4H-SiC Epilayers in a 10×100 mm Batch Reactor	129
B. Thomas, J. Zhang, G.Y. Chung, W. Bowen, V. Torres, D. Adams, D. Hansen and E. Sanchez	
Improvement of 4H-SiC Epitaxial Layers Grown on 2° Offcut Si-Face Substrates	133
H. Asamizu, K. Yamada, K. Tamura, C. Kudou, J. Nishio, K. Masumoto and K. Kojima	
p-Type Doping of 4H- and 3C-SiC Epitaxial Layers with Aluminum	137
M. Zielinski, R. Arvinte, T. Chassagne, A. Michon, M. Portail, P. Kwasnicki, L. Konczewicz, S. Contreras, S. Juillaguet and H. Peyre	
Structural Study of the Innovative 3C-SiC/Si/3C-SiC/Si Heterostructure for Electro-Mechanical Applications	143
R. Khazaka, M. Portail, P. Vennéguès, D. Alquier and J.F. Michaud	

Stacking Fault Analysis of Epitaxial 3C-SiC on Si(001) Ridges	
M. Meduña, T. Kreiliger, I. Prieto, M. Mauceri, M. Puglisi, F. Mancarella, F. La Via, D. Crippa, L. MIGLIO and H. von Känel	147
3C-SiC Epitaxy on Deeply Patterned Si(111) Substrates	
T. Kreiliger, M. Mauceri, M. Puglisi, F. Mancarella, F. La Via, D. Crippa, W. Kaplan, A. Schöner, A. Marzegalli, L. MIGLIO and H. von Känel	151
Optimization of the Silicidation and Growth Processes for 3C-SiC Heteroepitaxy on Diamond Substrate	
V. Soulière, D. Carole and G. Ferro	155
Voids-Free 3C-SiC/Si Interface for High Quality Epitaxial Layer	
R. Anzalone, N. Piluso, R. Reitano, A. Alberti, P. Fiorenza, M. Salanitri, A. Severino, S. Lorenti, G. Arena, S. Coffa and F. La Via	159
4H-SiC(0001) Surface Faceting during Interaction with Liquid Si	
V. Soulière, D. Carole, M. Camarda, J. Woerle, U. Grossner, O. Dezellus and G. Ferro	163
Advances in 3x150 mm Hot-Wall and 6x150 mm Warm-Wall SiC Epitaxy for 10kV-Class Power Devices	
M. O'Loughlin, A. Burk, D. Tsvetkov, S. Ustin and J.W. Palmour	167
Analysis and Reduction of Stacking Faults in Fast Epitaxial Growth	
H. Uehigashi, K. Fukada, M. Ito, I. Kamata, H. Fujibayashi, M. Naitou, K. Hara, H. Osawa, T. Kozawa and H. Tsuchida	173
Design of Silicon Carbide Devices to Minimize the Impact of Variation of Epitaxial Parameters	
R. Radhakrishnan, T. Witt, S. Lee and R. Woodin	177
Effect of H₂ Carrier Gas on CVD Growth Rate for 4H-SiC Trench Filling	
S. Ji, K. Kojima, R. Kosugi, S. Saito, Y. Sakuma, Y. Matsukawa, Y. Yonezawa, S. Yoshida and H. Okumura	181
Effects of Sulfur Passivation on 6H-SiC(0001) Surface and Si/6H-SiC Interface	
X.M. He, Z.M. Chen and L.B. Li	185
Elimination of BPD in 5~30um Thick 4H-SiC Epitaxial Layers Grown in a Warm-Wall Planetary Reactor	
G. Feng, Y.Q. Sun, W.N. Qian, L.P. Lv, J.H. Zhao, D. Tsai, M. Raghunathan and Y. Fei	189
Formation and Reduction of Large Growth Pits on 100 mm 4° 4H-SiC	
Y.Q. Sun, G. Feng, J.Y. Kang, W.N. Qian, L.P. Lv, Y.Y. Li, K.X. Li and J.H. Zhao	193
Hydrogen Flux Influence on Homo-Epitaxial 4H-SiC Doping Concentration Profile for High Power Application	
R. Anzalone, M. Salanitri, S. Lorenti, A. Campione, N. Piluso, F. La Via, P. Fiorenza, C.M. Marcellino, G. Arena and S. Coffa	197
Improvement on 150 mm 4H-SiC Epitaxial Wafer Quality	
T. Masuda, A. Miyasaka, J. Norimatsu, Y. Tajima, D. Muto, K. Momose and H. Osawa	201
Optimization of VLS Growth Process for 4H-SiC P/N Junctions	
S. Sejil, M. Lazar, F. Cayrel, D. Carole, C. Brylinski, D. Planson, G. Ferro and C. Raynaud	205
Smooth 4H-SiC Epilayers Grown with High Growth Rates with Silane/Propane Chemistry Using 4° Off-Cut Substrates	
L. Lilja, J. Hassan, E. Janzén and J.P. Bergman	209
Structure of Straight-Line Defect and its Effect on the Electrical Properties of Schottky Barrier Diodes	
K. Kamei, L. Guo, K. Momose and H. Osawa	213
Study of Ehrlich-Schwoebel Barrier in 4H-SiC Epitaxial Growths by Molecular Statics Method	
H.J. Guo, W. Huang, J. Peng, R.W. Zhou, X.C. Liu, Y.Q. Zheng and E.W. Shi	217
Study of In-Plane Orientation of Epitaxial Si Films Grown on 6H-SiC(0001)	
L.B. Li and Z.M. Chen	221
Study of Triangle-Shaped Defects on Nearly On-Axis 4H-SiC Substrates	
R.W. Zhou, X.C. Liu, H.J. Guo, H.K. Kong and E.W. Shi	225
The Relationship between Surface Pits Density and Growth Parameters during the Epitaxial Growth of 4H-SiC	
W.Y. Chen, H.C. Ho, P.F. Yang and L.C. Hsia	229
Mitigation of BPD by Pre-Epigrowth High Temperature Substrate Annealing	
N.A. Mahadik, R.E. Stahlbush, E.A. Imhoff, M.J. Tadjer, G.E. Ruland and C.A. Affouda	233

Chapter 2: SiC Theory and Characterization

2.1 Fundamental and Material Properties

Determination of 4H-SiC Ionization Rates Using OBIC Based on Two-Photon Absorption	245
H. Hamad, C. Raynaud, P. Bevilacqua, S. Scharnholz, B. Vergne and D. Planson	
Electrical Transport Properties of Highly Aluminum Doped p-Type 4H-SiC	249
S. Contreras, L. Konczewicz, P. Kwasnicki, R. Arvinte, H. Peyre, T. Chassagne, M. Zielinski, M. Kayambaki, S. Juillaguet and K. Zekentes	
Density-Functional Calculation of Carbon-Interstitial Energies in a 4H-SiC(0001)-SiO₂ Interface	253
J. Lehmann	
Identifying Performance Limiting Defects in Silicon Carbide pn-Junctions: A Theoretical Study	257
J. Cottom, G. Gruber, G. Pobegen, T. Aichinger and A.L. Shluger	
Investigation of Mo Defects in 4H-SiC by Means of Density Functional Theory	261
A. Csöré, A. Gällström, E. Janzén and Á. Gali	
Magnetic Field Sensing with Atomic Scale Defects in SiC Devices	265
C.J. Cochrane, J. Blacksberg, P.M. Lenahan and M.A. Anders	
Photoluminescence of 10H-SiC	269
A. Henry, H. Yano and T. Hatayama	
Mapping the Strain State of 3C-SiC/Si (001) Suspended Structures Using μ-XRD	274
G. Colston, S.D. Rhead, V.A. Shah, O.J. Newell, I.P. Dolbnja, D.R. Leadley and M. Myronov	
Heteropolytypic Superlattices	278
J. Pezoldt	
High Temperature Variable Range Hopping in Heavy Al Implanted 4H-SiC	283
A. Parisini, A. Parisini, M. Gorni and R. Nipoti	
Optical Nuclear Spin Polarization of Divacancies in SiC	287
V. Ivády, K. Szasz, A.L. Falk, P.V. Klimov, D.J. Christle, W.F. Koehl, E. Janzén, I.A. Abrikosov, D.D. Awschalom and Á. Gali	
Boron-Implanted 3C-SiC for Intermediate Band Solar Cells	291
Q.B. Ma, A. Galeckas, A. Azarov, A. Thøgersen, P.A. Carvalho, D.N. Wright, S. Diplas, O.M. Løvvik, V. Jokubavicius, X.Y. Liu, J.W. Sun, M. Syväjärvi and B.G. Svensson	

2.2 Point and Extended Defects

Correlation of Lifetime Mapping of 4H-SiC Epilayers with Structural Defects Using Synchrotron X-Ray Topography	297
O.Y. Goue, Y. Yang, J.Q. Guo, B. Raghothamachar, M. Dudley, J.L. Hosteller, R.L. Myers-Ward, P.B. Klein and D.K. Gaskill	
Doping of 4H-SiC with Group IV Elements	301
M. Krieger, M. Rühl, T. Sledziewski, G. Ellrott, T. Palm, H.B. Weber and M. Bockstedte	
Deep Level Characterization of 5 MeV Proton Irradiated SiC PiN Diodes	308
G. Alfieri, A. Mihaila, H.M. Ayedh, B.G. Svensson, P. Hazdra, P. Godignon, J. Millan and S. Kicin	
Engineering Single Defects in Silicon Carbide Bulk, Nanostructures and Devices	312
A. Lohrmann, B.C. Johnson, A.F.M. Almutairi, D.W.M. Lau, M. Negri, M. Bosi, B.C. Gibson, J.C. McCallum, Á. Gali, T. Ohshima and S. Castelletto	
ESR Study on Hydrogen Passivation of Intrinsic Defects in p-Type and Semi-Insulating 4H-SiC	318
K. Murakami, S. Tanai, T. Okuda, J. Suda, T. Kimoto and T. Umeda	

First Principles Identification of Divacancy Related Photoluminescence Lines in 4H and 6H-SiC	
V. Ivády, K. Szasz, A.L. Falk, P.V. Klimov, E. Janzén, I.A. Abrikosov, D.D. Awschalom and Á. Gali	322
Fluorescent P-Type 4H-SiC Grown by PVT Method	
S.Y. Zhuo, X. Liu, P. Gao, W. Huang, C.F. Yan and E.W. Shi	326
Formation and Annihilation of Carbon Vacancies in 4H-SiC	
H.M. Ayedh, V. Bobal, R. Nipoti, A. Hallén and B.G. Svensson	331
Lifetime Measurement in n-Type 4H-SiC by Mean of the Microwave Phase-Shift	
B. Berenguier, O. Palais, S. Bertaina, L. Ottaviani and A. Lyoussi	337
Modelling of Effective Minority Carrier Lifetime in 4H-SiC n-Type Epilayers	
D. Kaminzky, B. Kallinger, P. Berwian, M. Rommel and J. Friedrich	341
Recombination Processes in 4H-SiC pn Structures	
A.M. Strel'chuk, B. Berenguier, E.B. Yakimov and L. Ottaviani	345
Study of Nanoscale Inhomogeneities in Silicon Carbide Crystals via Small-Angle X-Ray Scattering	
M. Logunov, V. Neverov, B. Mamin, D. Skvortsov and R. Sidorov	349
Surface Voltage and μPCD Mapping of Defect in Epitaxial SiC	
M. Wilson, A. Savtchouk, A. Findlay, J. Lagowski, P. Edelman, D. Marinskiy, J. D'Amico, F. Korsos, N. Orsos and M.C. Varga	353
Thermal Stability of Deep-Level Defects in High-Purity Semi-Insulating 4H-SiC Substrate Studied by Admittance Spectroscopy	
N. Iwamoto, A. Azarov, T. Ohshima, A.M.M. Moe and B.G. Svensson	357
Three-Dimensional Imaging of Extended Defects in 4H-SiC	
R. Tanuma, M. Nagano, I. Kamata and H. Tsuchida	361
Post-Growth Micropipe Formation in 4H-SiC	
J. Quast, M. Dudley, J.Q. Guo, D. Hansen, I. Manning, S. Mueller, B. Raghorthamachar, E. Sanchez, C. Whiteley and Y. Yang	367
Observation of Pair Structures of Threading Dislocation and Surface Defect in 4H-SiC Wafer by Mirror Projection Electron Microscopy	
T. Isshiki and M. Hasegawa	371
Mapping of Threading Screw Dislocations in 4H n-Type SiC Wafers	
A. Ellison, E. Sörman, B. Sundqvist, B. Magnusson, Y. Yang, J.Q. Guo, O. Goue, B. Raghorthamachar and M. Dudley	376
Electrical Properties of Defects in 4H-SiC Investigated by Photo-Induced-Currents Measurements	
S. Privitera, G. Litrico, M. Camarda, N. Piluso and F. La Via	380
Effects of Basal Plane Dislocation Density in 4H-SiC Substrate on Degradation of Body-Diode Forward Voltage	
N. Kawabata, A. Tanaka, M. Tsujimura, Y. Ueji, K. Omote, H. Yamaguchi, H. Matsuhata and K. Fukuda	384
Dislocations in SiC Revealed by NaOH Vapor Etching and a Comparison with X-Ray Topography Taken with Various g-Vectors	
Y.Z. Yao, Y. Ishikawa, Y. Sugawara, K. Sato, K. Danno, T. Shirai, K. Sato, T. Bessho, Y. Takahashi, Y. Yamashita and K. Hirano	389
Dislocation Characterization in 4H-SiC Crystals	
J.J. Sumakeris, R.T. Leonard, E. Deyneka, Y. Khlebnikov, A.R. Powell, J. Seaman, M.J. Paisley, V. Tsevtkov, J.Q. Guo, Y. Yang, M. Dudley and E. Balkas	393
Cross Section and Plan View STEM Analysis on Identical Conversion Point of Basal Plane Dislocation to Threading Edge Dislocation of 4H-SiC	
T. Sato, Y. Orai, T. Isshiki, M. Fukui and K. Nakamura	397
Characterization of Threading Screw Dislocations of Burgers Vectors with A-Components in 4H-SiC	
S. Onda, T. Okamoto, H. Uehigashi, H. Kondo and H. Saka	401
Characterization of 4H-SiC PiN Diodes Formed on Defects Identified by PL Imaging	
Y. Bonyadi, P.M. Gammon, R. Bonyadi, V.A. Shah, C.A. Fisher, D.M. Martin and P.A. Mawby	405
Bipolar Degradation of 6.5 kV SiC pn-Diodes: Result Prediction by Photoluminescence	
L. Wehrhahn-Kilian, K.O. Dohnke, D. Kaminzky, B. Kallinger and S. Oppel	410

Controlling the Carbon Vacancy Concentration in 4H-SiC Subjected to High Temperature Treatment

H.M. Ayedh, R. Nipoti, A. Hallén and B.G. Svensson 414

Ion Implantation Defects in 4H-SiC DIMOSFET

E. Fontana, N. Piluso, A. Russo, S. Lorenti, C.M. Marcellino, S. Coffa and F. La Via 418

An Ultrafast I-V Measurement Technique Accounting for Capacitive and Leakage Currents in Reverse Mode for SiC Power Devices

J.B. Fonder, P. Brosselard, D. Tournier, M. Berthou and B. Vergne 422

2.3 Surfaces and Interfaces

4H-SiC Surface Structures and Oxidation Mechanism Revealed by Using First-Principles and Classical Molecular Dynamics Simulations

T. Yamasaki, N. Tajima, T. Kaneko, N. Nishikawa, J. Nara, T. Schimizu, K. Kato and T. Ohno 429

A Novel Approach to Analysis of F-N Tunneling Characteristics in MOS Capacitor Having Oxide Thickness Fluctuation

K. Yamada, J. Senzaki, K. Kojima and H. Okumura 433

Accuracy of the Energy Distribution of the Interface States at the SiO₂/SiC Interface by Conductance Method

M. Noguchi, T. Iwamatsu, H. Amishiro, H. Watanabe, S. Nakata, T. Kuroiwa and S. Yamakawa 437

Analysis of Gate Oxide Nitridation Effect on SiC MOSFETs by Using Hall Measurement and Split C-V Measurement

M. Tsujimura, H. Kitai, H. Shiomi, K. Kojima, K. Fukuda, K. Sakamoto, K. Yamasaki, S. Takagi and H. Okumura 441

Cathodoluminescence Study of SiO₂/4H-SiC Structures Treated with High-Temperature Post-Oxidation Annealing

A. Chanthaphan, Y. Fukushima, K. Yamamoto, M. Aketa, H. Asahara, T. Nakamura, T. Hosoi, T. Shimura and H. Watanabe 445

Characterization of Thermally Oxidized SiO₂/SiC Interfaces by Leakage Current under High Electric Field, Cathode Luminescence (CL), X-Ray Photoelectron Spectroscopy (XPS) and High-Resolution Rutherford Backscattering Spectroscopy (HR-RBS)

Y. Kiuchi, H. Kitai, H. Shiomi, M. Tsujimura, D. Nakata, S. Harada, Y. Yonezawa, K. Fukuda, K. Sakamoto, K. Yamasaki, H. Yano and H. Okumura 449

Dipole Type Behavior of NO Grown Oxides on 4H-SiC

D. Haasmann, H.A. Moghadam, J.S. Han, A. Aminbeidokhti, A. Iacopi and S. Dimitrijev 453

Importance of SiC Stacking to Interlayer States at the SiC/SiO₂ Interface

C.J. Kirkham and T. Ono 457

Measurement Issues Affecting Threshold-Voltage Instability Characterization of SiC MOSFETs

R. Green, A. Lelis and D.B. Habersat 461

Mechanisms of Nitrogen Incorporation at 4H-SiC/SiO₂ Interface during Nitric Oxide Passivation – A First Principles Study

D. Ettiserry, N. Goldsman, A. Akturk and A. Lelis 465

Nondestructive and Local Evaluation of SiO₂/SiC Interface Using Super-Higher-Order Scanning Nonlinear Dielectric Microscopy

N. Chinone, R. Kosugi, Y. Tanaka, S. Harada, H. Okumura and Y. Cho 469

On the Origin of Threshold Voltage Instability under Operating Conditions of 4H-SiC n-Channel MOSFETs

G. Pobegen, J. Weisse, M. Hauck, H.B. Weber and M. Krieger 473

Pragmatic Approach to the Characterization of SiC/SiO₂ Interface Traps near the Conduction Band with Split C-V and Hall Measurements

T. Hatakeyama, K. Takao, Y. Yonezawa and H. Yano 477

Threshold Voltage Instabilities of Present SiC-Power MOSFETs under Positive Bias Temperature Stress

G. Rescher, G. Pobegen and T. Grasser 481

Failure Analysis of a SiC MOS Capacitor with a Poly-Si Gate Electrode

S. Sato, K. Yamabe, T. Endoh and M. Niwa 485

Ultra-Fast SiC Wafer Surface Roughness Mapping

Y. Nakano, Y. Asakawa, H. Seki, J. Seaman and A.A. Burk 489

Photoluminescence Enhancement in Nanotextured Fluorescent SiC Passivated by Atomic Layer Deposited Al₂O₃ Films	493
W.F. Lu, Y.Y. Ou, V. Jokubavicius, A. Fadil, M. Syväjärvi, V. Buschmann, S. Rüttinger, P.M. Petersen and H.Y. Ou	
Junction Barrier Schottky (JBS) Rectifier Interface Engineering Facilitated by Two-Dimensional (2D) Dopant Imaging	497
H. ROSSMANN, U. Gysin, A. Bubendorf, T. Glatzel, S.A. Reshanov, A. Zhang, A. Schöner, T.A. Jung, E. Meyer and H. Bartolf	
Concentration Profile Simulation of SiC/Si Heterostructures	501
J. Pezoldt, V.S. Kharlamov, D.V. Kulikov, M.N. Lubov and Y.V. Trushin	
Development of the Compact Furnace for the <i>In Situ</i> Observation under Ultra-High Temperature by Synchrotron x-Ray Surface Diffraction	505
M. Yoshida, Y. Kutsuma, D. Dohjima, K. Ohwada, T. Inami, N. Ohtani, T. Kaneko and J. Mizuki	
Accurate Doping Density Determination in SiC with Constant Surface Potential Corona Charging; Industry Ready Alternative to Hg-CV	509
A. Savtchouk, M. Wilson, J. Lagowski, A. Czett and C. Buday	
A Surprising Result: “Bulk” SiC Defects in the Negative Bias Instability in 4H-SiC MOSFETs	513
M.A. Anders, P.M. Lenahan and A. Lelis	

Chapter 3: SiC Processing

3.1 Doping, Implantation and Contacts

1950°C Annealing of Al⁺ Implanted 4H-SiC: Sheet Resistance Dependence on the Annealing Time	523
R. Nipoti, A. Parisini, S. Vantaggio, G. Alfieri, A. Carnera, E. Centurioni, E. Ivan and U. Grossner	
Al Doping from Laser Irradiated Al Film Deposited on 4H-SiC	527
A. Ikeda, R. Sumina, H. Ikenoue and T. Asano	
Alternative Highly Homogenous Drift Layer Doping for 650 V SiC Devices	531
R. Rupp, W. Schustereder, T. Höchbauer, R. Kern, M. Rüb, C. Csato, F. Krippendorf, S. Akhmadaliev and J. von Borany	
High Efficiency Activation of Phosphorus Atoms in 4H-SiC by Atmospheric Pressure Thermal Plasma Jet Annealing	535
H. Hanafusa, K. Maruyama, R. Ishimaru and S. Higashi	
Silicon Carbide Recrystallization Mechanism by Non-Equilibrium Melting Laser Anneal	540
F. Mazzamuto, S. Halty and Y. Mori	
Warpage Structure of 4H-SiC after Implantation and Annealing Processes	544
K. Ishiji, S. Kawado, Y. Hirai and S. Nagamachi	
Low Resistance Ohmic Contact Formation on 4H-SiC C-Face with NbNi Silicidation Using Nanosecond Laser Annealing	549
W. De Silva, S. Ishikawa, T. Kikkawa and S. Kuroki	
Thermally Stable Ohmic Contact to p-Type 4H-SiC Based on Ti₃SiC₂ Phase	553
T. Abi-Tannous, M. Soueidan, G. Ferro, M. Lazar, C. Raynaud, B. Gardiola and D. Planson	
Ohmic Contact Reliability of Commercially Available SiC MOSFETs Isothermally Aged for Long Periods at 300°C in Air	557
D. Hamilton, S.A. Hindmarsh, S. York, D. Walker, S. Russell, M.R. Jennings, C.A. Fisher and P.A. Mawby	
Ohmic Contact for Silicon Carbide by Carbon Nanotubes	561
M. Inaba, K. Suzuki, Y. Hirano, W. Norimatsu, M. Kusunoki and H. Kawarada	
Low Thermal Budget Ohmic Contact Formation by Laser Anneal	565
F. Mazzamuto, S. Halty, H. Tanimura and Y. Mori	
Impact of Contact Material Deposition Technique on the Properties of Ti/4H-SiC Schottky Structures	569
L. Stöber, M. Schneider and U. Schmid	

4H-SiC nMOSFETs with As-Doped S/D and NbNi Silicide Ohmic Contacts H. Nagatsuma, S. Kuroki, W. De Silva, S. Ishikawa, T. Maeda, H. Sezaki, T. Kikkawa, M. Östling and C. Zetterling	573
An Investigation of SiC Schottky Contact Barrier Inhomogeneity for Temperature Sensing Applications G. Pristavu, G. Brezeanu, M. Badila, F. Draghici, R. Pascu and F. Craciunoiu	577
3.2 MOS Processing, SiC-SiO₂ Interfaces and Other Dielectrics	
Threshold-Voltage Instability in SiC MOSFETs Due to Near-Interfacial Oxide Traps A. Lelis, R. Green and D.B. Habersat	585
Relationship between C-Face Defects and Threshold-Voltage Instability in C-Face 4H-SiC MOSFETs Studied by Electrically Detected Magnetic Resonance G.W. Kim, R. Arai, S.J. Ma, M. Okamoto, H. Yoshioka, S. Harada, T. Makino, T. Ohshima and T. Umeda	591
Negative Bias Temperature Instability of SiC MOSFET C.T. Yen, H.T. Hung, C.C. Hung, C.Y. Lee, H.Y. Lee, L.S. Lee, Y.F. Huang, C.Y. Cheng, P.J. Chuang and F.J. Hsu	595
Impact of NO Annealing on Flatband Voltage Instability due to Charge Trapping in SiC MOS Devices Y. Katsu, T. Hosoi, Y. Nanen, T. Kimoto, T. Shimura and H. Watanabe	599
Quantified Density of Active near Interface Oxide Traps in 4H-SiC MOS Capacitors H.A. Moghadam, S. Dimitrijev, J.S. Han, A. Aminbeidokhti and D. Haasmann	603
Impact of Al Doping Concentration at Channel Region on Mobility and Threshold Voltage Instability in 4H-SiC Trench N-MOSFETs K. Kutsuki, S. Kawaji, Y. Watanabe, M. Tsujimura, T. Onishi, H. Fujiwara, K. Yamamoto and T. Kanemura	607
Time Resolved Gate Oxide Stress of 4H-SiC Planar MOSFETs and NMOS Capacitors M. Domeij, B. Buono, K. Gummelius and F. Allerstam	611
Time Dependent Dielectric Breakdown in High Quality SiC MOS Capacitors Z. Chbili, K.P. Cheung, J.P. Campbell, J. Chbili, M. Lahbabí, D.E. Ioannou and K. Matocha	615
Microscopic Difference between Dry and Wet Oxidations of C-Face 4H-SiC MOSFETs Studied by Electrically Detected Magnetic Resonance Y. Kagoyama, M. Okamoto, S. Harada, R. Arai and T. Umeda	619
High Temperature Nitridation of 4H-SiC MOSFETs H. Rong, Y.K. Sharma, T.X. Dai, F. Li, M.R. Jennings, S. Russell, D.M. Martin and P.A. Mawby	623
Improvement of SiO₂/4H-SiC Interface Quality by Post-Oxidation Annealing in N₂ at High-Temperatures A. Chanthaphan, Y.H. Cheng, T. Hosoi, T. Shimura and H. Watanabe	627
Analytical Evaluation of Thermally Oxidized and Deposited Dielectric in NMOS-PMOS devices M.H. Weng, M.I. Idris, H.K. Chan, A.E. Murphy, D.A. Smith, D.T. Clark, R.A.R. Young, E.P. Ramsay and A.B. Horsfall	631
Effect of Activation Annealing and Reactive Ion Etching on MOS Channel Properties of (11-20) Oriented 4H-SiC S. Chowdhury, K. Yamamoto and T.P. Chow	635
Systematic Investigation of 4H-SiC Trench Properties Dependence on Channel Concentration, Crystallographic Plane, and MOS Interface Treatment H. Kitai, T. Hatayama, H. Tamaso, S. Kyogoku, T. Masuda, H. Shiomi, S. Harada and K. Fukuda	639
Influence of Oxide Processing on the Defects at the SiC-SiO₂ Interface Measured by Electrically Detected Magnetic Resonance G. Gruber, T. Aichinger, G. Pobegen, D. Peters, M. Koch and P. Hadley	643
Investigation of the Interface Quality and Reliability of 4H-SiC MOS Structure with NO and Forming Gas Annealing Treatment Z.Y. Peng, Y.Y. Wang, H.J. Shen, Y. Bai, Y.D. Tang, J. Wu, C. Li, K. Liu and X.Y. Liu	647
High Channel Mobility 4H-SiC MOSFETs by As and P Implantation Prior to Thermal Oxidation in N₂O Atmosphere A.I. Mikhaylov, S.A. Reshanov, A. Schöner, A.V. Afanasyev, V.V. Luchinin, L. Knoll, R.A. Minamisawa, G. Alfieri and H. Bartolf	651

Irradiation and Post-Annealed nMOSFETs with Al Implanted P-Well: Limit of Robustness	
M. Cabello, M. Florentin, M. Alexandru, B. Schmidt, J. Rebollo, J. Montserrat, J. Millan and P. Godignon	655
X-Ray Irradiation on 4H-SiC MOS Capacitors Processed under Different Annealing Conditions	
M. Vivona, P. Fiorenza, S. Di Franco, C. Marcandella, M. Gaillardin, S. Girard and F. Roccaforte	659
Processing and Characterization of MOS Capacitors Fabricated on 2°-Off Axis 4H-SiC Epilayers	
M. Vivona, P. Fiorenza, T. Sledziewski, A. Gkanatsiou, M. Krieger, T. Chassagne, M. Zielinski and F. Roccaforte	663
Improved Channel Mobility by Oxide Nitridation for N-Channel MOSFET on 3C-SiC(100)/Si	
F. Li, Y.K. Sharma, M.R. Jennings, A. Pérez-Tomás, V.A. Shah, H. Rong, S. Russell, D.M. Martin and P.A. Mawby	667
High-Mobility SiC MOSFETs with Alkaline Earth Interface Passivation	
D.J. Lichtenwalner, V. Pala, B. Hull, S. Allen and J.W. Palmour	671
Alkali Metal Re-Distribution after Oxidation of 4H-SiC	
M.K. Linnarsson, S.S. Suvanam, L. Vines and A. Hallén	677
Flatband Voltage Shift Depending on SiO₂/SiC Interface Charges in 4H-SiC MOS Capacitors with AlON/SiO₂ Stacked Gate Dielectrics	
T. Hosoi, S. Azumo, K. Yamamoto, M. Aketa, Y. Kashiwagi, S. Hosaka, H. Asahara, T. Nakamura, T. Shimura and H. Watanabe	681
Atomic Layer Deposition of Al₂O₃ Thin Films for Metal Insulator Semiconductor Applications on 4H-SiC	
E. Schilirò, S. Di Franco, P. Fiorenza, C. Bongiorno, H. Gargouri, M. Saggio, R. Lo Nigro and F. Roccaforte	685
Investigation of Interface State Density with Varied SiO₂ Thickness in La₂O₃/SiO₂/4H-SiC MOS Capacitors	
Y.C. Wang, Y.M. Zhang and R.X. Jia	689
Interface Analysis of P-Type 4H-SiC/Al₂O₃ Using Synchrotron-Based XPS	
S.S. Suvanam, M.G. Yazdi, M. Usman, M. Götelid and A. Hallén	693
Passivation and Generation of States at P-Implanted Thermally Grown and Deposited N-Type 4H-SiC/SiO₂ Interfaces	
T. Sledziewski, H.B. Weber and M. Krieger	697
Impact of Phosphorus Implantation on the Electrical Properties of SiO₂/4H-SiC Interfaces Annealed in N₂O	
P. Fiorenza, S. Di Franco, F. Giannazzo, S. Rascunà, M. Saggio and F. Roccaforte	701
Conduction Mechanisms at SiO₂/4H-SiC Interfaces in MOS-Based Devices Subjected to Post Deposition Annealing in N₂O	
P. Fiorenza, F. Giannazzo, A. Frazetto, A. Guarnera, M. Saggio and F. Roccaforte	705

3.3 Etching, Passivation, Cutting and Other Machining

3C-SiC Microdisks for Visible Photonics	
M. Radulaski, T. Babinec, J.Y.L. Zhang, S. Buckley, Y. Kelaita, K. Müller, K. Lagoudakis, K. Alissaad, G. Ferro and J. Vučković	711
Etching Rate Behavior of 4H-Silicon Carbide Epitaxial Film Using Chlorine Trifluoride Gas	
A. Hirooka, H. Habuka and T. Kato	715
Development of “Si-Vapor Etching” and “Si Vapor Ambient Anneal” in TaC/Ta Composite Materials	
N. Yabuki, S. Torimi, S. Nogami, M. Kitabatake and T. Kaneko	719
Novel 3C-SiC Microstructure for MEMS Applications	
J.F. Michaud, M. Portail, R. Khazaka, M. Zielinski, T. Chassagne and D. Alquier	723

Chapter 4: SiC Devices

4.1 Diodes (SBDs, JBS, PiN, ...)

Study of 4H-SiC Junction Barrier Schottky(JBS) Diode Using Various Junction Structures K.H. Kim, Y.H. Kang, J.H. Lee, E.S. Jung, I.H. Kang and C.H. Yang	733
Design of Area-Efficient, Robust and Reliable Junction Termination Extension in SiC Devices A. Bolotnikov, P.A. Losee, P. Deeb, M.L. Wang, G. Dunne, J. Kretchmer, S. Arthur and L. Stevanovic	737
Modeling of Inhomogeneous 4H-SiC Schottky and JBS Diodes in a Wide Temperature Range B. Asllani, M. Berthou, D. Tournier, P. Brosselard and P. Godignon	741
Optimum Design of 4H-SiC Junction Barrier Schottky Diode with Consideration of the Anisotropic Impact Ionization H.P. Jiang, M.L. Ke, Y.K. Sharma, X.P. Dai, I. Deviny and C.W. Zheng	745
Anomalous Scatter of Forward Current-Voltage Characteristics of He⁺-Irradiated Ni/4H-SiC Schottky Diodes A.M. Strel'chuk, V.V. Zelenin, A.N. Kuznetsov, J. Tringe, A.V. Davydov and A.A. Lebedev	749
Epitaxial Layer Thickness Dependence on Heavy Ion Induced Charge Collection in 4H-SiC Schottky Barrier Diodes T. Makino, S. Onoda, N. Hoshino, H. Tsuchida and T. Ohshima	753
Comparison of 2.5D and 3D Simulation Methods for Limiting Electrode Debiasing of 4H-SiC Interdigitated Devices N. Thierry-Jebali, T. Kempf and F. Mandorlo	757
Electrical Performance of 4H-SiC Based Drift Step Recovery Diodes P.A. Ivanov, O. Kon'kov, T. Samsonova, A. Potapov and I. Grekhov	761
Low Resistivity SiC Devices with a Drift Layer Optimized by Variational Approach T. Tominaga, N. Kawabata, A. Koyama, T. Tanaka, H. Watanabe, N. Tomita, N. Miura, T. Kuroiwa and S. Yamakawa	765
A New Type of Single Carrier Conduction Rectifier on SiC S. Tanimoto, K. Ueoka, T. Fujita, S. Araki, K. Kojima, T. Makino and S. Yamasaki	769
Forward Current of Al⁺ Implanted 4H-SiC Diodes: A Study on Periphery and Area Components M. Puzzanghera and R. Nipoti	773
Silicon Carbide Schottky Rectifiers with Improved Avalanche Ruggedness A. Konstantinov, S. Jinman, S. Young, B. Lee, F. Allerstam, T. Neyer and S. Akram	777
Optimization of 1700V 4H-SiC JBS Diode Parameters R.K. Sharma, P. Hazdra, S. Popelka, A. Mihaila and H. Bartolf	782
High-Voltage Ultra-Fast Pulse Diode Stack Based on 4H-SiC V.A. Ilyin, A.V. Afanasyev, B.V. Ivanov, A.F. Kardo-Sysoev, V.V. Luchinin, S.A. Reshanov, A. Schöner, K.A. Sergushichev and A.A. Smirnov	786
High Voltage Diffusion-Welded Stacks on the Basis of SiC Schottky Diodes O. Korolkov, N. Sleptsuk, P. Annus, R. Land and T. Rang	790

4.2 MOSFETs

Wide Band Gap Semiconductor Technology for Energy Efficiency A. Agarwal, W.J. Sung, L. Marlino, P. Gradzki, J. Muth, R. Ivester and N. Justice	797
Advanced SiC Power MOSFETs Manufactured on 150mm SiC Wafers K. Matocha, S. Banerjee and K. Chatty	803
Short Circuit Robustness of 1200 V SiC Junction Transistors and Power MOSFETs S.G. Sundaresan, B. Grummel and R. Singh	807
Repetitive Short-Circuit Tests on SiC VMOS Devices M. Berthou, P. Bevilacqua, J.B. Fonder and D. Tournier	812
Comparative Simulation Study of Dynamic Behavior of the Body-Diode for 4H-SiC JFET and MOSFET R. Elpelt, B. Zippelius and D. Domes	817

Potential of 4H-SiC CMOS for High Temperature Applications Using Advanced Lateral p-MOSFETs	
M. Albrecht, T. Erlbacher, A.J. Bauer and L. Frey	821
Analytical Description of the Input Capacitance of 4H-SiC DMOSFET's in Presence of Oxide-Semiconductor Interface Traps	
G.D. Licciardo, L. di Benedetto and S. Bellone	825
Characteristics of High-Threshold-Voltage Low-Loss 4H-SiC MOSFETs with Improved MOS Cell Structure	
Y. Ebiike, T. Tanioka, M. Furuhashi, A. Osawa and M. Imaizumi	829
V_T in SiC MOSFETs	
D.B. Habersat, A. Lelis, R. Green and M. El	833
The Influence of Surface Pit Shape on 4H-SiC MOSFETs Reliability under High Temperature Bias Tests	
K. Uchida, T. Hiyoshi, T. Nishiguchi, H. Yamamoto, S. Matsukawa, M. Furumai and Y. Mikamura	840
Si/SiC Substrates for the Implementation of Linear-Doped Power LDMOS Studied with Device Simulation	
C.W. Chan, Y. Bonyadi, P.A. Mawby and P.M. Gammon	844
Trench-MOSFETs on 4H-SiC	
C.T. Banzhaf, S. Schwaiger, D. Scholten, S. Noll and M. Grieb	848
SiC Power Switches Evaluation for Space Applications Requirements	
P. Godignon, S. Massetti, X. Jordà, V. Soler, J. Moreno, D. Lopez and E. Maset	852
Effect of Electron Irradiation on 1700V 4H-SiC MOSFET Characteristics	
S. Popelka and P. Hazdra	856
Change in Characteristics of SiC MOSFETs by Gamma-Ray Irradiation at High Temperature	
T. Matsuda, T. Yokoseki, S. Mitomo, K. Murata, T. Makino, H. Abe, A. Takeyama, S. Onoda, Y. Tanaka, M. Kandori, T. Yoshie, Y. Hijikata and T. Ohshima	860
Characterization of 4H-SiC nMOSFETs in Harsh Environments, High-Temperature and High Gamma-Ray Radiation	
S. Kuroki, H. Nagatsuma, W. De Silva, S. Ishikawa, T. Maeda, H. Sezaki, T. Kikkawa, T. Makino, T. Ohshima, M. Östling and C. Zetterling	864
Gamma-Ray Irradiation Response of the Motor-Driver Circuit with SiC MOSFETs	
Y. Kobayashi, T. Yokozeki, T. Matsuda, S. Mitomo, K. Murata, M. Hachisuka, Y. Kaneko, T. Makino, A. Takeyama, S. Onoda, T. Ohshima, Y. Tanaka, M. Kandori, T. Yoshie and Y. Hijikata	868
Avalanche Capabilities of Commercial 1200 V 4H-SiC Power MOSFETs	
C. Di Marino and B. Hull	872
High Performance 1.2kV-2.5kV 4H-SiC MOSFETs with Excellent Process Capability and Robustness	
P.A. Losee, A. Bolotnikov, S. Kennerly, C. Collazo-Davila, D. Lilienfeld, G. Dunne, T. Gorczyca, P. Deeb, J. Kretchmer, D. Esler and L. Stevanovic	876
Using SiC MOSFET's Full Potential – Switching Faster than 200 kV/μs	
O. Kreutzer, T. Heckel and M. Maerz	880
Electrical Characterization of 1.2 kV-Class SiC MOSFET at High Temperature up to 380°C	
Y. Nanen, M. Aketa, Y. Nakano, H. Asahara and T. Nakamura	885
Design and Economic Considerations to Achieve the Price Parity of SiC MOSFETs with Silicon IGBTs	
W.J. Sung and B.J. Baliga	889
Readiness of SiC MOSFETs for Aerospace and Industrial Applications	
L. Stevanovic, P.A. Losee, S. Kennerly, A. Bolotnikov, B. Rowden, J. Smolenski, M. Harfman-Todorovic, R. Datta, S. Arthur, D. Lilienfeld, T. Schuetz, F. Carastro, F.F. Tao, D. Esler, R. Raju, G. Dunne, P. Cioffi and L.C. Yu	894

4.3 Other Transistors (JFETs, BJT, ...)

Experimental and Theoretical Study of 4H-SiC JFET Threshold Voltage Body Bias Effect from 25 °C to 500 °C	
P.G. Neudeck, D.J. Spry and L.Y. Chen	903

Processing and Prolonged 500 °C Testing of 4H-SiC JFET Integrated Circuits with Two Levels of Metal Interconnect	
D.J. Spry, P.G. Neudeck, L.Y. Chen, D. Lukco, C.W. Chang, G.M. Beheim, M.J. Krasowski and N.F. Prokop	908
Modelling of 4H-SiC VJFETs with Self-Aligned Contacts	
K. Zekentes, K. Vassilevski, A. Stavrinidis, G. Konstantinidis, M. Kayambaki, K. Vamvoukakis, E. Vassakis, H. Peyre, N. Makris, M. Bucher, P. Schmid, D. Stefanakis and D. Tassis	913
Conduction Loss Reduction for Bipolar Injection Field-Effect-Transistors (BIFET)	
A. Hürner, H. Mitlehner, T. Erlbacher, A.J. Bauer and L. Frey	917
A 500 °C Monolithic SiC BJT Latched Comparator	
Y. Tian, L. Lanni, A. Rusu and C. Zetterling	921
Design Impact on the Static and Short-Circuit Characteristics of SiC-SIT with Non-Uniformly Doped Channel	
S.Q. Niu, M. Berthou and D. Tournier	925
Current Gain Stability of SiC Junction Transistors Subjected to Long-Duration DC and Pulsed Current Stress	
S.G. Sundaresan, B. Grummel and R. Singh	929
Comparison of Energy Losses in High-Current 1700 V Switches	
S.G. Sundaresan, B. Grummel and R. Singh	933

4.4 HV Devices

6.5 kV n-Channel 4H-SiC IGBT with Low Switching Loss Achieved by Extremely Thin Drift Layer	
N. Watanabe, H. Yoshimoto, A. Shima, R. Yamada and Y. Shimamoto	939
An Analysis of Forward Conduction Characteristics of Ultra High Voltage 4H-SiC N-IGBTs	
S.H. Ryu, C. Capell, C. Jonas, M. O'Loughlin, J. Clayton, K. Lam, E. Van Brunt, Y. Lemma, J. Richmond, D. Grider, S. Allen and J.W. Palmour	945
Electro-Thermal TCAD Model for 22 kV Silicon Carbide IGBTs	
M. Hinojosa, A. Ogunniyi, S. Bayne, E. Van Brunt and S.H. Ryu	949
4H-SiC n-Channel DMOS IGBTs on (0001) and (000-1) Oriented Lightly Doped Free-Standing Substrates	
S. Chowdhury, C.W. Hitchcock, R.P. Dahal, I. Bhat and T.P. Chow	954
Geometrical Effect Dependency on the On-State Characteristics in 5.6 kV 4H-SiC BJTs	
A. Salemi, H. Elahipanah, C. Zetterling and M. Östling	958
3300V-Class 4H SiC Implantation-Epitaxial Mosfets with Low Specific On-Resistance of 11.6mΩcm² and High Avalanche Withstanding Capability	
T. Tsuji, H. Shiomi, N. Ohse, Y. Onishi and K. Fukuda	962
Improved Simulation Models for Designing Novel Edge Termination and Current Spreading Layers for 3300-V-Class 4H-SiC Implantation–Epitaxial MOSFETs with Low On-Resistance and Robustness	
H. Shiomi, T. Tsuji, N. Ohse, Y. Onishi and K. Fukuda	966
Silicon Carbide MOSFETs for Medium Voltage Megawatt Scale Systems	
V. Pala, E. Van Brunt, B. Hull, S. Allen and J.W. Palmour	970
3.3 kV-Class 4H-SiC UMOSFET by Double-Trench with Tilt Angle Ion Implantation	
Y. Kobayashi, S. Harada, H. Ishimori, S. Takasu, T. Kojima, K. Ariyoshi, M. Sometani, J. Senzaki, M. Takei, Y. Tanaka and H. Okumura	974
Modification of Etched Junction Termination Extension for the High Voltage 4H-SiC Power Devices	
H. Elahipanah, A. Salemi, C. Zetterling and M. Östling	978
Vertical Termination Filled with Adequate Dielectric for SiC Devices in HVDC Applications	
T.T.H. Nguyen, M. Lazar, J.L. Augé, H. Morel, L.V. Phung and D. Planson	982
High Performance of 5.7kV 4H-SiC JBSs with Optimized Non-Uniform Field Limiting Rings Termination	
H. Yuan, Q.W. Song, X.Y. Tang, Y.M. Zhang, H. Guo, Y.H. Wang, Y.M. Zhang, R.X. Jia and Y.M. Zhang	986

4.5 Other Devices (Sensors, Detectors, ...)

NO_x Sensing with SiC Field Effect Transistors P. Möller, M. Andersson, A. Lloyd Spetz, J. Puustinen, J. Lappalainen and J. Eriksson	993
Exploring the Gas Sensing Performance of Catalytic Metal/Metal Oxide 4H-SiC Field Effect Transistors D. Puglisi, J. Eriksson, M. Andersson, J. Huotari, M. Bastuck, C. Bur, J. Lappalainen, A. Schuetze and A. Lloyd Spetz	997
Comparison of Bottom-Up and Top-Down 3C-SiC NWFETs J.H. Choi, E. Bano, A. Henry, G. Attolini and K. Zekentes	1001
DNA Detection Using SiC Nanowire Based Transistor E. Bano, L. Fradetal, V. Stambouli and G. Attolini	1006
SiC for Biomedical Applications S.E. Saddow, C.L. Frewin, F. Araujo Cespedes, M. Gazziro, E. Bernadin and S. Thomas	1010
Ni₂Si/4H-SiC Schottky Photodiodes for Ultraviolet Light Detection M. Mazzillo, A. Sciuto, F. Roccaforte, C. Bongiorno, R. Modica, S. Marchese, P. Badalà, D. Calì, F. Patanè, B. Carbone, A. Russo and S. Coffa	1015
Large Area Visible Blind 4H-SiC p+/N UV Photodiode Obtained by Aluminium Implantation A. Sciuto, M. Mazzillo, S. Di Franco and F. Roccaforte	1019
Large Area Silicon Carbide Photodiode, and Monolithic Readout Design and Fabrication A. Akturk, B. Cusack and N. Goldsman	1023
Solar Driven Energy Conversion Applications Based on 3C-SiC J.W. Sun, V. Jokubavicius, L. Gao, I. Booker, M. Jansson, X.Y. Liu, J.P. Hofmann, E.J.M. Hensen, M.K. Linnarsson, P.J. Wellmann, I. Ramiro, A. Martí, R. Yakimova and M. Syväjärvi	1028
Ion Implanted 4H-SiC UV Pin-Diodes for Solar Radiation Detection – Simulation and Characterization C.D. Matthus, T. Erlbacher, A. Burenkov, A.J. Bauer and L. Frey	1032
Structural Optimization of 4H-SiC BJT for Ultraviolet Detection with High Optical Gain Y. Bai, C. Li, H.J. Shen, Y.D. Tang and X.Y. Liu	1036

4.6 Package, Circuits and Applications

History and Recent Developments of Packaging Technology for SiC Power Devices K.O. Dohnke, K. Guth and N. Heuck	1043
Reliability Evaluation of SiC Power Device Package Used Heat-Resistant Molding Plastic by Power Cycle Test T. Funaki and A. Yasui	1049
Studies on Floating Contact Press-Pack Diodes Surge Current Capability V. Banu, M. Berthou, J. Montserrat, X. Jordà, J. Millan and P. Godignon	1053
Impact of Package Parasitics on Switching Performance K. Kostov, J.K. Lim, Y.F. Zhang and M. Bakowski	1057
Investigation of Pressure Dependent Thermal Contact Resistance between Silver Metallized SiC Chip and Molybdenum Substrate and between Molybdenum Substrate and Bulk Copper Z. Toth-Pal, Y.F. Zhang, H.P. Nee and M. Bakowski	1061
Development of a Wire-Bonding-Less SiC Power Module Operating over a Wide Temperature Range S. Sato, H. Tanisawa, T. Anzai, H. Takahashi, Y. Murakami, F. Kato, K. Watanabe and H. Sato	1066
SPICE Modeling of Advanced Silicon Carbide High Temperature Integrated Circuits A. Akturk, N. Goldsman, A. Ahyi, S. Dhar, B. Cusack and M. Park	1070
Development of a PSpice Model for SiC MOSFET Power Modules D. Johannesson and M. Nawaz	1074
High-Temperature Transient Thermal Analysis for SiC Power Modules F. Kato, H. Nakagawa, H. Yamaguchi and H. Sato	1078

Utilization of SiC MOSFETs in Voltage Source Inverter of Inductive Power Transfer Systems for Enduring Capacitive Loads	1082
G. Kampitsis, E. Gati, S. Papathanassiou and S.N. Manias	
Application of 25mΩ SiC MOSFETs in a 10kVA Grid-Connected AC/DC Converter	1087
S. Piasecki, J. Rabkowski and M.P. Kaźmierkowski	
A Highly Efficient 3.3-kV SiC-Si Hybrid Power Module with a Novel SiC JBS Diode and a Si Advanced Trench HiGT	
R. Yamada, N. Kameshiro, Y. Toyota, T. Hirao, K. Yasui, H. Onose, K. Mochizuki, H. Miki, N. Yokoyama, H. Okino, H. Matsuhima, T. Oda, J. Hasegawa and M. Mori	1091
Cascode Configuration of SiC-BGSIT and Si-MOSFET with Low On-Resistance and High Transconductance	
M. Yamamoto, Y. Tanaka, T. Yatsuo and K. Yano	1095
Newly Developed Switching Analysis Method for 3.3 kV 400 a Full SiC Module	
S. Hatsukawa, S. Toyoshima, T. Tsuno and Y. Mikamura	1099
Novel vs Conventional Bipolar Logic Circuit Topologies in 4H-SiC	
H. Elgabra, A. Siddiqui and S. Singh	1103
3D Integration of Si-Based Peltier Device onto 4H-SiC Power Device	
Y. Furubayashi, T. Tanehira, K. Yonemori, N. Seo and S. Kuroki	1107
Evidence of Processing Non-Idealities in 4H-SiC Integrated Circuits Fabricated with Two Levels of Metal Interconnect	
D.J. Spry, P.G. Neudeck, L.Y. Chen, L.J. Evans, D. Lukco, C.W. Chang and G.M. Beheim	1112

Chapter 5: Related Materials

5.1 Other Carbon Based Materials

Atomistic Simulations and Interfacial Morphology of Graphene Grown on SiC(0001) and SiC(000-1) Substrates	1121
A. La Magna, I. Deretzis, F. Giannazzo, G. Nicotra, F. Roccaforte, C. Spinella and R. Yakimova	
The Interaction between Graphene and the SiC Substrate: <i>Ab Initio</i> Calculations for Polar and Nonpolar Surfaces	
I. Deretzis, F. Giannazzo and A. La Magna	1125
Interfacial Disorder of Graphene Grown at High Temperatures on 4H-SiC(000-1)	
F. Giannazzo, G. Nicotra, I. Deretzis, A. Piazza, G. Fisichella, S. Agnello, C. Spinella, A. La Magna, F. Roccaforte and R. Yakimova	1129
Wafer-Scale Graphene on 4-Inch SiC	
W.C. Yu, X.F. Chen, X.B. Hu and X.G. Xu	1133
Hot Electron Transistors Based on Graphene/AlGaN/GaN Vertical Heterostructures	
G. Fisichella, G. Greco, S. Di Franco, R. Lo Nigro, E. Schilirò, F. Roccaforte and F. Giannazzo	1137
Amplification in Graphene Nanoribbon Junctions	
J. Pezoldt, B. Hählein, H.O. Jacobs and F. Schwierz	1141
Modified Epitaxial Graphene on SiC for Extremely Sensitive and Selective Gas Sensors	
J. Eriksson, D. Puglisi, C. Strandqvist, R. Gunnarsson, S. Ekeroth, I.G. Ivanov, U. Helmersson, K. Uvdal, R. Yakimova and A. Lloyd Spetz	1145
Highly Sensitive NO₂ Graphene Sensor Made on SiC Grown in Ta Crucible	
S. Novikov, Y. Makarov, H. Helava, S. Lebedev, A. Lebedev and V. Davydov	1149
Graphene-Silicon Heterojunction Infrared Photodiode at 1.3/1.55 μm	
T.M. Ou, T. Borsa and B. Van Zeghbroeck	1153
Abnormal Raman Spectral Variation with Excitation Wavelength in Boron-Doped Single-Crystalline Diamond	
M. Yoshikawa	1158

5.2 Nitrides and other Materials

Development of GaN-Based Gate-Injection Transistors and its Power Switching Application	1165
T. Morita and T. Ueda	

Metal/P-GaN Contacts on AlGaN/GaN Heterostructures for Normally-Off HEMTs	
G. Greco, F. Iucolano, F. Giannazzo, S. Di Franco, D. Corso, E. Smecca, A. Alberti, A. Patti and F. Roccaforte	1170
Tri-Gate Al_{0.2}Ga_{0.8}N/AlN/GaN HEMTs on SiC/Si-Substrates	
W. Jatal, U. Baumann, H.O. Jacobs, F. Schwierz and J. Pezoldt	1174
Trapping States in SiO₂/GaN MOS Capacitors Fabricated on Recessed AlGaN/GaN Heterostructures	
P. Fiorenza, G. Greco, F. Iucolano, A. Parisi, S. Reina, A. Patti and F. Roccaforte	1178
Visualization of Polarization and Two Dimensional Electron Gas Distribution in AlGaN/GaN Heterostructure Using Scanning Nonlinear Dielectric Microscopy	
K. Hirose, N. Chinone and Y. Cho	1182
15 eV Protons Irradiation of the GaN Schottky Diodes	
A.A. Lebedev, S.V. Belov, M.G. Mynbaeva, A.M. Strel'chuk, E.V. Bogdanova, Y. Makarov, A.S. Usikov, S. Kurin, I.S. Barash, A.D. Roenkov and V.V. Kozlovski	1186
Study and Optimization of a 600V Pseudo-Vertical GaN-on-Silicon Rectifier by Finite Element Simulations	
A. Souguir-Aouani, N. Thierry-Jebali, D. Tournier, A. Yvon, E. Collard and D. Planson	1190
Growth of Crack-Free GaN on Si HEMTs with Fe-Doped GaN Using Un-Doped GaN Interlayer	
A. Era, S. Hatakenaka, H. Okazaki, Y. Kamo, T. Nishida and H. Watanabe	1194
HVPE GaN Growth on 4H SiC and Die Dicing	
A. Usikov, S. Kurin, I. Barash, A.D. Roenkov, A. Antipov, O. Khait, O. Medvedev, H. Helava and Y. Makarov	1198
Design and Optimization of AlGaN Solar-Blind Double Heterojunction Ultraviolet Phototransistor	
Y. Bai, H.J. Shen, C. Li, Y.D. Tang and X.Y. Liu	1202
AlGaN/SiC Heterojunction Ultraviolet Photodiodes	
A.V. Sampath, Y. Chen, Q. Zhou, R.W. Enck, G.A. Garrett, B.L. Vanmil, R.B. Chung, M.L. Reed, H. Shen, J.C. Campbell and M. Wraback	1206
High-Speed Solution Growth of Single Crystal AlN from Cr-Co-Al Solvent	
S. Watanabe, M. Nagaya, Y. Takeuchi, K. Aoyagi, S. Harada, M. Tagawa and T. Ujihara	1210