

2010 International Conference on Simulation of Semiconductor Processes and Devices

(SISPAD 2010)

**Bologna, Italy
6 – 8 September 2010**



**IEEE Catalog Number: CFP10SSD-PRT
ISBN: 978-1-4244-7701-2**

Table of Contents

Session 01-A: Invited

Monday, September 6, 2010, 09:20-10:00
Room A
Chair: Giorgio Baccarani

9:20

- 01-A.1 Transport and Noise Properties of Graphene-Based Transistors Revealed Through Atomistic Modeling** 3
G. Iannaccone, A. Betti, G. Fiori
University of Pisa, Italy

Session 02-A: Graphene

Monday, September 6, 2010, 10:00-10:40
Room A
Chair: Giorgio Baccarani

10:00

- 02-A.1 Quantum Transport of Dirac Fermions in Graphene Field Effect Transistors** 9
V. Nguyen, A. Bournel, C. Chassat, P. Dollfus
Université Paris Sud, France

10:20

- 02-A.2 Improving Channel Mobility in Graphene-FETs by Minimizing Surface Phonon Scattering – A Simulation Study** 13
X. Yu, J. Kang, J. Zhang, L. Tian, Z. Yu
Tsinghua University, China

Session 02-B: Process: Metallizations & Interconnects

Monday, September 6, 2010, 10:00-10:40
Room B
Chair: Herve Jaouen

10:00

- 02-B.1 A Kinetic Monte Carlo Study on the Dynamic Switching Properties of Electrochemical Metallization RRAMs During the Set Process** 19
F. Pan, V. Subramanian
University of California Berkeley, United States

10:20

- 02-B.2 Simulation of Three Dimensional Grain Growth for Cu-Interconnects** 23
X. Cheng, Y. Wang
Tsinghua University, China

Session 03-A: Nanoelectronics and Interfaces

Monday, September 6, 2010, 11:20-12:40
Room A
Chair: Wim Magnus

11:20

- 03-A.1 Fabry-Perot Oscillations in the Thermopower of Ballistic Graphene Ribbons** 29
G. Kliros¹, P. Divari²
¹*Hellenic Air-Force Academy, Greece*; ²*Hellenic Army Academy, Greece*

11:40

- 03-A.2 Modeling of Thin-Film Cu(In,Ga)Se₂ Solar Cells** 33
F. Troni, F. Dodi, G. Sozzi, R. Menozzi
Università di Parma, Italy

12:00

- 03-A.3 Spin-Transfer Torques: Self-Consistent Solution of the Spin-Diffusion Equation and the Landau-Lifshitz Equation** 37
S. Possanner, N. Ben Abdallah
Paul Sabatier University, France

12:20

- 03-A.4 First-Principle Calculation for Luminescent-Effects of Si and Zn Impurities in GaN** 41
X. Ji, M. Gao, Y. Wang
Tsinghua University, China

Session 03-B: Process: Deposition & Etching

Monday, September 6, 2010, 11:20-12:40
Room B
Chair: Kenichiro Sonoda

11:20

- 03-B.1 Topography Simulation of BiCS Memory Hole Etching Modeled by Elementary Experiments of SiO₂ and Si Etching** 45
T. Ichikawa, D. Ichinose, K. Kawabata, N. Tamaoki
Toshiba Corporation, Japan

11:40

- 03-B.2 Three-Dimensional Simulation of Focused Ion Beam Processing Using the Level Set Method** 49
O. Ertl, L. Filipović, S. Selberherr
TU Wien, Austria

12:00

- 03-B.3 Coupling of Monte Carlo Sputter Simulation and Feature-Scale Profile Simulation and Application to the Simulation of Back Etching of an Intermetal Dielectric** 53
E. Baer¹, D. Kunder¹, J. Lorenz¹, M. Sekowski², U. Paschen³
¹*Fraunhofer IISB, Germany*; ²*University of Erlangen-Nuernberg, Germany*; ³*Fraunhofer IMS, Germany*

12:20

- 03-B.4 Coupling of Equipment Simulation and Feature-Scale Profile Simulation for Dry-Etching of Polysilicon Gate Lines** 57
E. Baer, D. Kunder, P. Evanschitzky, J. Lorenz
Fraunhofer IISB, Germany

Session 04-A: Invited

Monday, September 6, 2010, 14:00-14:40
Room A
Chair: Nobuyuki Sano

14:00

- 04-A.1 Si Nanowire Device and its Modeling** 63
H. Iwai¹, K. Natori¹, K. Kakushima¹, P. Ahmet¹, K. Shiraishi², J. Iwata², A. Oshiyama³, K. Yamada⁴, K. Ohmori⁴
¹*Tokyo Institute of Technology, Japan*; ²*Tsukuba University, Japan*; ³*University of Tokyo, Japan*; ⁴*Waseda University, Japan*

Session 05-A: Nanowires: Transport Models I

Monday, September 6, 2010, 14:40-15:20
Room A
Chair: Nobuyuki Sano

14:40

- 05-A.1 Steep-Slope Nanowire Field-Effect Transistor (SS-NWFET)** 69
E. Gnani, A. Gnudi, S. Reggiani, G. Baccarani
ARCES-University of Bologna, Italy

15:00

- 05-A.2 Molecular Dynamics Simulation on LO Phonon Mode Decay in Si Nano-Structure Covered with Oxide Films** 73
T. Zushi¹, Y. Kamakura², K. Taniguchi², I. Ohdomari¹, T. Watanabe¹
¹*Waseda University, Japan*; ²*Osaka University, Japan*

Session 05-B: TCAD: Applications I

Monday, September 6, 2010, 14:40-15:20
Room B
Chair: Wladek Grabinski

14:40

05-B.1 Modeling Gate-Pitch Scaling Impact on Stress-Induced Mobility and External Resistance for 20nm-Node MOSFETs 79

S. Kim¹, S. Jain¹, H. Rhee², A. Scholze¹, M. Yu¹, S. Lee², S. Furkay¹, M. Zorzi³, F. Bufler³, A. Erlebach³
¹IBM, United States; ²Samsung Electronics, United States; ³Synopsys, Switzerland

15:00

05-B.2 Schrödinger-Poisson and Monte Carlo Analysis of III-V MOSFETs for High Frequency and Low Consumption Applications 83

M. Shi, J. Saint-Martin, A. Bournel, P. Dollfus
CNRS, Université Paris Sud, France

Session 06-A: Nanowires: Transport Models II

Monday, September 6, 2010, 15:40-16:40
Room A
Chair: Philippe Dollfus

15:40

06-A.1 Coupled Monte Carlo Simulation of Transient Electron-Phonon Transport in Nanoscale Devices 89

Y. Kamakura¹, N. Mori¹, K. Taniguchi¹, T. Zushi², T. Watanabe²
¹Osaka University, Japan; ²Waseda University, Japan

16:00

06-A.2 A Theoretical Study of Effect of Gate Voltage on Electron-Modulated-Acoustic-Phonon Interactions in Silicon Nanowire MOSFETs 93

J. Hattori¹, S. Uno¹, N. Mori², K. Nakazato¹
¹Nagoya University, Japan; ²Osaka University, Japan

16:20

06-A.3 Dissipative Transport in Multigate Silicon Nanowire Transistors 97

N. Dehdashti, A. Kranti, I. Ferain, C. Lee, R. Yan, P. Razavi, R. Yu, J. Colinge
Tyndall National Institute, Cork, Ireland

Session 06-B: TCAD: Applications II

Monday, September 6, 2010, 15:40-16:40
Room B
Chair: Anco Heringa

15:40

06-B.1 Optimal Design of III-V Heterostructures MOSFETs 103

A. Nainani, Z. Yuan, T. Krishnamohan, K. Saraswat
Stanford University, United States

16:00

06-B.2 Microscopic Simulation of Electron Transport and Self-Heating Effects in InAs Nanowire MISFETs 107

T. Sadi¹, J. Thobel², F. Dessenne²
¹Technische Universität Ilmenau, Germany; ²Université Lille 1, France

16:20

06-B.3 Numerical Investigation of the Total SOA of Trench Field-Plate LDMOS Devices 111

S. Poli¹, S. Reggiani¹, G. Baccarani¹, E. Gnani¹, A. Gnudi¹, M. Denison², S. Pendharkar², R. Wise²
¹University of Bologna, Italy; ²Texas Instruments, United States

Session 07-A: Invited

Tuesday, September 7, 2010, 09:20-10:00
Room A
Chair: Tibor Grasser

9:20

07-A.1 Cost-Effective Variability Reduction Approaches to Enable Future Technology Nodes 117

A. Strojwas
Carnegie Mellon University, United States

Session 08-A: Variability: Simulation Approaches

Tuesday, September 7, 2010, 10:00-10:40
Room A
Chair: Tibor Grasser

10:00

08-A.1 A Comparative 3D Simulation Approach with Extensive Experimental Vt/Avt Data and Analysis of LER/RDF/Reliability of CMOS SRAMs at 40-nm Node and Beyond 121

T. Okada, M. Sengoku, H. Aikawa, O. Fujii, H. Yoshimura, H. Oyamatsu
Toshiba Corporation, Japan

10:20

08-A.2 A Novel Approach to the Statistical Generation of Non-Normal Distributed PSP Compact Model Parameters Using a Nonlinear Power Method 125

U. Kovac, D. Dideban, B. Cheng, N. Moezi, G. Roy, A. Asenov
University of Glasgow, United Kingdom

Session 08-B: TCAD: Simulation Approaches I

Tuesday, September 7, 2010, 10:00-10:40
Room B
Chair: Phil Oldiges

10:00

08-B.1 A Simple and Efficient Method for the Calculation of Carrier-Carrier Scattering in Monte-Carlo Simulations 131

W. Lee, U. Ravaioli
University of Illinois at Urbana-Champaign, United States

10:20

08-B.2 Inclusion of the Pauli Principle in a Deterministic Boltzmann Equation Solver for Semiconductor Devices 135

S. Hong, C. Jungemann
Bundeswehr University, Germany

Session 09-A: Variability: CMOS & Memories

Tuesday, September 7, 2010, 11:20-12:40
Room A
Chair: Asen Asenov

11:20

09-A.1 Compact Process and Layout Aware Model for Variability Optimization of Circuit in Nanoscale CMOS 141

Y. Kim, J. Jeon, Y. Jang, Y. Park, G. Yang, Y. Park, M. Yoo, C. Chung
Samsung Electronics, Korea, South

11:40

09-A.2 Halo Profile Engineering to Reduce Vt Fluctuation in High-K/Metal-Gate nMOSFETs 145

W. Chen¹, T. Yu¹, T. Ohtou¹, Y. Sheu¹, J. Wu¹, C. Liu²
¹TSMC, Taiwan; ²National Taiwan University, Taiwan

12:00
09-A.3 Lithography Induced Layout Variations in 6-T SRAM Cells 149

C. Kampen, P. Evanschitzky, A. Burenkov,
J. Lorenz
Fraunhofer IISB, Germany

12:20
09-A.4 Statistical Simulation of Metal-Gate Work-Function Fluctuation in High-K/Metal-Gate CMOS Devices 153

C. Yu, M. Han, H. Cheng, Z. Su, Y. Li,
H. Watanabe
National Chiao Tung University, Taiwan

Session 09-B: TCAD: Simulation Approaches II

Tuesday, September 7, 2010, 11:20-12:40
Room B
Chair: Shinichi Takagi

11:20
09-B.1 System Matrix Compression for Spherical Harmonics Expansions of the Boltzmann Transport Equation 159

K. Rupp, T. Grasser, A. Jünger
TU Wien, Austria

11:40
09-B.2 Study of the Wigner Function Boundary Conditions at Different Barrier Heights 163

A. Savio, A. Poncet
Lyon Institute of Nanotechnologies, France

12:00
09-B.3 Spherical Harmonics Expansion of the Conduction Band for Deterministic Simulation of SiGe HBTs with Full Band Effects 167

G. Matz, S. Hong, C. Jungemann
Bundeswehr University, Germany

12:20
09-B.4 A Non-Linear Variational Principle for the Self-Consistent Solution of Poisson's Equation and a Transport Equation in the Local Density Approximation 171

H. Carrillo Nuñez¹, W. Magnus², F. Peeters¹
¹*University of Antwerp, Belgium*; ²*University of Antwerp/imec-Leuven, Belgium*

Session 10-A: Invited

Tuesday, September 7, 2010, 14:00-14:40
Room A
Chair: Massimo Fischetti

14:00
10-A.1 Quasi-Ballistic Transport in Nano-Scale Devices: Boundary Layer, Potential Fluctuation, and Coulomb Interaction 177

N. Sano
University of Tsukuba, Japan

Session 11-A: Variability: SOI & Nanowires

Tuesday, September 7, 2010, 14:40-15:20
Room A
Chair: Massimo Fischetti

14:40
11-A.1 Variability in Nano-Scale Intrinsic Silicon-on-Thin-Box MOSFETs (SOTB MOSFETs) 183

Y. Yang, G. Du, R. Han, X. Liu
Peking University, China

15:00
11-A.2 Simulation of Line-Edge Roughness Effects in Silicon Nanowire MOSFETs 187

T. Yu, R. Wang, R. Huang
Peking University, China

Session 11-B: Process: Ion Implantation

Tuesday, September 7, 2010, 14:40-15:20
Room B
Chair: Juergen Lorenz

14:40
11-B.1 Proposal of a Point-Source Model for Highly-Accurate Analytical 3D Calculation of Ion Implanted Dopant Profiles 193

K. Nishi¹, M. Mochizuki², H. Hayashi²,
K. Fukuda², I. Kurachi²
¹*Kinki Univ Tech College, Japan*; ²*Oki semiconductor, Japan*

15:00
11-B.2 Compact Process Model of Temperature Dependent Amorphization Induced by Ion Implantation 197

A. Schmidt, I. Jang, T. Kim, K. Lee, Y. Park,
M. Yoo, C. Chung
Samsung Electronics, Korea, South

Session 12-A: Nanowires: RF & Strain

Tuesday, September 7, 2010, 15:40-16:20
Room A
Chair: Massimo Rudan

15:40
12-A.1 Modeling of NQS Effects in Carbon Nanotube Transistors 203

M. Claus, S. Mothes, M. Schröter
Technische Universität Dresden, Germany

16:00
12-A.2 Strain Effects on Hole Current in Silicon Nanowire FETs 207

H. Minari¹, T. Kitayama², M. Yamamoto²,
N. Mori¹
¹*CREST, Japan*; ²*Osaka University, Japan*

Session 12-B: Process: Interfaces & Electromigration

Tuesday, September 7, 2010, 15:40-16:20
Room B
Chair: Valery Axelrad

15:40
12-B.1 Improvement of the Interface Integrity Between a High-K Dielectric Film and a Metal Gate Electrode by Controlling Point Defects and Residual Stress 213

K. Suzuki, T. Inoue, H. Miura
Tohoku University, Japan

16:00
12-B.2 Impact of Parameter Variability on Electromigration Lifetime Distribution 217

H. Ceric, R. Lacerda de Orio, S. Selberherr
TU Wien, Austria

Session 13-A: Invited

Wednesday, September 8, 2010, 09:00-09:40
Room A
Chair: Bernd Meinerzhagen

9:00
13-A.1 Future High Density Memories for Computing Applications: Device Behavior and Modeling Challenges 223

G. Spadini, I. Karpov, D. Kencke
Intel Corporation, United States

Session 14-A: Memories I

Wednesday, September 8, 2010, 09:40-10:40
Room A
Chair: Bernd Meinerzhagen

09:40

- 14-A.1 A Novel Algorithm for the Solution of Charge Transport Equations in MANOS Devices Including Charge Trapping in Alumina and Temperature Effects** 229

A. Padovani, L. Larcher
Università di Modena e Reggio Emilia, Italy

10:00

- 14-A.2 Investigation of Charge Loss Mechanisms in Planar and Raised STI Charge Trapping Flash Memories** 233

Z. Xia, D. Kim, J. Lee, K. Lee, Y. Park, M. Yoo, C. Chung
Samsung Electronics, Korea, South

10:20

- 14-A.3 Stochastic Modeling Hysteresis and Resistive Switching in Bipolar Oxide-Based Memory** 237

A. Makarov, V. Sverdlov, S. Selberherr
TU Wien, Austria

Session 14-B: Compact Modeling

Wednesday, September 8, 2010, 09:40-10:40
Room B
Chair: Susanna Reggiani

09:40

- 14-B.1 Modeling of 2D Bias Control in Overlap Region of High-Voltage MOSFETs for Accurate Device/Circuit Performance Prediction** 243

A. Tanaka¹, Y. Oritsuki¹, H. Kikuchi¹, M. Miyake¹, H. Mattausch¹, M. Miura-Mattausch¹, Y. Liu², K. Green²
¹Hiroshima University, Japan; ²TI, United States

10:00

- 14-B.2 Compact Modeling of Fe-FET and Implications on Variation-Insensitive Design** 247

C. Wang, Y. Ye, Y. Cao
Arizona State University, United States

10:20

- 14-B.3 Proposal of a Fitting Accuracy Metric Suitable for Compact Model Qualification in All MOSFET Operation Regions** 251

H. Sakamoto, T. Iizuka
Renesas Electronics, Japan

Session 15-A: Memories II

Wednesday, September 8, 2010, 11:20-12:40
Room A
Chair: Kaustav Banerjee

11:20

- 15-A.1 Modeling of the Voltage Snap-Back in Amorphous-GST Memory Devices** 257

M. Rudan¹, F. Giovanardi¹, T. Tsafack¹, F. Xiong², E. Piccinini¹, F. Buscemi¹, A. Liao², E. Pop², R. Brunetti³, C. Jacoboni³
¹University of Bologna, Italy; ²University of Illinois at Urbana-Champaign, United States; ³University of Modena and Reggio Emilia, Italy

11:40

- 15-A.2 Detailed Physical Simulation of Program Disturb Mechanisms in Sub-50 nm NAND Flash Memory Strings** 261

C. Nguyen¹, A. Kuligk¹, M. Vexler¹, M. Klawitter¹, V. Beyer², T. Melde³, M. Czernohorsky², B. Meinerzhagen¹
¹TU Braunschweig, Germany; ²CNT, Germany; ³NaMLab gGmbH, Germany

12:00

- 15-A.3 Multiphysics Modeling of PCM Devices for Scaling Investigation** 265

G. Ferrari¹, A. Ghetti², D. Ielmini¹, A. Redaelli², A. Pirovano²
¹Politecnico di Milano, Italy; ²Numonyx, Italy

12:20

- 15-A.4 FinFET SRAM Cell Optimization Considering Temporal Variability Due to NBTI/PBTI and Surface Orientation** 269

V. Hu, M. Fan, C. Hsieh, P. Su, C. Chuang
National Chiao Tung University, Taiwan

Session 15-B: TCAD: Transport Models

Wednesday, September 8, 2010, 11:20-12:40
Room B
Chair: Axel Erlebach

11:20

- 15-B.1 Symmetry Reduction by Surface Scattering and Mobility Model for Stressed <100>/(001) MOSFETs** 275

F. Bufer, A. Erlebach, M. Oulmane
Synopsys Schweiz GmbH, Switzerland

11:40

- 15-B.2 Analytical Models of Effective DOS, Saturation Velocity and High-Field Mobility for SiGe HBTs Numerical Simulation** 279

G. Sasso¹, G. Matz², C. Jungemann², N. Rinaldi¹
¹University of Naples - Federico II, Italy; ²Bundeswehr University, Germany

12:00

- 15-B.3 TCAD Simulation Vs. Experimental Results in FDSOI Technology: from Advanced Mobility Modeling to 6T-SRAM Cell Characteristics Prediction** 283

M. Jaud¹, P. Scheiblin¹, S. Martinie², M. Cassé¹, O. Rozeau¹, J. Dura¹, J. Mazurier¹, A. Toffoli¹, O. Thomas¹, F. Andrieu¹, O. Weber¹
¹CEA-LETI, MINATEC, France; ²IM2NP-CNRS, France

12:20

- 15-B.4 Improved Impact-Ionization Modelling and Validation with pn-Junction Diodes** 287

Z. Pan¹, S. Holland¹, D. Schroeder², W. Krautschneider²
¹NXP Semiconductors, Germany; ²Hamburg University of Technology, Germany

Session 16-A: Invited

Wednesday, September 8, 2010, 14:00-14:40
Room A
Chair: Andreas Schenk

14:00

- 16-A.1 Solving Boltzmann Transport Equation Without Monte-Carlo Algorithms - New Methods for Industrial TCAD Applications** 293

B. Meinerzhagen¹, A. Pham¹, S. Hong², C. Jungemann²
¹TU Braunschweig, Germany; ²Bundeswehr University, Germany

Session 17-A: Numerics for Device Simulation

Wednesday, September 8, 2010, 14:40-15:40

Room A

Chair: Andreas Schenk

14:40

17-A.1 Pseudo-Spectral Method for the Modelling of Quantization Effects in Nanoscale MOS Transistors 299

A. Paussa, F. Conzatti, D. Breda, R. Vermiglio,
D. Esseni
Università degli studi di Udine, Italy

15:00

17-A.2 Stable Implementation of a Deterministic Multi-Subband Boltzmann Solver for Silicon Double-Gate nMOSFETs 303

K. Zhao¹, S. Hong², C. Jungemann², R. Han¹
¹*Peking University, China;* ²*Bundeswehr
University, Germany*

15:20

17-A.3 Improving the Accuracy of the Schroedinger-Poisson Solution in CNWs and CNTs 307

M. Rudan, A. Gnudi, E. Gnani, S. Reggiani,
G. Baccarani
University of Bologna, Italy

Session 17-B: Sensors and MEMS

Wednesday, September 8, 2010, 14:40-15:40

Room B

Chair: Mitiko Miura-Mattausch

14:40

17-B.1 Fast DNA Sequencing via Transverse Differential Conductance 313

Y. He¹, R. Scheicher², A. Grigoriev², R. Ahuja²,
S. Long¹, Z. Ji¹, Z. Yu¹, M. Liu¹
¹*Chinese Academy of Sciences, China;*
²*Uppsala University, Sweden*

15:00

17-B.2 Modeling and Fast Simulation of RF-MEMS Switches Within Standard IC Design Frameworks 317

M. Niessner¹, G. Schrag¹, J. Iannacci²,
G. Wachutka¹
¹*Munich University of Technology, Germany;*
²*Fondazione Bruno Kessler, Italy*

15:20

17-B.3 Giant Piezoresistance Effect in P-Type Silicon 321

T. Nghiêm, V. Aubry-Fortuna, C. Chassat,
A. Bossebeuf, P. Dollfus
Université Paris Sud, France