IEEE TRANSACTIONS ON
ELECTRON DEVICES

JANUARY 2019 VOLUME 66 NUMBER 1 IETDAI (ISSN 0018-9383)

SPECIAL ISSUE ON COMPACT MODELING FOR CIRCUIT DESIGN

GUEST EDITORIAL

Foreword

Special Issue on Compact Modeling for Circuit Design . . . . *B. Iñiguez, W. Grabinski, S. Mijalković, K. Xia, A. J. Scholten, Y. Singh Chauhan, A. S. Roy, S. Yoshitomi, K. Xu* 7

SPECIAL ISSUE PAPERS

Compact Models for MOS Transistors: Successes and Challenges *(Invited Paper)* . . . . *C. C. McAndrew* 12
From Process Corners to Statistical Circuit Design Methodology: Opportunities and Challenges *(Invited Paper)* . . . . *S. Dongaonkar, S. P. Mudanai, and M. D. Giles* 19
Industrial View of III–V Devices Compact Modeling for Circuit Design *(Invited Paper)* . . . . *P. J. Zampardi and F. Kharabi* 28
Environment for Modeling and Simulation of Biosystems, Biosensors, and Lab-on-Chips *(Invited Paper)* . . . . *M. Madec, A. Bonament, E. Rosati, Y. Takakura, J. Haiech, L. Hébrard, and C. Lallement* 34
Accurate and Computationally Efficient Modeling of Nonquasi Static Effects in MOSFETs for Millimeter-Wave Applications . . . . *C. Gupta, N. Mohamed, H. Agarwal, R. Goel, C. Hu, and Y. S. Chauhan* 44
Potential-Based Modeling of Depletion-Mode MOSFET Applicable for Structural Variations . . . . *T. Iizuka, T. Umeda, Y. Hirano, H. Kikuchihara, M. Miura-Mattausch, U. Feldmann, D. Navarro, K. Molnár, W. Posch, T. Yonamine, H. Kishigami, H. Hashigami, and H. J. Mattausch* 52
REL-MOS—A Reliability-Aware MOS Transistor Model . . . . *T. Hillebrand, S. Paul, and D. Peters-Drolshagen* 60
Statistical MOSFET Modeling Methodology for Cryogenic Conditions . . . . *A. Kabaoğlu, N. Ş. Solmaz, S. İlik, Y. Uzun, and M. B. Yelten* 66
A Compact Charge and Surface Potential Model for III–V Cylindrical Nanowire Transistors . . . . *M. D. Ganeriwala, F. G. Ruiz, E. G. Marin, and N. R. Mohapatra* 73
ASM GaN: Industry Standard Model for GaN RF and Power Devices—Part 1: DC, CV, and RF Model . . . . *S. Khandelwal, Y. S. Chauhan, T. A. Fjeldly, S. Ghosh, A. Pampori, D. Mahajan, R. Dangi, and S. A. Ahsan* 80
ASM GaN: Industry Standard Model for GaN RF and Power Devices—Part-II: Modeling of Charge Trapping . . . . *S. A. Albahrani, D. Mahajan, J. Hodges, Y. S. Chauhan, and S. Khandelwal* 87
Facilitation of GaN-Based RF- and HV-Circuit Designs Using MVS-GaN HEMT Compact Model . . . . *U. Radhakrishna, P. Choi, and D. A. Antoniadis* 95

(Contents Continued on Page 2)

A PUBLICATION OF THE IEEE ELECTRON DEVICES SOCIETY

(Contents Continued from Page 1)

HiSIM_GaN: Compact Model for GaN-HEMT With Accurate Dynamic Current-Collapse Reproduction ... *Y. Okada, T. Mizoguchi, Y. Tanimoto, H. Kikuchihara, T. Naka, W. Saito, M. Miura-Mattausch, and H. J. Mattausch* 106
Physics-Based 2-D Analytical Model for Field-Plate Engineering of AlGaN/GaN Power HFET ... *T. Chen, Q. Zhou, D. Wei, C. Dong, W. Chen, and B. Zhang* 116
Plasmons in Ballistic Nanostructures With Stubs: Transmission Line Approach ... *G. R. Aizin, J. Mikalopas, and M. S. Shur* 126
2-D Physics-Based Compact DC Modeling of Double-Gate Tunnel-FETs ... *F. Horst, A. Farokhnejad, Q.-T. Zhao, B. Iñíguez, and A. Kloes* 132
Modeling Current–Voltage Characteristics of Bilayer Organic Light-Emitting Diodes ... *L. Zhang, L. Wang, W.-J. Wu, and M. Chan* 139
Variability Modeling for Printed Inorganic Electrolyte-Gated Transistors and Circuits ... *F. Rasheed, M. Hefenbrock, M. Beigl, M. B. Tahoori, and J. Aghassi-Hagmann* 146
Use of InGaAs/GaSb Quantum Ratchet in p-i-n GaAs Solar Cell for Voltage Preservation and Higher Conversion Efficiency ... *G. S. Sahoo and G. P. Mishra* 153
Compact Modeling of Charge Transfer in Pinned Photodiodes for CMOS Image Sensors ... *R. Capoccia, A. Boukhayma, F. Jazaeri, and C. Enz* 160
Analysis and Compact Modeling of Insulator–Metal Transition Material-Based PhaseFET Including Hysteresis and Multidomain Switching ... *A. Dasgupta, A. Verma, and Y. S. Chauhan* 169
Compact Model of Carrier Transport in Monolayer Transition Metal Dichalcogenide Transistors ... *T. Wu, X. Cao, and J. Guo* 177
A Dynamic Time Evolution Method for Concurrent Device-Circuit Aging Simulations ... *L. Zhang, C. Ma, Y. Xiao, H. Zhang, X. Lin, and M. Chan* 184
Parasitic RC Aware Delay Corner Model for Sub-10-nm Logic Circuit Design ... *T. H. Choi, T. W. Oh, and S.-O. Jung* 191
Compact Scalable Modeling of Chipless RFID Tag Based on High-Impedance Surface ... *N. Chen, Y. Shen, G. Dong, and S. Hu* 200

INVITED REVIEW PAPERS

Metamaterial-Inspired Vacuum Electron Devices and Accelerators ... *Z. Duan, M. A. Shapiro, E. Schamiloglu, N. Behdad, Y. Gong, J. H. Booske, B. N. Basu, and R. J. Temkin* 207
Reverse-Conducting Insulated Gate Bipolar Transistor: A Review of Current Technologies ... *E. M. Findlay and F. Udrea* 219

REGULAR PAPERS

Silicon and Column IV Semiconductors Devices

Impact of Mixed Negative Bias Temperature Instability and Hot Carrier Stress on MOSFET Characteristics—Part I: Experimental ... *B. Ullmann, M. Jech, K. Puschkarsky, G. A. Rott, M. Waltl, Y. Illarionov, H. Reisinger, and T. Grasser* 232
Impact of Mixed Negative Bias Temperature Instability and Hot Carrier Stress on MOSFET Characteristics—Part II: Theory ... *M. Jech, B. Ullmann, G. Rzepa, S. Tyaginov, A. Grill, M. Waltl, D. Jabs, C. Jungemann, and T. Grasser* 241
Compact Model for Tunnel Diode Body Contact SOI n-MOSFETs ... *Y. Chang, J. Luo, J. Chen, L. Xu, Z. Chai, S. Wang, Y. Dong, and X. Wang* 249
Ambipolar SB-FinFETs: A New Path to Ultra-Compact Sub-10 nm Logic Circuits ... *T. F. Canan, S. Kaya, A. Karanth, H. Xin, and A. Louri* 255
A Compact Formulation for Avalanche Multiplication in SiGe HBTs at High Injection Levels ... *M. Jaoul, C. Maneux, D. Céli, M. Schröter, and T. Zimmer* 264
A Simulation Study of NBTI Impact on 14-nm Node FinFET Technology for Logic Applications: Device Degradation to Circuit-Level Interaction ... *S. Mishra, H. Amrouch, J. Joe, C. K. Dabhi, K. Thakor, Y. S. Chauhan, J. Henkel, and S. Mahapatra* 271
Gate Oxide Local Thinning Mechanism-Induced Sub-60 mV/Decade Subthreshold Swing on Charge-Coupled MIS(p) Tunnel Transistor ... *C.-F. Yang, B.-J. Chen, W.-C. Chen, K.-W. Lin, and J.-G. Hwu* 279
Steep Slope Silicon-On-Insulator Feedback Field-Effect Transistor: Design and Performance Analysis ... *C. Lee, E. Ko, and C. Shin* 286
Modeling Short-Channel Effects in Core–Shell Junctionless MOSFET ... *N. Jaiswal and A. Kranti* 292

(Contents Continued on Page 3)

(Contents Continued from Page 2)

Transadmittance Efficiency under NQS Operation in Asymmetric Double Gate FDSOI MOSFET . . . . *S. El Ghouli, J.-M. Sallese, A. Juge, P. Scheer, and C. Lallement* 300

Layout Modification of a PD-SOI n-MOSFET for Total Ionizing Dose Effect Hardening . . . . *Y. T. Roh and H. C. Lee* 308

Device to Circuit Framework for Activity- Dependent NBTI Aging in Digital Circuits . . . . *A. Thirunavukkarasu, H. Amrouch, J. Joe, N. Goel, N. Parihar, S. Mishra, C. K. Dabhi, Y. S. Chauhan, J. Henkel, and S. Mahapatra* 316

Compound Semiconductor Devices

Performance of Recessed Anode AlGaN/GaN Schottky Barrier Diode Passivated With High-Temperature Atomic Layer-Deposited Al_2O_3 Layer . . . . *J.-H. Lee, K.-S. Im, J. K. Kim, and J.-H. Lee* 324

The Impact of Temperature on GaN/Si HEMTs Under RF Operation Using Gate Resistance Thermometry . . . . *G. Pavlidis, S. Som, J. Barrett, W. Struble, and S. Graham* 330

Hot-Electron Trapping and Hole-Induced Detrapping in GaN-Based GITs and HD-GITs . . . . *E. Fabris, M. Meneghini, C. De Santi, M. Borga, Y. Kinoshita, K. Tanaka, H. Ishida, T. Ueda, G. Meneghesso, and E. Zanoni* 337

The Performance of Operational Amplifiers Consisting of 4H-SiC CMOS After Gamma Irradiation . . . . *M. Masunaga, S. Sato, A. Shima, and R. Kuwana* 343

Thermal Characterization of Quasi-Vertical GaAs Schottky Diodes Integrated on Silicon . . . . *S. Nadri, C. M. Moore, N. D. Sauber, L. Xie, M. E. Cyberey, J. T. Gaskins, A. W. Lichtenberger, N. S. Barker, P. E. Hopkins, M. Zebarjadi, and R. M. Weikle, II* 349

Analytical Gate Capacitance Models for Large-Signal Compact Model of AlGaN/GaN HEMTs . . . . *Y. Jia, Y. Xu, Z. Wen, Y. Wu, and Y. Guo* 357

Impact of Channel Thickness on the Large-Signal Performance in InAlGaN/AlN/GaN HEMTs With an AlGaN Back Barrier . . . . *A. Malmros, P. Gamarra, M. Thorsell, H. Hjelmgren, C. Lacam, S. L. Delage, H. Zirath, and N. Rorsman* 364

The Effect of Proton Irradiation in Suppressing Current Collapse in AlGaN/GaN High-Electron-Mobility Transistors . . . . *A. Stockman, A. Tajalli, M. Meneghini, M. J. Uren, S. Mouhoubi, S. Gerardin, M. Bagatin, A. Paccagnella, G. Meneghesso, E. Zanoni, P. Moens, and B. Bakeroot* 372

Memory Devices and Technology

Fluorine Effects Originating From the CVD-W Process on Charge-Trap Flash Memory Cells . . . . *J. Moon, T. Y. Lee, H. J. Ahn, T. I. Lee, W. S. Hwang, and B. J. Cho* 378

Thorough Understanding of Retention Time of Z2FET Memory Operation . . . . *M. Duan, C. Navarro, B. Cheng, F. Adamu-Lema, X. Wang, V. P. Georgiev, F. Gamiz, C. Millar, and A. Asenov* 383

Effect of Millisecond Annealing Temperature of $Ni_{1-x}Pt_xSi$ Formation on Leakage Current Characteristics of Static Random-Access Memory Cells . . . . *J. Kim, T. Park, S. Lee, S. Lee, C. Kim, S. Hyun, Y. Kim, K. Hwang, and H. Kim* 389

Adaptive Weight Quantization Method for Nonlinear Synaptic Devices . . . . *D. Kwon, S. Lim, J.-H. Bae, S.-T. Lee, H. Kim, C.-H. Kim, B.-G. Park, and J.-H. Lee* 395

Resistive RAM With Multiple Bits Per Cell: Array-Level Demonstration of 3 Bits Per Cell . . . . *B. Q. Le, A. Grossi, E. Vianello, T. Wu, G. Lama, E. Beigné, H.-S. P. Wong, and S. Mitra* 402

Ferroelectric-Gated Nanoelectromechanical Nonvolatile Memory Cell . . . . *K. Choe and C. Shin* 407

Static Random Access Memory Characteristics of Single-Gated Feedback Field-Effect Transistors . . . . *J. Cho, D. Lim, S. Woo, K. Cho, and S. Kim* 413

3-D Stacked Synapse Array Based on Charge-Trap Flash Memory for Implementation of Deep Neural Networks . . . . *Y. J. Park, H. T. Kwon, B. Kim, W. J. Lee, D. H. Wee, H.-S. Choi, B.-G. Park, J.-H. Lee, and Y. Kim* 420

1T-DRAM With Shell-Doped Architecture . . . . *Md. H. R. Ansari, N. Navlakha, J.-T. Lin, and A. Kranti* 428

Thin Film Transistors

Novel Top-Anode OLED/a-IGZO TFTs Pixel Circuit for 8K4K AM-OLEDs . . . . *P.-C. Lai, C.-L. Lin, and J. Kanicki* 436

Fully Printed Top-Gate Metal–Oxide Thin-Film Transistors Based on Scandium-Zirconium-Oxide Dielectric . . . . *Y. Li, L. Lan, S. Hu, P. Gao, X. Dai, P. He, X. Li, and J. Peng* 445

Drain Conductance Oscillations in Poly-Si Junctionless Nanowire Thin-Film Transistors . . . . *T.-K. Kang and Y.-H. Peng* 451

(Contents Continued on Page 4)

(Contents Continued from Page 3)

Highly Reliable Amorphous In-Ga-Zn-O Thin-Film Transistors Through the Addition of Nitrogen Doping . . . . . *K. Park, J. H. Kim, T. Sung, H.-W. Park, J.-H. Baeck, J. Bae, K.-S. Park, S. Yoon, I. Kang, K.-B. Chung, H.-S. Kim, and J.-Y. Kwon* 457

Back-Channel-Etched Thin-Film Transistors With Tunable Acid-Resistant Zr-Doped Indium Oxide Active Layer . . . . . *P. Xiao, J. Huang, T. Dong, J. Yuan, J. Chen, D. Yan, Y. Yu, and H. Tan* 464

Optoelectronics, Displays, and Imaging

Monolithic Waveguide-Based Linear Photodetector Array for Use as Ultracompact Spectrometer . . . . . *M. Grundmann* 470

Numerical Investigation on the Enhanced Performance of N-Polar AlGaN-Based Ultraviolet Light-Emitting Diodes With Superlattice p-Type Doping . . . . . *H. Tao, S. Xu, J. Zhang, P. Li, Z. Lin, and Y. Hao* 478

Fabrication of Photodiodes Based on Solution-Processed Perovskite Single Crystals . . . . . *X. Wang, Y. Wu, G. Li, Y. Li, J. Wu, X. Zhang, Q. Li, B. Wang, J. Chen, and W. Lei* 485

Fully Depleted SOI Pixel Detector With Multijunction Structure in p-Type Substrate . . . . . *H. Lan, Y. Wang, J. Chen, X. Luo, and F. Cao* 491

Statistical Study of Intrinsic Parasitics in an SPAD-Based Integrated Fiber Optical Receiver . . . . . *H. Mahmoudi, M. Hofbauer, B. Steindl, K. Schneider-Hornstein, and H. Zimmermann* 497

Performance Improvement of GaN-Based Light-Emitting Diodes With a Microhole Array, 45° Sidewalls, and a SiO$_2$ Nanoparticle/Microsphere Passivation Layer . . . . . *C.-H. Chang, Y.-L. Lee, Z.-F. Wang, R.-C. Liu, J.-H. Tsai, and W.-C. Liu* 505

Power Efficiency Figure of Merit for Image Sensors . . . . . *Y. Yamashita and S. Sugawa* 512

Characterization of Fine-Pixel X-Ray Imaging Detector Array Fabricated by Using Thick Single-Crystal CdTe Layers on Si Substrates Grown by MOVPE . . . . . *M. Niraula, K. Yasuda, S. Tsubota, T. Yamaguchi, J. Ozawa, T. Mori, and Y. Agata* 518

Influence of Fundamental Model Uncertainties on Silicon Solar Cell Efficiency Simulations . . . . . *S. Wasmer, A. Fell, and J. M. Greulich* 524

Solid-State Power and High Voltage Devices

Ultrafast and Low-Turn-OFF Loss Lateral IEGT With a MOS-Controlled Shorted Anode . . . . . *J. Wei, X. Luo, G. Deng, T. Sun, C. Wang, K. Zhu, W. Cui, Z. Wang, Z. Li, and B. Zhang* 533

Effects of LaSiO$_x$ Thickness and Forming Gas Anneal Temperature on Threshold Voltage Instability of 4H-SiC MOSFETs With LaSiO$_x$ . . . . . *X. Yang, B. Lee, and V. Misra* 539

Investigations on the Degradations of Double-Trench SiC Power MOSFETs Under Repetitive Avalanche Stress . . . . . *J. Wei, S. Liu, L. Yang, L. Tang, R. Lou, T. Li, J. Fang, S. Li, C. Zhang, and W. Sun* 546

Buffer Vertical Leakage Mechanism and Reliability of 200-mm GaN-on-SOI . . . . *X. Li, M. Zhao, B. Bakeroot, K. Geens, W. Guo, S. You, S. Stoffels, V.-P. Lempinen, J. Sormunen, G. Groeseneken, and S. Decoutere* 553

Part I: Physical Insight Into Carbon-Doping-Induced Delayed Avalanche Action in GaN Buffer in AlGaN/GaN HEMTs . . . . . *V. Joshi, S. P. Tiwari, and M. Shrivastava* 561

Part II: Proposals to Independently Engineer Donor and Acceptor Trap Concentrations in GaN Buffer for Ultrahigh Breakdown AlGaN/GaN HEMTs . . . . . *V. Joshi, S. P. Tiwari, and M. Shrivastava* 570

C_{OSS} Measurements for Superjunction MOSFETs: Limitations and Opportunities . . . . . *G. D. Zulauf, J. Roig-Guitart, J. D. Plummer, and J. M. Rivas-Davila* 578

The Effect of Shallow Trench Isolation and Sinker on the Performance of Dual-Gate LDMOS Device . . . . . *S. Chahar, G. M. Rather, and N. Hakim* 585

A Novel High-Voltage Pseudo-p-LDMOS Device With Three Current Conductive Paths . . . . . *M. Kong, B. Yi, and B. Zhang* 592

The Minimum Specific ON-Resistance of Semi-SJ Device . . . . *W. Zhang, C. Lai, M. Qiao, Z. Li, and B. Zhang* 598

Investigation on the Self-Sustained Oscillation of Superjunction MOSFET Intrinsic Diode . . . . . *P. Xue, L. Maresca, M. Riccio, G. Breglio, and A. Irace* 605

Vertical Current Transport in AlGaN/GaN HEMTs on Silicon: Experimental Investigation and Analytical Model . . . . . *N. Remesh, N. Mohan, S. Kumar, S. Prabhu, I. Guiney, C. J. Humphreys, S. Raghavan, R. Muralidharan, and D. N. Nath* 613

Interconversion Between Bipolar and Complementary Behavior in Nanoscale Resistive Switching Devices . . . . . *Y. He, G. Ma, H. Cai, C. Liu, Q. Chen, A. Chen, H. Wang, and T.-C. Chang* 619

(Contents Continued on Page 5)

(Contents Continued from Page 4)

Materials, Processing and Packaging

Thermal and Wirelength Optimization With TSV Assignment for 3-D-IC .... *Y. Zhao, C. Hao, and T. Yoshimura* 625
Variance Analysis in 3-D Integration: A Statistically Unified Model With Distance Correlations .... *A. Ayres, O. Rozeau, B. Borot, L. Fesquet, P. Batude, L. Brunet, and M. Vinet* 633
Thermal-Aware Shallow Trench Isolation Design Optimization for Minimizing I_{OFF} in Various Sub-10-nm 3-D Transistors .... *I. Myeong, D. Son, H. Kim, M. Kang, J. Jeon, and H. Shin* 641

Solid State Device Phenomena

Quantum Transport Study of Si Ultrathin-Body Double-Gate pMOSFETs: I–V, C–V, Energy Delay, and Parasitic Effects .... *S. Zhang, J. Z. Huang, A. Khaliq, H. Xie, W. Chen, and W.-Y. Yin* 647
Controlling the Current Conduction Asymmetry of HfO_2 Metal–Insulator–Metal Diodes by Interposing Al_2O_3 Layer .... *W. Jeon, O. Salicio, A. Chaker, P. Gonon, and C. Vallée* 655
Carrier Transport and Thermoelectric Properties of Differently Shaped Germanene (Ge) and Silicene (Si) Nanoribbon Interconnects .... *L. Banerjee, A. Sengupta, and H. Rahaman* 664

Molecular and Organic Devices

Lumped-Parameter Equivalent Circuit Model for S-Shaped Current–Voltage Characteristics of Organic Solar Cells .... *F. Yu, G. Huang, W. Lin, and C. Xu* 670
Thermally Induced Fullerene Domain Coarsening Process in Organic Solar Cells .... *A. Agresti, S. Pescetelli, Y. Busby, and T. Aernouts* 678

Sensors and Actuators

Using Single-Layer HfS_2 as Prospective Sensing Device Toward Typical Partial Discharge Gas in SF_6-Based Gas-Insulated Switchgear .... *D. Chen, X. Zhang, J. Tang, Y. Li, Z. Cui, and Q. Zhou* 689
Ammonia Sensing Characteristics of a Tungsten Trioxide Thin-Film-Based Sensor .... *T.-C. Chou, C.-H. Chang, C. Lee, and W.-C. Liu* 696

Vacuum Electron Devices

Design Studies of a 3-MW, Multifrequency (170/204/236 GHz) DEMO Class Triangular Corrugated Coaxial Cavity Gyrotron .... *S. Yuvaraj, M. V. Kartikeyan, and M. K. Thumm* 702
Evaluation of the Modulation Performance of Injection-Locked Continuous-Wave Magnetrons .... *B. Yang, T. Mitani, and N. Shinohara* 709
Thickness Effect on Field-Emission Properties of Carbon Nanotube Composite Cathode .... *Y. Song, J. Li, and W. Ou-Yang* 716
Investigation of an X-Band Long Pulse High-Power High-Gain Coaxial Multibeam Relativistic Klystron Amplifier .... *Z. Liu, H. Huang, X. Jin, S. Li, T. Wang, and X. Fang* 722
Design and Analysis of a High-Order Mode Ladder-Type RF Circuit for Stable Operation in a W-Band Extended Interaction Oscillator .... *L. Bi, L. Meng, Y. Yin, C. Xu, S. Zhu, R. Peng, F. Zeng, Z. Chang, B. Wang, H. Li, and P. Zhang* 729

Emerging Technologies and Devices

Alloy Engineered Nitride Tunneling Field-Effect Transistor: A Solution for the Challenge of Heterojunction TFETs .... *T. A. Ameen, H. Ilatikhameneh, P. Fay, A. Seabaugh, R. Rahman, and G. Klimeck* 736
On the ESD Behavior of Large-Area CVD Graphene Transistors: Physical Insights and Technology Implications .... *N. K. Kranthi, A. Mishra, A. Meersha, and M. Shrivastava* 743
Insights Into the Impact of Pocket and Source Elevation in Vertical Gate Elevated Source Tunnel FET Structures .... *Ashita, S. A. Loan, and M. Rafat* 752
Analysis of Cell Variability Impact on a 3-D Vertical RRAM (VRRAM) Crossbar Array Using a Modified Lumping Method .... *S. Choi, W. Sun, and H. Shin* 759
Device Investigation of Nanoplate Transistor With Spacer Materials .... *H. Ko, M. Kang, J. Jeon, and H. Shin* 766
Threshold Voltage Characteristics for Silicon Nanowire Field-Effect Transistor With a Double-Layer Gate Structure .... *H. Yang* 771
TDDB Mechanism in a-Si/TiO_2 Nonfilamentary RRAM Device .... *J. Ma, Z. Chai, W. D. Zhang, J. F. Zhang, J. Marsland, B. Govoreanu, R. Degraeve, L. Goux, and G. S. Kar* 777

(Contents Continued on Page 6)

(Contents Continued from Page 5)

Wirelessly Operated, Implantable Optoelectronic Probes for Optogenetics in Freely Moving Animals .... Y. Zhao, C. Liu, Z. Liu, W. Luo, L. Li, X. Cai, D. Liang, Y. Su, H. Ding, Q. Wang, L. Yin, J. Guan, M. Luo, and X. Sheng 785

Convolutional Neural Networks Based on RRAM Devices for Image Recognition and Online Learning Tasks .... Z. Dong, Z. Zhou, Z. Li, C. Liu, P. Huang, L. Liu, X. Liu, and J. Kang 793

BRIEF PAPERS

A Substrate Model for On-Chip Tapered Spiral Inductors With Forward and Reverse Excitations .... J. Sathyasree, V. Vanukuru, D. R. Nair, and A. Chakravorty 802

Prediction of Alpha Particle Effect on 5-nm Vertical Field-Effect Transistors .... Y. Seo, M. Kang, J. Jeon, and H. Shin 806

Alleviating Conductance Nonlinearity via Pulse Shape Designs in TaO$_x$ Memristive Synapses .... S.-J. Li, B.-Y. Dong, B. Wang, Y. Li, H.-J. Sun, Y.-H. He, N. Xu, and X.-S. Miao 810

A Novel Double-RESURF SOI Lateral TIGBT With Self-Biased nMOS for Improved $V_{\mathrm{CE(sat)}}$–E_{off} Tradeoff Relationship .... H. Hu, H. Huang, and X. B. Chen 814

Single-Side Fabricated p$^+$Si/Al Thermopile-Based Gas Flow Sensor for IC-Foundry-Compatible, High-Yield, and Low-Cost Volume Manufacturing .... D. Xue, F. Song, J. Wang, and X. Li 821

Implementation of Dopant-Free Hafnium Oxide Negative Capacitance Field-Effect Transistor .... C.-H. Cheng, C.-C. Fan, C.-Y. Tu, H.-H. Hsu, and C.-Y. Chang 825

Temperature Effects in SET/RESET Voltage–Time Dilemma in Pr$_{0.7}$Ca$_{0.3}$MnO$_3$-Based RRAM .... N. Panwar and U. Ganguly 829

CORRESPONDENCE

Correction to “Delta Doping in HgCdTe-Based Unipolar Barrier Photodetectors” .... N. D. Akhavan, G. A. Umana-Membreno, R. Gu, J. Antoszewski, and L. Faraone 833