

# SYMPOSIUM ED7

Materials and Device Engineering for Beyond the Roadmap  
Devices in Logic, Memory and Power  
April 18 - April 21, 2017

## Symposium Organizers

Alexander Demkov, University of Texas, Austin  
Andrew Kummel, University of California, San Diego  
John Robertson, University of Cambridge  
Shinichi Takagi, University of Tokyo

## Proceedings Statement

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\* Invited Paper

## SESSION ED7.1: Memory I

Session Chairs: Andrew Kummel and Dirk Wouters  
Tuesday Morning, April 18, 2017  
PCC North, 100 Level, Room 131 A

### 10:30 AM \*ED7.1.01

**Computing with Coupled Dynamical Systems** [Suman Datta](#); University of Notre Dame, United States.

### 11:00 AM ED7.1.02

**Growth of NbO<sub>2</sub> by Molecular-Beam Epitaxy and Characterization of its Metal-Insulator Transition** [Lindsey Noskin](#); Cornell University, United States.

### 11:15 AM ED7.1.03

**Infrared Near-Field Spectroscopy of Free Charge Carriers at Grain Boundaries in Sr<sub>1-x</sub>La<sub>x</sub>TiO<sub>3</sub> Ceramics on the nm-Scale** [Martin Lewin](#)<sup>1,2</sup>; <sup>1</sup>RWTH Aachen University, Germany; <sup>2</sup>Fraunhofer Institute for Laser Technology (ILT), Germany.

### 11:30 AM ED7.1.04

**Molecular Beam Epitaxy Grown NbO<sub>2</sub> Thin Films for Selector Devices** [Alex Demkov](#); University of Texas, United States.

### 11:45 AM ED7.1.05

**A Novel Forming-Free Bipolar Resistive Memory Based On ITO/V<sub>2</sub>O<sub>5</sub>/ITO Structure** [Zhenni Wan](#); University of Washington, United States.

## SESSION ED7.2: Memory II

Session Chairs: Alex Demkov and John Robertson  
Tuesday Afternoon, April 18, 2017  
PCC North, 100 Level, Room 131 A

### 1:30 PM \*ED7.2.01

**ReRAM Devices—From New Memory to beyond von Neumann Computing Applications** [Dirk J. Wouters](#); RWTH Aachen University, Germany.

### 2:00 PM ED7.2.02

**Oxygen Stoichiometry Controlled Resistive Switching Modes in HfO<sub>x</sub> and TaO<sub>x</sub> Based RRAM Devices** [Sankaramangalam U. Sharath](#); TU Darmstadt, Germany.

### 2:15 PM ED7.2.03

**The Effect of Oxygen Exchange Layer on the Performance of Tantalum Oxide-Based RRAM** [Zahiruddin Alamgir](#); State University of New York Polytechnic Institute, United States.

### 2:30 PM \*ED7.2.04

**In Case of Emergency Break the Z-Glass Ceiling—Thin Film Processes for Advanced Integration and Devices** [R. D. Clark](#); TEL Technology Center, America LLC, United States.

### 3:00 PM BREAK

### 3:30 PM \*ED7.2.05

**Quantum Computing in Silicon with Donors** [Michelle Y. Simmons](#); Centre for Quantum Computation and Communication Technology, Australia.

### 4:00 PM ED7.2.06

**Impact of *In Situ* Reducing Plasma Treatments on the Electrical Properties of RRAM Devices Based on ALD Deposited Al<sub>2</sub>O<sub>3</sub> Dielectric Material** [Brice Eychehne](#)<sup>1,2</sup>; <sup>1</sup>LTM-CNRS, France; <sup>2</sup>CEA-LETI, France.

### 4:15 PM ED7.2.07

**Investigation of the Cell-to-Cell Interference Induced by the Bended ONO Structure in 3D NAND Flash Memories** [Won-Hyo Cha](#); SK HYNIX, Korea (the Republic of).

### 4:30 PM ED7.2.08

**Controllable Formation of Conductive Filament by Selective Oxidation near the Tip-Region of Pyramid-Structured Active Electrode in Resistive Memory** [Youngjin Kim](#)<sup>1,2</sup>; <sup>1</sup>Korea Institute of Science and Technology, Korea (the Republic of); <sup>2</sup>Korea University, Korea (the Republic of).

### 4:45 PM ED7.2.09

**The Low Temperature Data Retention Improvement in 1Znm TLC NAND Flash** [Jaewook Yang](#); SK Hynix Inc., Korea (the Republic of).

## SESSION ED7.3: CMOS

Session Chair: Robert Clark  
Wednesday Morning, April 19, 2017  
PCC North, 100 Level, Room 131 A

### 8:00 AM ED7.3.01

**Selective Isotropic Etching of Silicon in Preference to Germanium and Si<sub>0.5</sub>Ge<sub>0.5</sub>** [Christopher Ahles](#); University of California, San Diego, United States.

### 8:15 AM ED7.3.02

**Reducing Fermi Level Pinning at Contacts on Ge by Germanides** [Hongfei Li](#); University of Cambridge, United Kingdom.

### 8:30 AM ED7.3.03

**Trap Characterization and Capacitance-Voltage Hysteresis of Al<sub>2</sub>O<sub>3</sub>/InGaAs Gate Stacks** [Kechao Tang](#); Stanford University, United States.

### 8:45 AM ED7.3.04

**Temperature Dependent Border Trap Response Produced by a Defective Interfacial Oxide Layer in Al<sub>2</sub>O<sub>3</sub>/InGaAs Gate Stacks** [Kechao Tang](#); Stanford University, United States.

### 9:00 AM \*ED7.3.05

**Bringing III-Vs into CMOS—From Epitaxy to Circuits** [Lukas Czornomaz](#); IBM Research GmbH, Switzerland.

### 9:30 AM BREAK

### 10:00 AM \*ED7.3.06

**Reliability of Metal Gate/High-K Devices and Its Impact on CMOS Technology Scaling** [Andreas Kerber](#); GLOBALFOUNDRIES, United States.

### 10:30 AM ED7.3.07

**Al<sub>2</sub>O<sub>3</sub>-HfO<sub>2</sub> Nanolaminate Gate Oxides with Organic Precursor on Silicon Germanium** [Mahmut Sami Kavrik](#); University of California San Diego, United States.

### 10:45 AM ED7.3.08

**Yttrium Passivation of Defects in GeO<sub>2</sub> and GeO<sub>2</sub>/Ge Interfaces** [Hongfei Li](#); University of Cambridge, United Kingdom.

11:00 AM ED7.3.09

**High-Dielectric Constant  $\text{Al}_2\text{O}_3 / \text{TiO}_2$  Nanolaminates for Next Generation Gates in Nanoscale Devices** [Orlando Auciello](#); University of Texas at Dallas, United States.

11:15 AM ED7.3.10

**DFT Molecular Dynamic Simulations of Nealy Ideal Sub-Nanometer Interface Passivation Layer for  $\alpha\text{-HfO}_2/\text{SiGe}$  Devices and Comparison to Experiment** [Andrew C. Kummel](#); University of California, San Diego, United States.

11:30 AM \*ED7.3.11

**High Performance Ge and GeSn Epi Channels** [C. W. Liu](#)<sup>1,2</sup>; <sup>1</sup>National Taiwan University, Taiwan; <sup>2</sup>National Nano Device Laboratories, Taiwan.

SESSION ED7.4: Ferroelectrics

Session Chairs: Suman Datta and Alex Demkov

Wednesday Afternoon, April 19, 2017

PCC North, 100 Level, Room 131 A

1:30 PM \*ED7.4.01

**Ferroelectric  $\text{HfO}_2$  or  $\text{ZrO}_2$  for Non-Volatile Memory Devices** [Uwe Schroeder](#); Namlab, Germany.

2:00 PM ED7.4.02

**Structural Study of Ferroelectric  $\text{HfO}_2$  in Metal-Insulator-Metal Stack—Lateral Grain Growth and Transition to Non-Centrosymmetric Phase** [Takashi Ando](#); IBM T.J. Watson Research Center, United States.

2:15 PM ED7.4.03

**Ferroelectric Capacitors with Quasi-Amorphous  $\text{BaTiO}_3$  Integrated on Silicon** [Catherine Dubourdieu](#)<sup>1,5</sup>; <sup>1</sup>Institut des Nanotechnologies de Lyon, France; <sup>2</sup>Helmholtz Zentrum Berlin für Materialien und Energie, Germany.

2:30 PM BREAK

3:30 PM \*ED7.4.04

**Ferroelectricity in Hf-Based Oxide—Negative Capacitance FETs for Steep Subthreshold Swing** [Min-Hung Lee](#); National Taiwan Normal University, Taiwan.

4:00 PM \*ED7.4.05

**Recent Advances in Negative Capacitance for Ultra-Low Power Computing** [Asif Khan](#); Georgia Institute Technology, United States.

4:30 PM ED7.4.06

**Flexible Ferroelectric Hafnia Films and Devices** [Hyeonggeun Yu](#); North Carolina State University, United States.

4:45 PM ED7.4.07

**Rapid Imaging of Polarization Switching in Ferroelectrics Using the Complete Information Stream from Scanning Probe Microscopes** [Suhas Somnath](#); Oak Ridge National Laboratory, United States.

SESSION ED7.5: Poster Session

Session Chairs: Andrew Kummel and John Robertson

Wednesday Afternoon, April 19, 2017

8:00 PM - 10:00 PM

Sheraton, Third Level, Phoenix Ballroom

ED7.5.01

**Hydrogen Silsesquioxane (HSQ) Resistance Switching Nanopillar Arrays** [Wing H. Ng](#); University College London, United Kingdom.

ED7.5.02

**Investigation of Ferroelectric Behavior in Doped Hafnium Oxide** [Irving Cashwell](#); Norfolk State University, United States.

ED7.5.03

**Dependences of Memory Characteristics on Schottky Parameters in  $\text{Pt/Nb:SrTiO}_3$  Schottky Junction Type Resistive Memory** [Kentaro Kinoshita](#)<sup>1,2</sup>; <sup>1</sup>Tottori University, Japan; <sup>2</sup>Tottori Integrated Frontier Research Center, Japan.

ED7.5.04

**Beyond the Nanoparticle—Memory Devices Using Near Atomic Structures** [Febin Paul](#); De Montfort University, United Kingdom.

ED7.5.05

**Analog Memcapacitance in  $\text{Pt/HfO}_x/\text{n-IGZO}$  Structure through Redistribution of Oxygen** [Paul Yang](#); Myongji University, Korea (the Republic of).

ED7.5.06

**Strain-Induced Shift of the Electrical Properties in  $\text{AlGaN/GaN}$  Heterostructures** [Wulin Tong](#); University of Electronic Science and Technology of China, China.

ED7.5.07

**Directly Observation of the Switching Behaviors in VCM-Based  $\text{Ta}_2\text{O}_5$  Memristor** [Jui-Yuan Chen](#); National Chiao Tung University, Taiwan.

ED7.5.08

**Radiation Effects on Tantalum Oxide Resistive Memory under Applied Bias** [Joshua Holt](#); State University of New York Polytechnic Institute, United States.

ED7.5.09

**Resistive Memory Structures of Nano-Layered  $\text{Al}_2\text{O}_3$**  [Sita Dugu](#); University of Puerto Rico, United States.

ED7.5.10

**Switching Characteristic Improvement of  $\text{TaO}_x$ -Based ReRAM Stack by Magnetron Sputtering Method** [Yusuke Miyaguchi](#); Institute of Semiconductor and Electronics Technologies, ULVAC, Inc., Japan.

ED7.5.11

**Taguchi Design of Experiment Enabling the Reduction of Spikes on the Sides of Patterned Thin Films for Tunnel Junction Fabrication** [Pawan Tyagi](#); University of the District of Columbia, United States.

ED7.5.12

**Polarity Dependent Resistive Switching Characteristics in  $\text{Ta}_2\text{O}_5/\text{Ag}_2\text{Se}$  and  $\text{Ag}_2\text{Se}/\text{Ta}_2\text{O}_5$  Bilayer Structures** [Tae Sung Lee](#); Myoung Ji University, Korea (the Republic of).

ED7.5.13

**Oxygen Vacancy Electromigration versus Joule Heating in Local Programming of  $\text{TiO}_2$  RRAM Conductivity** [Kechao Tang](#); Stanford University, United States.

ED7.5.14

**Multi-Level Organolead Halide Perovskite Resistive Random Access Memories** [Feichi Zhou](#); HK Polytechnic Universtiy, Hong Kong.

ED7.5.15

**Amorphous In-Ga-ZnO Thin-Film Transistors with Embedded Reduced-Graphene Oxide for Mobility Enhancement** [Myung ju Kim](#); Korea University, Korea (the Republic of).

ED7.5.16

**Subsurface Engineering of Silicon for 3D Devices** [Onur Tokel](#); Bilkent University, Turkey.

ED7.5.17

**The Influence of Local Defects on the Magnetic Properties of  $\text{NiCO}_2\text{O}_4$**  [Sibylle Gemming](#)<sup>1,2</sup>; <sup>1</sup>Helmholtz-Zentrum Dresden-Rossendorf, Germany; <sup>2</sup>Technische Universität Chemnitz, Germany.

ED7.5.18

**Reliable Resistive Switching Memory with Self-Compliance Based on Electrodeposited  $\text{CuO}_x$  Multilayer** [Min-Kyu Kim](#); Pohang University of Science and Technology (POSTECH), Korea (the Republic of).

ED7.5.19

**Flexible Threshold Switching Device Based on Electrochemical Deposition** [Youngjun Park](#); POSTECH, Korea (the Republic of).

ED7.5.20

**First-Principles Study on Charge Trap States in Amorphous  $\text{Si}_3\text{N}_{4-x}$**  [Gijae Kang](#); Seoul National University, Korea (the Republic of).

**ED7.5.21**  
**Resistive Switching Characteristics of All-Solution-Processed Ag/TiO<sub>2</sub>/Mo-Doped In<sub>2</sub>O<sub>3</sub> Nonvolatile Memory Device** [Sujayakumar Vishwanath](#); Kongju National University, Korea (the Republic of).

**ED7.5.22**  
**Effect of Off-Center Ion Substitution in Morphotropic Composition Lead Zirconate Titanate** [Mohan K. Bhattarai](#); Department of Physics and Institute for Functional Nanomaterials, University of Puerto Rico, United States.

**ED7.5.23**  
**Forming-Free Resistive Switching Characteristics of Ag/CeO<sub>2</sub>/Pt Structure** [Hong Zheng](#); Myongji University, Korea (the Republic of).

**ED7.5.24**  
**Resistive Switching Properties and Behaviors in Core-Shell Ni/NiO/HfO<sub>2</sub> Nanowire ReRAM Device** [Ting Kai Huang](#); National Chiao Tung University, Taiwan.

**ED7.5.25**  
**Performance of Hydrogenated Diamond MISFET Using Zr-Si-N as the Dielectric Layer** [Pengfei Zhang](#)<sup>1,2</sup>; <sup>1</sup>Inner Mongolia University of Technology, China; <sup>2</sup>Xi'an Jiaotong University, China.

**ED7.5.26**  
**Direct Observation of Resistive Switching Behavior in Core-shell Ni/NiO Nanowires Based Memristor Crossbar** [Yi-Hsin Ting](#); National Chiao Tung University, Taiwan.

**ED7.5.27**  
**Organic Non-Volatile Memory Using Nickel Oxide Nano-Floating-Gate and Polymer Electrets** [Yeon-Ju Kim](#); GIST, Korea (the Republic of).

**ED7.5.28**  
**Detection and Mapping of Static Charges in Nanometer Scale Memory Devices** [Rudra S. Dhar](#); National Institute of Technology Mizoram, India.

SESSION ED7.6: 2D and Others  
Session Chair: John Conley  
Thursday Morning, April 20, 2017  
PCC North, 100 Level, Room 131 A

**8:00 AM ED7.6.01**  
**Cause of RRAM Device Switching Variability and its Impact on Memristive Dynamic Adaptive Neural Network Arrays** [Nathaniel Cady](#); SUNY Polytechnic Institute, United States.

**8:15 AM ED7.6.02**  
**The Analog Information Limit of Magnetic Domain Wall Positions in Nanowires** [Sumit Dutta](#); Massachusetts Institute of Technology, United States.

**8:30 AM \*ED7.6.03**  
**Tunnel FETs—Vertical or Lateral?** [Huili G. Xing](#); Cornell University, United States.

**9:00 AM \*ED7.6.04**  
**2D Semiconductor Electronics—Advances, Challenges and Opportunities** [Ali Javey](#); University of California, Berkeley, United States.

**9:30 AM BREAK**

**10:00 AM \*ED7.6.05**  
**Graphene and Beyond—Creating and Exploring Atomically Thin Materials** [Joshua A. Robinson](#); The Pennsylvania State University, United States.

**10:30 AM ED7.6.06**  
**Quasi-2D β-Ga<sub>2</sub>O<sub>3</sub> Field-Effect Transistors with Hexagonal Boron Nitride Gate Dielectric** [Janghyuk Kim](#); Korea University, Korea (the Republic of).

**10:45 AM ED7.6.07**  
**Approaching the Quantum Conductance Limit in Carbon Nanotube Array Transistors** [Gerald J. Brady](#); University of Wisconsin–Madison, United States.

**11:00 AM \*ED7.6.08**  
**Two Dimensional Materials for Electronic Devices** [Seongjun Park](#); Samsung Advanced Institute of Technology, Korea (the Republic of).

**11:30 AM ED7.6.09**  
**Internal Photoemission Spectroscopy Measurement of Energy Barriers between Amorphous Metals and High-K Dielectrics** [John F. Conley](#); Oregon State University, United States.

**11:45 AM ED7.6.10**  
**All-Transparent and Flexible Schottky Barrier Transistors and Logics Based on Ion Gel-Gated Graphene/Metal Oxide Heterostructure** [Seong Chan Kim](#); Sungkyunkwan University, Korea (the Republic of).

SESSION ED7.7: TFET  
Session Chairs: Lukas Czornomaz and Huili Xing  
Thursday Afternoon, April 20, 2017  
PCC North, 100 Level, Room 131 A

**1:30 PM \*ED7.7.01**  
**The Impact of Contact Deposition Ambient on the Interfacial Chemistry of 2D Materials** [Robert M. Wallace](#); University of Texas at Dallas, United States.

**2:00 PM ED7.7.02**  
**Vertical InAs/GaAsSb/GaSb Tunneling Field-Effect Transistors on Si with Sub 50 mV/dec. Operation** [Lars-Erik M. Wernersson](#); Lund University, Sweden.

**2:15 PM ED7.7.03**  
**Band Engineering, Doping and Tunnel FETs with InSe** [Yuzheng Guo](#); University of Swansea, United Kingdom.

**2:30 PM \*ED7.7.04**  
**2D Crystals for Smart Life** [Kaustav Banerjee](#); University of California, Santa Barbara, United States.

**3:00 PM BREAK**

**3:30 PM \*ED7.7.05**  
**Exploring Interfacial Properties of Pristine MoS<sub>2</sub> MOS Interface** [Mitsuru Takenaka](#)<sup>1,2</sup>; <sup>1</sup>The University of Tokyo, Japan; <sup>2</sup>JST-CREST, Japan.

**4:00 PM \*ED7.7.06**  
**ON Current Boosting Technology for Si-Based Tunnel Field-Effect Transistors Utilizing Isoelectronic Trap** [Takahiro Mori](#); National Institute of Advanced Industrial Science and Technology (AIST), Japan.

**4:30 PM ED7.7.07**  
**Probing the Nanostructure in State-of-the-Art FinFET Devices** [Pritesh Parikh](#); University of California, San Diego, United States.

**4:45 PM ED7.7.08**  
**Charge Transition Levels in ZrO<sub>2</sub> and Si:ZrO<sub>2</sub> Interfacial Layer Probed by DLTS** [Sandip Mondal](#); Indian Institute of Science, India.

SESSION ED7.8: Processing and Others  
Session Chairs: Alex Demkov and John Robertson  
Friday Morning, April 21, 2017  
PCC North, 100 Level, Room 131 A

**8:30 AM ED7.8.01**  
**Heat-Induced Bipolar to Unipolar Resistive Switching Transition** [Simone Cortese](#); University of Southampton, United Kingdom.

**8:45 AM ED7.8.02**  
**How Do the Electrodes Affect the Electrical Response of a M/La<sub>2</sub>NiO<sub>4</sub>/M' Memristive Device?** [Klaasjan Maas](#); Univ Grenoble Alpes, CNRS, LMGP, France.

**9:00 AM ED7.8.03**  
**Structural Properties of Cerium Dioxide Film Prepared by Atomic Layer Deposition on TiN and Si Substrates** [Silvia Vangelista](#); IMM-CNR, MDM Unit, Italy.

**9:15 AM ED7.8.04**  
**Characterization of Low Temperature Thermal ALD BN on Si<sub>0.7</sub>Ge<sub>0.3</sub>(001)** [Steven Wolf](#); University of California, San Diego, United States.

**9:30 AM ED7.8.05**

**Uniform Atomic Layer Deposition of  $\text{Al}_2\text{O}_3$  on Graphene by Reversible Hydrogen Plasma Functionalization** [Rene Vervuurt](#); Eindhoven University of Technology, Netherlands.

**9:45 AM ED7.8.06**

**Inkjet-Printed Four-Terminal Microelectromechanical Relays for 3-Dimensional Logic Applications** [Seungjun Chung](#)<sup>1,2</sup>; <sup>1</sup>Seoul National University, Korea (the Republic of); <sup>2</sup>University of California, Berkeley, United States.

**10:00 AM BREAK**

**10:30 AM ED7.8.07**

**Chemical Vapor Deposition of Stoichiometric  $\text{TaSi}_2$  on Si(001)** [Jong Youn Choi](#); University of California, San Diego, United States.

**10:45 AM ED7.8.08**

**Antiferromagnetic Ordering in 25% Ca Doped Antisite-Disordered Ferromagnetic  $\text{La}_2\text{CoMnO}_6$  Double Perovskite** [Ramchandra Sahoo](#); IIT Kharagpur, India.

**11:00 AM ED7.8.09**

**Flexible Memristive Memory Arrays Based on Vapor-Phase Deposited Polymer Thin Film** [Byung Chul Jang](#); KAIST, Korea (the Republic of).

**11:15 AM ED7.8.10**

**Resistive Switching of Nanoengineered  $\text{LaMnO}_{3+d}$  Thin Films for ReRAM Applications** [Dolors D. Pla Asesio](#); Laboratoire des Matériaux et du Génie Physique (LMGP), France.

**11:30 AM ED7.8.11**

**Interface-Type Resistive Switching in Epitaxial  $\text{GdBaCO}_2\text{O}_{5+\delta}$  Thin Film Heterostructures** [Sarunas Bagdzevicius](#); Univ Grenoble Alpes, CNRS, LMGP, France.