

2024 IEEE Silicon Nanoelectronics Workshop

Hilton Hawaiian Village, Honolulu, HI USA

June 15-16, 2024

Advance Program

Opening Remarks

Saturday June 15 8:30 a.m.

Peide Ye & Zhihong Chen, Purdue University

Session 1: Plenary

Saturday June 15 8:40 a.m.

Session Chair: *Pei-Wen Li, NYCU*

- 8:40 AM **1.1 (Keynote) Future Perspectives of CMOS Logic Innovation Beyond 2nm, *T. Hiramoto*¹, *H. Wakabayashi*², ¹University of Tokyo, ²Tokyo Inst. of Tech.**
- 9:15 AM **1.2 (Keynote) Gate Oxide Reliability: Upcoming Trends, Challenges and Opportunities, *B. Kaczer*¹, *R. Degraeve*¹, *J. Franco*¹, *T. Grasser*², *Ph. J. Roussel*¹, *E. Bury*¹, *P. Weckx*¹, *A. Chasin*¹, *S. Tyaginov*¹, ¹imec, ²TU Vienna**

Session 2: GAA/Nanosheet Transistors I

Saturday June 15 9:50 a.m.

Session Chair: *Takahiro Shinada, Tohoku University*

- 9:50 AM **2.1 (Invited) Heterogeneous CFET: A Pathway to CMOS Performance Balance Engineering, *X.-R. Yu*¹, *W.-H. Lu*¹, *S.-W. Chang*¹, *W.-H. Chang*², *Darsen D. Lu*¹, *Y.-J. Lee*^{3,4}, *T. Maeda*³, *W.-F. Wu*⁴, *Y.-M. Li*³, *Y.-H. Wang*¹, ¹Natl. Cheng Kung University, ²AIST, ³National Yang Ming Chiao Tung University, ⁴TSRI**
- 10:20 AM **2.2 Enhanced Electrical Performance of Ultrathin Body Nanosheets, *B.-W. Huang*, *Y.-R. Chen*, *T. Chou*, *H.-C. Lin*, *C.-T. Tu*, *Y.-C. Liu*, *W.-H. Hsieh*, *W.-J. Chen*, *M.-K. Lin*, *Y.-Q. Liu*, *L.-K. Wang*, *H.-C. Chou*, *Y. Huang*, *D.-W. Lin*, *C.-W. Liu*, National Taiwan University**

Coffee Break 10:35 a.m. – 10:55 a.m.

Session 3: Quantum Computing Devices/Circuits

Saturday June 15 10:55 a.m.

Session Chair: *Louis Hutin, CEA-Leti*

- 10:55 AM **3.1 (Invited) Integration Technology for Superconducting Quantum Circuits,**

Shiro Kawabata, AIST

- 11:25 AM **3.2 Demonstration of 99.9% Single Qubit Control Fidelity of a Silicon Quantum Dot Spin Qubit Made in a 300 nm Foundry Process**, N. D. Stuyck^{1,2}, F. Mengke^{1,2}, W. H. Lim^{1,2}, S. S. Ramirez^{1,2}, C. Escott^{1,2}, T. Botzem^{1,2}, T. Tantt^{1,2}, H. Yang^{1,2}, A. Saraiva^{1,2}, A. Laucht^{1,2}, S. Kubicek³, J. Jussot³, S. Beyne³, B. Raes³, C. Godfrin³, D. Wan, K. D. Greve^{3,4}, A. Dzurak⁴. ¹Dirac, ²UNSW, ³imec, ⁴KU-Leven
- 11:40 AM **3.3 Tunneling Current Spectroscopy of Self-assembled Ge Double Quantum Dots with Hard-wall Barrier Engineering**, Y.-W. Chiu, I. H. Wang, T. Tsai, H.-C. Lin, P.-W. Li, National Yang Ming Chiao Tung University
- 11:55 AM **(Lunch Break)**

Session 4: Memory Technology

Saturday June 15 1:30 p.m.

Session Chair: Jiezhong Chen, Shandong University

- 1:30 PM **4.1 (Invited) IGZO Channel VCT (Vertical Channel Transistor) Technology for sub-10nm DRAM : Challenges and Opportunities**, Y. Lee, Daewon Ha, W. Lee, S. Yoo, J. H. Bae, M. H. Cho, K. Yoo, S. M. Lee, S. Lee, M. Terai, T. H. Lee, K. J. Moon, C. Sung, M. Hong, D. G. Cho, H. Kim, J. H. Seo, K. Park, B. J. Kuh, S. Hyun, S. J. Ahn, and J. H. Song, Samsung Electronics
- 2:00 PM **4.2 A Novel 2-Tier Stacked Vertical Channel GAA Transistor Architecture with Area-Saving 3-Dimensional Local Interconnect to Achieve Gb-Density 6T SRAM with Acceptable Low Standby Chip Leakage (~1mA)**, H.-T. Lue, W. Chen, T.-H. Yeh, K.-C. Wang, and C.-Y. Lu, Macronix
- 2:15 PM **4.3 A Comparative Study of HBL and VBL 3D DRAM: Signal Margin, Bit-cell Density, and Scalability**, X. Wu¹, L. Upton¹, P.-K. Hsu², J. Chen¹, S. Yu², H.-S. P. Wong¹, ¹Stanford University, ²Georgia Institute of Technology
- 2:30 PM **4.4 Impact of Proton Irradiation on SiNx and Si-SiO₂ Interfaces in FLASH Memory**, H. Kim¹, J. Park¹, J. Im², H. Kim², Y. Jun Yoon³, Y.-M. Kim⁴, K. Park⁵, S. Y. Woo², J.-H. Bae¹, ¹Kookmin University, ²Kyungpook National University, ³Andong National University, ⁴Korea Atomic Energy Research Institute, ⁵Yonsei University
- 2:45 PM **4.5 A Novel RRAM-based Ternary Strong-PUF with High Security Intensity Feasible for Low-earth Orbit Satellites in the 6G Era**, S. H. Lin, E. R. Hsieh, National Central University

Break 3:00 p.m. – 3:10 p.m.

Session 5: Ferroelectric Memory

Saturday June 15 3:10 p.m.

Session Chair: K. Toprasertpong, The Univ. of Tokyo

- 3:10 PM **5.1 (Invited) Outlook and Prospects for Ferroelectric Augmentation of Vertical NAND Flash Technology**, *Asif Khan, Georgia Institute of Technology*
- 3:40 PM **5.2 Investigating the Correlation Between Material Ferroelectricity and Silicon-Channel FeFET Performances: Insights for Material Engineering in Device Optimization**, *X. Wang, L. Jiao, Z. Zhou, Z. Zheng, Y. Chen, R. Shao, C. Sun, D. Zhang, G. Liu, X. Gong, National University of Singapore*
- 3:55 PM **5.3 Ferroelectricity Engineered AlScN Thin Films Prepared by Hydrogen Included Reactive Sputtering for Analog Applications**, *S.-M. Chen¹, H. Nishida¹, T. Hoshii¹, K. Tsutsui¹, H. Wakabayashi¹, Edward Y. Chang², and K. Kakushima¹ Tokyo Inst. of Technology, National Yang Ming Chiao Tung Univ.*
- 4:10 PM **5.4 Investigation of HfO₂ and ZrO₂ Nanolamination Thickness on Superlattice HZO FeRAMs Exhibiting Enhanced Remnant Polarization and Improved Endurance**, *D. R. Hsieh, Z. Y. Hong, W. J. Yeh, J. C. Ni, H. E. Luo, Y.-K. Liang, S. L. Hsieh, K. L. Chen, T.-S. Chao, National Yang Ming Chiao Tung University*
- 4:25 PM **5.5 Impact of Time Delay Schemes on Reliability Degradation During Program/Erase Cycling in HZO-based FeFETs**, *X. Li¹, G. Zhao¹, L. Tai¹, P. P. Sang¹, X. Dou¹, X. Zhan¹, X. Wang², J. Wu¹, J. Chen¹, ¹Shandong University, ²Institute of Microelectronics of Chinese Academy of Sciences*
- 4:40 PM **5.6 Study on the Anomalous Characteristics of Random Telegraph Noise in FeFETs**, *P. Cai¹, Y. Wu², Z. Sun¹, H. Li¹, X. Wang³, Z. Ji², R. Wang¹, R. Huang¹, ¹Peking University, ²Shanghai Jiao Tong University, ³Institute of Microelectronics of Chinese Academy of Sciences*

Poster Session 1

Saturday June 15 5:00 p.m. – 7:00 pm

5:00 p.m. **Poster Introductions** (2 minutes each)

Session Chair: Steve Chung, National Yang Ming Chiao Tung University

(served with coffee/drinks/snacks after the presentation)

P1-1 Single Electron Charge Detection in Nanoscale Metal Double-dot: DC Single Electron Transistor vs. gate RF sensing, *M. I. Rahaman¹, G. Szakmany¹, X. Jehl², A. Orlov¹, G. Snider¹, ¹University of Notre Dame, ²Univ. Grenoble Alpes*

P1-2 Ferromagnetic Manganese Silicide Nanoparticles Formed by Ion Implantation in Silicon, *R. Ohsugi, M. Kawano, Y. K. Wakabayashi, Y. Krockenberger, H. Sumikura, J. Noborisaka, K. Nishiguchi, NTT*

P1-3 The Simulation of Double Germanium Quantum Dots in a Ring-Shaped Quantum Structure, C. Liang, Y.-T. E. Tang, *National Central University*

P1-4 Improved Uniformity and Excellent Endurance Characteristics of TaOx-Based RRAM by Laser-Mediated Interface Engineering, L. Wu¹, Q. Wang¹, H. Liao¹, C. Ban¹, L. Shan¹, Z. Wang^{1,2}, Y. Wang^{1,2}, Y. Cai^{1,2}, ¹*Peking University*, ²*Beijing Advanced Innovation Center for Integrated Circuits*

P1-5 Effects of Modulation Pulse on Resistive Switching Dynamics of RRAM Devices, C.-H. Chien, Y.-H. Wang, *National Cheng Kung University*

P1-6 Innovative Switching Mechanism, Performance Investigations and Scaling Effects in a-V₂O₃ Based ReRAM devices, K. Veyret^{1,2}, L. Laborie¹, R. Bon¹, G. Navaro¹, R. Hida¹, N. Castellani¹, C. Carabasse¹, P. Gonon¹ and E. Jalaguier¹, ¹*CEA-Leti*, ²*Univ. Grenoble Alpes*

P1-7 Floating Gate Field Effect Transistors for Logic-In-Memory Application, S. Jae Baik¹, S. Kim², M. Kang³, and J. Jeon², ¹*Samsung Electronics*, ²*Sungkyunkwan University*, ³*Korea National University of Transportation*

P1-8 (withdrawn)

P1-9 High Performance HfLaO-based TiO₂-Channel FE V-NAND with High Consistency and Low Operation Voltage, X. Song, S. Li, D. Sun, X. Liu, J. Kang, *Peking University*

P1-10 Accelerated Program Inhibition Failure by Trap-Mediated Tunneling in the Polycrystalline Floating-Channel 3-D NAND Flash Memory Array, S. Kim¹, U. Lee², Y. Lee¹, C. Ahn², J. Sim², S. Cho¹, ¹*Ewha Womans University*, ²*SK hynix inc.*

P1-12 Investigation of Row Hammer and Passing Gate Effects Based on the Work Functions of Dual Gates in DRAM Cells, H. Kim¹, J. Im¹, J. Kim¹, S. Woo¹, T. Kwon¹, Y. J. Yoon², J.-H. Bae³, S. Y. Woo¹, ¹*Kyungpook National University*, ²*Andong National University*, ³*Kookmin University*

P1-12 Analysis of Row Hammer and Passing Gate Effect in DRAM Cells by BCAT Structural Design, J. Im¹, H. Kim¹, J. Kim¹, S. Woo¹, T. Kwon¹, Y. J. Yoon², J.-H. Bae³, S. Y. Woo¹, ¹*Kyungpook National University*, ²*Andong National University*, ³*Kookmin University*

P1-13 Controllable Polarization Switching of Hafnia-Based Ferroelectric Bilayers, J. Jeong, H. Park, J. Woo, *Kyungpook National University*

P1-14 Short-term and Long-term T-O Phase Transition Responsible for Two stages of Wake-up Process in Ferroelectric Hf_{0.5}Zr_{0.5}O₂ Film, D. Chen, G. Qiang, F. Yuyan, Y. Zikang, J. Liu, S. Mengwei, L. Xiuyan, *Shanghai Jiao Tong University*

P1-15 Enhancing Annealing Strategies for Back-End-of-Line-Compatible HfO₂-Based Ferroelectric Capacitors with Time Periods and Gas Species, C.-H. Wu¹, T.-Y. Lin², C.-Y. Chiu², C.-J. Su², V. P.-H. Hu¹, ¹*National Taiwan University*, ²*National Yang Ming Chiao Tung University*

P1-16 Plasma-enhanced Atomic Layer Deposition Based FEFETs, C. Park^{1,2}, P. V. Ravindran¹, D. Das³,

P. G. Ravikumar¹, W. Chern¹, S. Yu¹, A. I. Khan¹, ¹Georgia Institute of Technology, ²SK hynix, ³NIT Silchar

P1-17 Investigation on the Local Polarization Scheme in Ferroelectric Tunnel Field-Effect Transistors for Ternary Content-Addressable Memory Applications, M. Ryu, J. S. Woo, W. Y. Choi, Seoul National University

P1-18 Study of Spacing-induced Fringing Effects on Emerging CFET Technology Nodes, Y.-Z. Chen¹, N. Thoti², Y.-T. E. Tang¹, ¹National Central University, ²University of Oulu

Day-2 Sunday June 16, 2024

Session 6: Neuromorphic Computing

Sunday June 16 8:30 a.m.

Session Chair: Takahide Oya, Yokohama National University

8:30 AM **6.1 Reservoir Computing Using Nonlinear Polarization and Charge Dynamics of Anti-ferroelectric HZO/Si FETs**, S.-Y. Min, K. Toprasertpong, E. Nako, R. Nakane, M. Takenaka, S. Takagi, The University of Tokyo

8:45 AM **6.2 Design Space Trade-offs in Networks of Coupled Injection-locked Ring Oscillators for Ising-based Optimum Search**, A. Bazzi, F. Badets, L. Hutin, CEA-Leti

9:00 AM **6.3 Background-Pattern-Dependency-Tolerant Weight Transfer Method for Accurate NAND-Flash Based Spiking Neural Networks**, B. Jeon, J. H. Chang, W. Y. Choi, Seoul National University

9:15 AM **6.4 Artificial VO₂ Spiking Neurons with Protective Mechanism for Enhancing Resilience of Spiking Neural Network Against Adversarial Attacks**, C. Ban¹, L. Shan¹, G. Yang¹, J. Gao¹, L. Wu¹, Z. Wang^{1,2}, Y. Cai^{1,2}, R. Huang^{1,2}, ¹Peking University, ²Beijing Advanced Innovation Center for Integrated Circuits

9:30 AM **6.5 Flash-based Computing-in-Memory (CiM) Towards Stochastic Computing with Low Power-consumption and High Noise-immunity**, H. Wang, Y. Feng, X. Zhan, M. Bai, P. P. Sang, J. Wu, Q. Wang, J. Chen, Shandong University

Session 7: GAA/Nanosheet Transistors II

Sunday June 16 9:45 a.m.

Session Chair: Woo Young Choi, SNU

9:45 AM **7.1 (Invited) Multi-Vt Gate Stack Technologies for Nanosheet and CFET Devices**, H. Arimura¹, J. Franco¹, L.-Å. Ragnarsson¹, A. Vandooren¹, S. Brus¹, W. Maqsood¹, T. Conard¹, G. Alessio Verni², J. W. Maes², B. Kannan², M. Givens², N. Horiguchi¹, ¹imec, ²ASM

10:15 AM **7.2 Investigation of Sheet Width Dependence on Hot Carrier Degradation in GAA Nanosheet Transistors**, Z. Sun, Z. Wang, R. Wang, R. Huang, Peking University

Coffee Break 10:30 a.m. – 10:50 a.m.

Session 8: Process and Transistor Technology

Sunday June 16 10:50 a.m.

Session Chair: Xiao Gong, NUS

10:50 AM **8.1 Investigating HfO₂/ZrO₂ Superlattice Dielectric with High-κ Value of 52 via Annealing Temperature and Layer Thickness Modulation Beyond Moore's law**, Y. C. Wu¹, Y.-J. Yao¹, H. J. Chang¹, C.-Y. Wei¹, Y.-M. Fu¹, B.-X. Chen¹, T.-J. Lin¹, Y.-T. Fang¹, G.-L. Luo² and F.-J. Hou², ¹National Tsing Hua University, ²Taiwan Semiconductor Research Institute

11:05 AM **8.2 First Demonstration of SRAM Transistor Based on 3-dimensional Stacked FET with Back Side Interconnection Structure Beyond 1nm Node**, M. Kim^{1,2}, J. Park², S. Park², J. Park², J. Kim¹, D. Ha², H. Shin^{1,3}, ¹Seoul National University, ²Samsung, ³Integra Semiconductor

11:20 AM **8.3 High Performance Te/ZnO CMOS Inverter Operated at 77K**, M. Kim, K. Kim, K. Kim, J. H. Jun, H.-W. Lee, B. H. Lee, Pohang University of Science and Technology

11:35 AM **8.4 Steep Slope Device N-type Gate-Controlled Carrier-Injection SOI-Transistor: Suppression of Hysteresis by Ar-ion Implantation and Possibility of CMOS**, H. Yonezaki, T. Mori, J. Ida, Kanazawa Institute of Technology

11:50 AM **(Lunch break)**

Session 9: 2D Materials and Oxide Semiconductor Devices for 3D integration

Sunday June 16 1:30 a.m.

Session Chair: Byoung Hun Lee, POSTECH

1:30 PM **9.1 (Invited) Potential and Challenges of 2D Materials Based Electronics**, L.-J. Li, University of Hong Kong

2:00 PM **9.2 A Nanosheet Oxide Semiconductor FET Using ALD InZnOx Channel**, S.-H. Kim, K. Hikake, Z. Li, T. Saraya, T. Hiramoto, M. Kobayashi, University of Tokyo

2:15 PM **9.3 Investigation of In-Sn-Zn Composition on the Characterization of Submicron Channel Length Ultra-Thin Atomic Layer Deposited InSnZnO**

Channel Transistors, Y.-K. Liang^{1,2}, L.-C. Peng¹, Y.-L. Lin¹, J.-Y. Zheng¹, D. R. Hsieh¹, T.-T. Chow³, H.-Y. Huang⁴, Y.-M. Lin⁴, Y.-C. Tseng¹, T.-S. Chao¹, E. Y. Chang¹, K. Toprasertpong², S. Takagi², C.-H. Lin¹, ¹National Yang Ming Chiao Tung University, ²The Univ of Tokyo, ³Taiwan Instrument Research Institute, ⁴Taiwan Semiconductor Manufacturing Company

2:30 PM **9.4 BEOL-Compatible In₂O₃ Thin-Film Transistor with Linear Dielectric ZrO₂ Achieving Dielectric Constant over 27 and Enhanced Field-Effect Mobility up to 89.3 cm²/V·s**, Z. Lin, P. Ye, Purdue University

2:45 PM **9.5 First Investigation of Low-Frequency Noise in Scaled Atomic-Layer-Deposited IGZO FETs with Different Indium Ratio**, S. Lee, C. Niu, Z. Zhang, Y. Zhang, L. Long, Z. Lin, H. Wang, P. Ye, Purdue University

3:00 PM **9.6 A Novel Ternary Transistor with Nested Source Design Incorporating Hybrid Switching Mechanism for Low-Power and High-Performance Applications**, S. Xu¹, L. Tianyang¹, T. Luo¹, R. Huang^{1,2}, Q. Huang^{1,2}, ¹Peking University, ²Beijing Advanced Innovation Center for Integrated Circuits

Break 3:15 p.m. – 3:25 p.m.

Poster Session 2

Sunday June 16 3:25 p.m. – 5:30 p.m.

3:25 p.m. **Poster Introductions** (2 minutes each)

Session Chair: K. Kakushima, Tokyo Institute of Technology

(served with coffee/drinks/snacks after the presentation)

P2-1 Compact Model of Feedback Field-Effect Transistor Using Artificial Neural Network, J. S. Su, J. H. Oh, Y. S. Yu, Hankyong National University

P2-2 Neural Encoder Using “PN-Body Tied SOI-FET”, M. Kobayashi, J. Ida, T. Mori, Kanazawa Institute of Technology

P2-3 Engineering Strategies in HfO_x RRAM-Based Analog Synapses Toward Linear Weight Update for Neuromorphic Hardware Accelerators, Y. Kim, H. Choi, J. Woo, Kyungpook National University

P2-4 Enhancing Single-Electron Reservoir Computing Performance with Delay Function and Multiple-layer Reservoir Circuits, S. Watanabe, T. Oya, Yokohama National University

P2-5 Design of Single-Electron Circuit Representing Brownian Motion of Particles to Implement Circuit Capable of Computing Diffusion Limited Aggregation Model, R. Miyakoshi, T. Oya, Yokohama National University

P2-6 A Machine-Learning-based Model for Emerging Memories Featuring Multiple States, Z. Wang¹, Z. Rong², R. Wang³, M. Chan², L. Zhang¹, ¹Peking University Shenzhen, ²Hong Kong University of Science and Technology, ³Peking University

P2-7 Automated Recipe Creation and Verification of Single Wafer Wet Etching: Ensemble Learning with Backcasting and Forecasting AIs Using Scarce Data, K. Shibata¹, H. Horiguchi², C. Matsui¹, K. Takeuchi¹, ¹University of Tokyo, ²SCREEN Semiconductor Solutions Co., Ltd.

P2-8 Design of the 2-nm Nanosheet NAND-type TCAM with High Speed and Compat Cell-size: 45% Layout-reduction of 3-nm TCAM, L.-A. Yu, C.-Y. Chou, C.-C. Lin, T.-Y. Tsai and E. R. Hsieh, NCU

P2-9 Design of Single-electron Information-processing Circuit for Particle Computation, S. Mizuno, T. Oya, Yokohama National University

P2-10 Predicting the Retention Property of Scaled Cylindrical IGZO 2T0C DRAM Cells, S.-M. Jeong, S. -M. Hong, GIST

P2-11 A novel Ballistic Model for the Subthreshold Current of FinFET Nanotransistors, T. -K. Chiang, C.-T. Lin, Y.-X. Liu, J.-W. Lin, and K.-B. Chen, University of Kaohsiung

P2-12 (withdrawn)

P2-13 Simulation of Trap-Induced Noise Characteristics in 3-nm Complementary FET, J. Xu, Z. Zhou, F. Liu, X. Liu, Peking University

P2-14 Simultaneously Improved Electrical Characteristics of Ge n/p-FinFETs by Using HfN Interface Layer with In-Situ Plasma Oxidation Treatments, K.-S. Chang-Liao¹, Y.-Y. Chen², D.-B. Ruan¹, C.-H. Li¹, ¹National Tsing Hua University, ²Fuzhou University

P2-15 High Performance Ge FinFET CMOS Inverter with Post Plasma Oxidation and Nitridation Treatments before Supercritical Fluid Process, K.-S. Chang-Liao¹, W.-C. Hung², D.-B. Ruan¹, K.-C. Yang¹, ¹National Tsing Hua University, ²Fuzhou University

P2-16 Characteristics of Aluminum-based Oxide with ALD SiO₂ Interfacial Layer as the Gate Dielectric of the Silicon Carbide (SiC) MOS Capacitor with RTA Annealing, C.-L. Lin, B. X. Su, Y. L. Lee, Feng Chia University

P2-17 Electrical Characteristics of BEOL-Compatible Top-Gate In₂O₃ Transistors, P. Hong, J. Hao, X. Li, Huazhong University of Science and Technology

Closing Remarks

5:25 p.m. Announcement of 2025 SNW (in Kyoto)