Session 15 - Memory Technology - Ferroelectrics
Tuesday, December 10, 9:00 a.m.
Continental Ballroom 6
Co-Chairs: J. van Houdt, imec/KU Leuven
M. Kobayashi, University of Tokyo

9:05 AM **15.1** Material Perspectives of HfO_2-based Ferroelectric Films for Device Applications
Akira Toriumi, Lun Xu, Yuki Mori, Xuan Tian, Patrick Lomenzo, Halid Mulaosmanovic, Monica Materano, Thomas Mikolajick, Uwe Schroeder, The University of Tokyo, TU-Dresden

This paper gives material fundamentals and new insights to ferroelectric HfO2 for device applications. The key role of dopants, effects of the interface on ferroelectric phase, and a detailed discussion of switching kinetics are of central focus. Based on them, we discuss opportunities of ferroelectric HfO_2 for device applications.

9:30 AM **15.2** First Direct Measurement of Sub-Nanosecond Polarization Switching in Ferroelectric Hafnium Zirconium Oxide
Xiao Lyu, Mengwei Si, Pragya Shrestha, Kin Cheung, Peide Ye, Purdue University, National Institute of Standards and Technology

We report on an ultrafast direct measurement on the transient ferroelectric polarization switching in hafnium zirconium oxide with metal-insulator-metal structures. A record low sub-nanosecond characteristic switching time of 925 ps was achieved. The impact of electric field, film thickness and device area on the polarization switching speed is systematically studied.

9:55 AM **15.3** 3D Scalable, Wake-up Free, and Highly Reliable FRAM Technology with Stress-Engineered $HfZrO_x$
Yu-De Lin, Heng-Yuan Lee, Ying-Tsan Tang, Po-Chun Yeh, Hsin-Yun Yang, Po-Shao Yeh, Chih-Yao Wang, Jian-Wei Su, Sih-Han Li, Shyh-Shyuan Sheu, Tuo-Hung Hou, Wei-Chung Lo, Min-Hung Lee, Meng-Fan Chang, Ya-Chin King, Chrong-Jung Lin, Taiwan Semiconductor Research Institute, Industrial Technology Research Institute, National Taiwan Normal University, National Tsing Hua University

The major challenge in FRAM scaling is to maintain the high polarization density on the vertical sidewall of 3D-ferroelectric capacitors. We achieved a 3D-sidewall FRAM with high reliability of 10^9 endurance, 10-year retention and sidewall P_r 18μC/cm^2. Two simple methods are contributed to the scaling capability of 3D-FRAM in 3X-nm.

10:20 AM *COFFEE BREAK*

10:45 AM **15.4** Impact of Homogeneously Dispersed Al Nanoclusters by Si-monolayer Insertion into $Hf_{0.5}Zr_{0.5}O_2$ Film on FeFET Memory Array with Tight Threshold Voltage Distribution
Keiichi Maekawa, Tadashi Yamaguchi, Takahiro Ohara, Atsushi Amo, Eiji Tsukuda, Kenichiro Sonoda, Hiroshi Yanagita, Masao Inoue, Masazumi Matsuura, Tomohiro Yamashita, Renesas Electronics Corporation

Threshold voltage variation for ferroelectric field-effect transistor memory using $Hf_{0.5}Zr_{0.5}O_2$ films with Al nanoclusters is investigated. Si-monolayer formed over Al nanoclusters effectively reduces the variation, due to suppressing the migration and aggregation of Al nanoclusters, resulting that the orientation and the growth rate for each ferroelectric domain is successfully aligned.

11:10 AM **15.5** Next Generation Ferroelectric Memories Enabled by Hafnium Oxide (Invited)

Thomas Mikolajick, Uwe Schroeder, Patrick Lomenzo, Evelyn Breyer, Halid Mulaosmanovic, Michael Hoffmann, Terence Mittmann, Furqan Mehmood, Benjamin Max, Stefan Slesazeck, NaMLab gGmbH, Technische Universtität Dresden

Ferroelectrics are an ideal solution for low write power nonvolatile memories. The complexity of ferroelectric perovskites has hindered the scaling. Ferroelectricity in hafnium oxide solved this issue making ferroelectric memories in its three variants, ferroelectric RAM, ferroelectric field effect transistors and ferroelectric tunneling junctions interesting for future memory solutions again.

11:35 AM **15.6** Impact of Charge Trapping on Imprint and its Recovery in HfO_2 based FeFET
Yusuke Higashi, Nicolò Ronchi, Ben Kaczer, Kaustuv Banerjee, Sean McMitchell, Barry O'Sullivan, Sergiu Clima, Albert Minj, Umberto Celano, Luca DiPiazza, Masamichi Suzuki, Dimitri Linten, Jan Van Houdt, Kioxia Corporation, imec, KU Leuven

For ferroelectric-HfO_2 based FET (FeFET), imprint has been regarded as a major issue. However, most studies have been conducted only on capacitors. In this paper, imprint of FeFET as well as simulation of charge trapping is reported. The strong effect of charge trapping is responsible for imprint and its recovery.

12:00 PM **15.7** Demonstration of BEOL-Compatible Ferroelectric Scaled $Hf_{0.5}Zr_{0.5}O_2$ FeRAM Co-Integrated with 130nm CMOS for Embedded NVM Applications
Terry Francois, Laurent Grenouillet, Jean Coignus, Philippe Blaise, Catherine Carabasse, Nicolas Vaxelaire, Thomas Magis, François Aussenac, Virginie Loup, Catherine Pellissier, Stefan Slesazeck, Viktor Havel, Claudia Richter, Adam Makosiej, Bastien Giraud, Evelyn Breyer, Monica Materano, Philippe Chiquet, Marc Bocquet, Etienne Nowak, Uwe Schroeder, Fred Gaillard, CEA-Leti, NaMLab gGmbH, Aix-Marseille Université

We demonstrate scalability of HZO capacitors down to 300nm by co-integrating them for the first time in Back-End-Of-Line of 130nm CMOS technology. Excellent performance are reported: $2.P_R$ >40µC/cm², endurance $>10^{11}$, switching speeds <100ns, operating voltages <4V, and data retention at 125°C paving the way towards <10fJ/bit ultra-low power FeRAM for IoT applications.