DS 3: Thin Film Applications I

Time: Monday 9:30–10:30 Location: CHE 91

DS 3.1 Mon 9:30 CHE 91

Intrinsic oxygen vacancy driven universal 1/f noise behaviour of yttrium oxide-based Resistive Random Access Memory devices — •Eszter Piros[1], Martin Lonsky[2], Stefan Petzold[1], Jens Müller[2], and Lambert Alff[1] — [1]Institute of Materials Science, ATFT, Technische Universität Darmstadt, Darmstadt, Germany — [2]Institute of Physics, Goethe- University Frankfurt, Frankfurt am Main, Germany

Resistive Random Access Memory (RRAM) is an outstanding next-generation memory candidate due to its excellent performance and scaling potential. However, further improvement of device reliability and variability is required. In this respect, the choice of materials can play a key role. Y_2O_3 is a very interesting material for resistive switching as 25% of the anion sublattice is unoccupied. Yttria-based devices show gradual switching under DC and nanosecond-regime voltage pulse operation [1], and thus can be utilized in multi-bit and neuromorphic applications. To assess device reliability and to gain insight into the charge transport characteristics, low-frequency noise measurements were performed on Y_2O_3-based RRAM devices at several intermediate resistance states and as a function of DC switching cycles. A universal noise behaviour was observed with a frequency exponent of $\alpha \approx 1.2$ that is independent of the device resistance and the number of DC switching cycles. The noise magnitude is found to systematically decrease with DC cycling and to increase with the maximum applied voltage in the reset process.

[1] S. Petzold et al., Semicond. Sci. Technol. 34, 075008 (2019)

DS 3.2 Mon 9:45 CHE 91

Heavy ion irradiation effects on emerging memories: OxRAM, FeRAM and PCM — •Tobias Vogel[1], Nico Kaiser[1], Eszter Piros[1], Maximilian Lederer[2], Ricardo Olivo[2], Tarek Ali[2], Anna Lisa Serra[3], Thomas Kämpfe[2], Stefan Petzold[1], Gabriele Navarro[3], Christelle Charpin-Nicolle[3], Christina Trautmann[1,4], and Lambert Alff[1] — [1]TU Darmstadt, Darmstadt, Germany — [2]Fraunhofer IPMS, Dresden, Germany — [3]CEA LETI, Grenoble, France — [4]GSI Helmholtzzentrum, Darmstadt, Germany

Emerging memory classes such as oxide based resistive random-access memory (OxRAM), ferroelectric random-access memory (FeRAM) or phase-change memory (PCM) are discussed as the successor of flash technology for highly-scaled device technology. Thereby, radiation hardness is of particular interest, enabling applications e.g. in space conditions. Here, Resistive Random-Access Memory (RRAM) devices are promising for applications in harsh radiation environments due to their superior data retention upon ionizing radiation, especially compared to flash technology. [1] In this study, we compare the effect of heavy ion irradiation, the most hazardous kind of ionizing irradiation, on the structural and electrical properties of different emerging memory classes: Phase Change Memory (PCM) based on GST, Ferroelectic Random Access Memory (FeRAM) and OxRAM based on HfO_x. [1] S. Petzold et al., Heavy Ion Radiation Effects on Hafnium Oxide-Based Resistive Random Access Memory, IEEE Trans. Nucl. Sci. 66, 1715 (2019).

DS 3.3 Mon 10:00 CHE 91

Simulation of resistive switching in HfOx based RRAM and the role of low temperature tetragonal and hexagonal hafnia phases in conductive switching — •Nico Kaiser[1], Stefan Petzold[1], Enrique Miranda[2], Alexander Zintler[1], Leopoldo Molina-Luna[1], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt, Germany — [2]Departament d Enginyeria Electrònica, Universitat Autònoma de Barcelona, Spain

HfOx is a promising candidate for the functional layer in Resistive Random Access Memory (RRAM) with the potential to replace conventional FLASH memory and being implemented in emerging technologies such as neuromorphics or in-memory computing. Although resistive switching was intensively investigated in recent years, the exact mechanism and the role of oxygen vacancies is not completely understood and highly debated. In this study, we developed an electrical conduction model utilizing two antiserially connected memdiodes (diodes with memory). In this way, all switching modes observed in stoichiometric monoclinic (m-HfO2) and oxygen-vacancy-stabilized low-temperature tetragonal (LTP t-HfOx) phase can be simulated. The separation of conduction characteristics via memdiodes allows to evaluate the role of both electrode-oxide interfaces separately. Through experimental thin film characterization methods such as XRD, XPS and electrical measurements, we investigate the physical properties of HfOx phases. Using TEM, we identify HfOx structures and their fingerprints in EELS which can be used to identify the role of LTP t-HfOx and hcp-HfOx in the switching process.

DS 3.4 Mon 10:15 CHE 91

Towards a large-scale quantum simulator at room temperature — •Philipp J. Vetter[1], Thomas Unden[1], Nikolas Tomek[1], Tamara Sumarac[2], Elana K. Urbach[2], Timo Weggler[1], Maximilian G. Hirsch[1], Hideyuki Watanabe[3], Kohei M. Itoh[4], Boris Naydenov[5], Mikhail D. Lukin[2], Martin B. Plenio[6], and Fedor Jelezko[1] — [1]Institute for Quantum Optics and Center for Integrated Quantum Science and Technology, Universität Ulm — [2]Department of Physics, Harvard University — [3]Correlated Electronics Group, Electronics and Photonics Research Institute, National Institute of Advanced Industrial Science and Technology, Tsukuba — [4]Department of Applied Physics and Physico-Informatics, Faculty of Science and Technology, Keio University — [5]Helmholtz-Zentrum Berlin für Materialien und Energie — [6]Institute for Theoretical Physics and Center for Integrated Quantum Science and Technology, Universität Ulm

Quantum simulators enable the study of strongly-correlated many-body systems that may exhibit exotic phases, such as spin liquids and supersolids. We present our progress of creating a large-scale quantum simulator at room-temperature, which is based on the nitrogen vacancy center in diamond, coupled to surrounding nuclear spins. We demonstrate the fabrication of a 1 nm thin 13C layer in diamond which is polarized and coherently controlled by the NV center. Furthermore, 2D-Materials which offer a clearly identifiable symmetry and thickness are transferred onto the diamond surface. The nuclear spins within the transferred flake are sensed via the NV center aiming for full polarization by tailored pulse schemes.