HL 5: Innovative Systems and Devices

Time: Monday 10:15–12:30 Location: POT 06

HL 5.1 Mon 10:15 POT 06

Memristive switching in vanadium dioxide thin films — Danilo Bürger, Varun John, György Kovács, Ilona Skorupa, Manfred Helm, and •Heidemarie Schmidt — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01314 Dresden

Memristive devices [1] exhibit an improved performance at ultra-small scales. The microscopic model for memristive behavior in oxide nanostructures often depends on the distribution of oxygen vacancies and is determined by the cation species. In 2008 HP presented the first bipolar TiO2-based memristor for resistive applications, where the drift of oxygen vacancies causes a change in the resistance of ultrathin TiO2 films [2] which can be locally modified by ion implantation [3]. We prepared vanadium dioxide (VO2) thin films with the reversible metal-insulator phase transition at the thermochromic switching temperature of around 340 K by pulsed laser deposition on (0001)-sapphire substrates and analyzed the electric-pulse-induced thermochromic switching in the VO2 gap region at room temperature due to local heating. As a result, we find the typical pinched hysteresis loop of a memristor, a repeatable switching behavior for billions of voltage pulses and switching times shorter than 50 ns in VO2 thin films.

[1] L. Chua, IEEE Transactions on Circuits Theory 18, 507 (1971). [2] D. B. Strukov, G. S. Snider, D. R. Stewart, and R. S. Williams, Nature 453, 80 (2008). [3] S. Zhou, E. Čižmár, K. Potzger, M. Krause, G. Talut, M. Helm, J. Fassbender, S. A. Zvyagin, J. Wosnitza, and H. Schmidt, Phys. Rev. B 79, 113201 (2009)

HL 5.2 Mon 10:30 POT 06

Disorder induced localization in crystalline phase-change materials — •Peter Jost[1], Theo Siegrist[1,2], Hanno Volker[1], Michael Woda[1], Philipp Merkelbach[1], Carl Schlockermann[1], and Matthias Wuttig[1] — [1]I. Physikalisches Institut (IA), RWTH Aachen University, 52056 Aachen, Germany — [2]Department of Chemical and Biomedical Engineering, Florida State University, Tallahassee, FL 32310

Phase-change materials (PCMs) are ideally suited for data storage devices employing the amorphous to crystalline phase transition. In this work[1] we report on a metal insulator transition (MIT) in the crystalline state of the pseudo-binary alloys between GeTe and Sb_2Te_3. The insulating state results from a degree of disorder which is untypically high for crystalline solids. The change of disorder upon annealing leads to the MIT. Moreover, we will demonstrate that this MIT is accompanied by a universal minimum metallic conductivity for all alloys under investigation. While MITs have been discussed as consequences of disorder induced localization (Anderson) and electron correlation effects (Mott) at the same time, the latter (Mott type) is often dominant. We will, however, show that disorder induced localization must be prevalent here. Thus, the crystalline phase of PCMs constitutes a very uncommon state of matter being equally interesting for technical applications and fundamental research on localization physics.

[1] Siegrist, T. et al. Accepted for publication in Nature Mater.

HL 5.3 Mon 10:45 POT 06

Electronic Transport Properties of Nb/InAs-Nanowire/Nb Josephson Junctions — •h. yusuf günel[1], igor e. batov[2], hilde hardtdegen[1], kamil sladek[1], andreas penz[1], gregor panaitov[3], detlev grützmacher[1], and thomas schäpers[1] — [1]Institute of Bio- and Nanosystems (IBN-1) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, Moscow district, Institutskaya 2, 142432 Russia — [3]Institute of Bio- and Nanosystems (IBN-2) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany

We experimentally studied the electronic transport properties of Nb/InAs-Nanowire/Nb Josephson junctions. Highly doped InAs nanowires were used as a weak link between two superconducting electrodes, in order to form a Josephson junction (JJs). At temperatures below the critical temperature of Nb (Tc~7K) a clear supercurrent was observed in the current-voltage characteristics. In addition, we analyzed the temperature and magnetic field dependence of the Josephson supercurrent. A complete suppression of the supercurrent was observed at a temperature of around 7K and a magnetic field of 0.5T, respectively. In detailed magnetic field dependent measurements clear oscillations were observed in the differential resistance. Furthermore, at zero magnetic field the differential resistance revealed characteristic features of multiple Andreev reflections.

HL 5.4 Mon 11:00 POT 06

low-k dielectric and amorphous SiO2 - a comparative TEM/EELS analysis — •Pradeep Singh[1], Sven Zimmerman[2], Steffen Schulz[1], Stefan Schulze[2], and Michael Hietschold[1] — [1]Chemnitz University of Technology, Institute of Physics, Chemnitz, Germany — [2]Fraunhofer ENAS, Department Back-End of Line, Chemnitz, Germany

The use of low dielectric constant materials (k<3) as a replacement of SiO2 (k=3.9) in the Back End of Line (BEOL) reduces interconnect delay, power dissipation and crosstalk noise. Current low-k dielectrics (SiCOH) prepared by the doping of methyl group in the SiO2 networks; have been studied very little from the structural point of view. In this study, we choose porous SiCOH as a low k dielectric material with dielectric constant k = 2.4 to investigate its structural, optical and electronic properties. The radial distribution function (rdf) derived from the Selected Area Electron Diffraction (SAED) allows to identify the atomic arrangement in the matrix. This gives the opportunity to investigate the structural difference between amorphous SiO2 and low-k dielectrics. Careful investigation of electron energy-loss spectroscopy (EELS) combined with TEM, provides information about the elemental composition, chemical bonding, band structure, dielectric functions, valence, and conduction electron densities. The rdf curve of porous SiCOH indicates a significant difference in density and structural arrangement as compared to amorphous SiO2.

15 min. break

HL 5.5 Mon 11:30 POT 06

Quantitative Characterization of Dielectric and Electronic Properties on the Nanometer Scale — •Matthias Fenner[1], Ferry Kienberger[1], Hassan Tanbakuchi[1], Hans-Peter Huber[2], and Markus Hochleitner[2] — [1]Agilent Technologies Inc., — [2]Christian-Doppler-Laboratory, Johannes Kepler University Linz, Austria

We report recent advances in calibrating methods for Scanning Microwave Microscopy (SMM). This combines Atomic Force Microscopy (AFM) and a Vector Network Analyzer using microwave tip sample interaction to characterize dielectric and electronic material properties on the nanometer scale. It features quantitative measurements of

1.Calibrated capacitance with attofarad sensitivity

2.Calibrated semiconductor dopant density in the range from 10^14 atoms/cm^3 to 10^20 atoms/cm^3

For capacitance calibration, a standard sample of stepped dielectric with differently sized conductive gold pads is used. Depending on the size of the various gold pads and the dielectric step height, the corresponding capacitance values ranged from 0.1 fF to 22 fF at a noise level of ~1 aF. The electrical footprint of the AFM-tip was measured on the stepped dielectric when the tip is placed on the dielectric only, resulting in an effective tip diameter of ~50 nm and tip-sample capacitance of ~5 aF. The dopant density calibration is performed by imaging the cross section of a standard sample with differently doped layers (dopant stair case) from 10^14 atoms/cm^3 to 10^20 atoms/cm^3. We present the methods for calibration as well as applications of SMM.

HL 5.6 Mon 11:45 POT 06

Si-InAs heterojunction Esaki tunnel diodes with high current densities — •Cedric Bessire, Mikael Björk, Heinz Schmid, Kirsten Moselund, Hesham Ghoneim, Siegfried Karg, and Heike Riel — IBM Research Zurich, Säumerstrasse 4, 8803 Rüschlikon, Switzerland

The tunnel field effect transistor (TFET) is considered to be one of the most promising candidates for low power operation because its turn-on characteristics can be steeper than that of conventional FETs, which could allow drastic scaling of the supply voltage. However, to date TFET implementations show poor performance of the drive current compared to conventional CMOS devices due to low tunneling probability. For high currents in TFETs degenerated semiconductors and abrupt interfaces are needed. This can be evaluated by Esaki tunnel diodes that indicate the limits of the drive current.

We report on Si-InAs heterojunctions with high tunnel current densities and negative differential resistance region in low forward bias. The p-n diodes were fabricated by growing InAs nanowires in oxide mask openings on silicon substrates. At substrate doping concentrations of 1e16 and 1e19 cm-3, conventional diode characteristics were obtained, from which a valence band offset between Si and InAs of 130 meV was extracted. For a substrate doping of 4e19 cm-3, heterojunction tunnel diode characteristics were obtained showing current densities in the range of 50 kA/cm2 at 0.5 V reverse bias. In addition, in situ doping of the InAs wires was performed using disilane to further boost the tunnel currents up to 100 kA/cm2 at 0.5 V reverse bias.

HL 5.7 Mon 12:00 POT 06

Evaluation of measurement techniques for characterization of charge trapping materials for memory applications — •Ekaterina Yurchuk, Thomas Melde, and Thomas Mikolajick — NaMLab gGmbH, Nöthnitzer Str. 64, 01187 Dresden, Germany

The charge trapping memories are based on the charge storage in isolated trap states within the gate dielectric of the field effect transistor. The trap parameters can be extracted from the charge loss dynamics, as retention measurements. The aim of the present work was to identify the most suitable measuring technique for subsequent evaluation of the trap density distribution within the memory layer.

Two methods for experimental determination of retention characteristics on SONOS (silicon-oxide-nitride-oxide-polysilicon) capacitor structures were studied. The most common approach for measuring the threshold voltage shift is the application of zero gate voltage during the wait time. On the contrary, the constant capacitance method applies a regulated gate voltage to maintain the flatband condition. The effect of temperature, program state and programming conditions on the charge loss for both measuring techniques are analyzed. The constant capacitance method allows the predefinition of the field conditions in bottom oxide and thus must be more appropriate for the extraction of trap density distribution. However, the carried out experiments and simulations of the discharging process could only partially confirm this assumption.

HL 5.8 Mon 12:15 POT 06

Silicon to nickel-silicide axial nanowire heterostructures as Bio-FETs — •Sebastian Pregl[1], Walter Weber[2], and Gianaurelio Cuniberti[1] — [1]Institute for Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, 01062 Dresden, Germany — [2]NaMLab GmbH, D-01187 Dresden, Germany

Silicon Nanowire based field effect transistors (FETs) have shown to be capable of label-free and real-time detection of biomolecules in fluidic media. Antagonist binding events lead to a gating effect and therefore a change in source-drain current. Next generations of biosensor FETs have to become more sensitive and strategies have to be developed to handle sample related screening and parasitic pH effects. Our research is focused on utilization of bottom-up synthesised Schottky barrier FETs (SB-FETs) for this new kind of sensors. Silicon nanowires grown with catalytic chemical vapor deposition (CVD) are contacted to Nickel pads which form source and drain. Annealing leads to axial nickel-silicidation resulting in an atomic sharp metal-semiconductor interface and therefore a defined Schottky barrier. So build SB-FETs show inverse subthreshold slopes as low as 110 mV/dec and a high on/off current ratio. This indicates the possibility of manipulating the barrier height by applied electrical fields in a very efficient way. Using this SB-FET as a detector for biological species promises therefore a very high sensitivity. Current investigations on the nature of the sensing effect on protein adsorption are running. The effect on the sensing regions (Schottky junctions vs. channel) will be assessed.