HL 57: Thin Oxides and Oxide Layers I (joint session DS/HL/O)

Time: Thursday 9:30–10:45 Location: CHE 91

HL 57.1 Thu 9:30 CHE 91

Atomically sharp epitaxial interface between Ba_2SiO_4 and Si(001) — •Julian Koch and Herbert Pfnür — Leibniz Universität Hannover, Institut für Festkörperphysik

Epitaxial growth of Ba_2SiO_4 on Si(001) is a challenge, since neither crystal symmetry nor lattice constants match in a simple manner, but as we show, it has the potential to become the first high quality crystalline high-k gate dielectric. We combined X-ray photoelectron spectroscopy (XPS), low energy electron diffraction (LEED) and aberration-corrected scanning transmission electron microscopy (STEM) in order to optimize the epitaxial growth by molecular beam epitaxy. The films were grown by a co-deposition method that requires no diffusion of Si from the substrate. While 400 °C turned out to be sufficient to form chemically homogeneous films, crystalline films required an annealing step to $670-690$ °C with the break-up of interfacial Si-O bonds as crucial step. STEM confirms that the interface is atomically sharp and that a single layer of the silicate is changed to a (2×3) structure at the interface from the (2×1.5) bulk structure. Electrical measurements on MOS-diodes with this material show small hysteresis in CV-curves, low interface trap densities ($<6\times10^{10}$ cm^2eV^{-1}) and low leakage currents.

HL 57.2 Thu 9:45 CHE 91

Nano-scale spectroscopic analysis of $LaAlO_3/SrTiO_3$ interfaces using scattering-type Scanning Near-field Optical Microscopy — •Yigong Luan[1], Julian Barnett[1], Marc Rose[2], Felix Gunkel[2], Martin Lewin[1], and Thomas Taubner[1] — [1]Institute of Physics (IA) RWTH Aachen — [2]PGI-3, Forschungszentrum Jülich

In the group of functional oxide materials, the interface of bulk insulators $LaAlO_3$ and $SrTiO_3$ (LAO/STO) attracts attention due to its highly confined and conductive two-dimensional electron gas (2DEGs), which could be interesting for high-electron-mobility transistors. 2DEGs at oxide interfaces result from electronic reconstruction, which is highly dependent on the local structure [1]. The extraction of their electronic properties is difficult for far-field spectroscopy and conventional nano-resolved microscopy (e.g. STM), as the conducting layer is highly confined and buried below an insulating layer (LAO). We overcome these limitations by using scattering-type Scanning Near-field Optical Microscopy for a quantitative extraction of electron properties from "phonon-enhanced spectroscopy", as the presence of free charge carriers leads to significant changes to the phonon resonance due to plasmon-phonon coupling [2]. We use an improved model (Finite Dipole Model) combining with Transfer Matrix Method to interpret the experimental results, investigating the influence of both LAO layer and 2DEGs on the STO phonon near-field resonance in detail, which allows us to extract the local electronic properties.
[1] A. Ohtomo et al., Nature 427, 423 (2004)
[2] M. Lewin et al., Adv. Funct. Mater, 28. 1802834 (2018)

HL 57.3 Thu 10:00 CHE 91

Optoelectrical properties of VO_2 ultra-thin films — •Maximilian Obst[1], Laura Rodríguez[2], Gustau Catalan[2,3], Susanne C. Kehr[1], and Lukas M. Eng[1,4] — [1]Institute of Applied Physics, Technische Universität Dresden, Germany — [2]Institut Catalá de Nanociéncia i Nanotecnologia and The Barcelona Institute of Nanoscience and Technology, Campus UAB, Barcelona, Catalonia — [3]ICREA-Institució Catalana de Recerca i Estudis Avançats, Barcelona, Catalonia — [4]ct.qmat: Dresden-Würzburg Cluster of Excellence - EXC 2147, Technische Universität Dresden, Germany

Vanadium dioxide (VO_2) is a material that is in the central research focus due to its metal-to-insulator phase transition (MIT) at room temperature. Experimentally, this temperature-regime is easily accessible, and hence allows profound MIT-studies while dreaming of interesting applications, such as phase-change memories. Although thicker VO_2 films are intensively investigated, the properties and physical behavior of ultrathin VO_2 layers are far from being understood.

In this work, an epitaxial VO_2-film of 10 nm grown on a rutile(001) single-crystal is explored, applying a broad set of electrical and optical methods. While Raman-spectroscopy revealed no structural phase transition of the film, electrical transport measurements as well as spectrally-resolved (UV to mid-IR) reflectivity measurements clearly show the MIT at ~300 K. In conclusion, the structural and electrical phase transition seems to be completely disentangled in these ultrathin films. However, thin VO_2-films might easily oxidize to V_2O_5, as was indicated by measuring the vanadium $2p_{3/2}$-peak using XPS.

HL 57.4 Thu 10:15 CHE 91

Towards quasi two-dimensional β-Ga2O3 — •Constance Schmidt, Mahfujur Rahaman, and Dietrich R. T. Zahn — Semiconductor Physics, Chemnitz University of Technology, D-09107 Chemnitz, Germany

β-Ga2O3 is a transparent oxide semiconductor with outstanding properties due to its wide bandgap (Eg = 4.9 eV). It is already intensively studied in its bulk and thin film form. Studies on ultrathin films or even quasi-2D films are less common. Nevertheless, for nano electronics quasi-2D β-Ga2O3 can be beneficial as semiconductor or insulator, depending on layer thickness and doping [1]. β-Ga2O3 is not a van-der-Waals material, which makes conventional exfoliation challenging. Attempts show that layer thicknesses below 60 nm are not yet possible by exfoliating β-Ga2O3 [2]. To overcome this difficulty, we use a van-der-Waals material (GaSe), exfoliate thin flakes on Si with 300 nm SiO2, HOPG and Mica substrates, and oxidize these flakes by thermal annealing ((600 - 1000)°C, 30 min, in air) to obtain quasi 2D β-Ga2O3. In this work, we show the preparation of Se free quasi-2D β-Ga2O3 by annealing using temperatures higher than 700°C. The thin flakes obtained have thicknesses in the range of (0.5 - 50) nm as measured with atomic force microscopy. Energy dispersive X-ray spectra reveal the chemical composition of the 2D flakes and most importantly the absence of Se. Raman spectroscopy (excitation: 325 nm) verifies the β-Ga2O3 phase.

[1] J. Su, et al., J. Phys. Chem. C 122 43 24592-24599 (2018) [2] Y. Kwon, et al., APPLIED PHYSICS LETTERS 110 131901 (2017)

HL 57.5 Thu 10:30 CHE 91

Thermal phase transformations through iron oxides/ oxide substrates interfaces — •Mai Hussein Hamed[1,2], David N. Mueller[1], Tomáš Duchoň[1], Ronja Hinz[1], Claus M. Schneider[1,3], and Martina Müller[1,4] — [1]Peter-Grünberg-Institut (PGI-6), Forschungszentrum Jülich GmbH, Germany — [2]Faculty of Science, Helwan University, Cairo, Egypt — [3]Fakultät für Physik, Duisburg-Essen Universität , Germany — [4]Experimentelle Physik I, Technische Universität Dortmund, Germany

Oxide heterostructures possess a wide range of electrical and magnetic properties arising, in particular, vie interactions across their interfaces. Therefore, our primary goal is understanding, controlling and tuning the interface properties. In this study, using hard X-ray photoelectron spectroscopy (HAXPES), we demonstrate phase transformations from Fe_3O_4 to either γ-Fe_2O_3 or FeO through active redox reactions across three relevant interfaces, i.e. (1) the outside atmosphere/Fe_xO_y film interface, (2) the interface between phase-transformed Fe_xO_y/Fe_xO_y intralayers and (3) the Fe_xO_y/oxide substrate interface. We find that the "active" oxide substrates ($SrTiO_3$ or YSZ) play an important role as an additional oxygen supplier or scavenger. This leads to a clear alteration of the standard temperature-pressure phase diagram of iron oxides. Accordingly, we calculate the effective oxygen pressure through the interfaces and adjust the phase diagram. Our findings allow us not only to control the interfaces but more importantly, to tune their physical functionalities by a controlled thermal phase design, giving access to far from equilibrium phases.