

HL 41: Heterostructures, interfaces, and surfaces

Time: Thursday 15:00–17:15

Location: H31

HL 41.1 Thu 15:00 H31

Electronic properties of hybrid organic/inorganic semiconductor pn-junctions — MORITZ FUTSCHER^{1,3}, ●THORSTEN SCHULTZ¹, JOHANNES FRISCH², MARYLINE RALAIARISOA¹, EZZELDIN METWALLI³, MARCO NARDI¹, PETER MÜLLER-BUSCHBAUM³, and NORBERT KOCH^{1,2} — ¹Institut für Physik & IRIS Adlershof, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — ²Helmholtz-Zentrum Berlin für Materialien und Energie GmbH-BESSY II, 12489 Berlin, Germany — ³Physik-Department, Lehrstuhl für Funktionelle Materialien, Technische Universität München, 85748 Garching, Germany

Hybrid inorganic/organic semiconductor heterojunctions are candidates to expand the scope of purely organic or inorganic junctions. Comprehensive understanding of bulk and interface doping on the junction's electronic properties is therefore desirable. In this work, we elucidate the energy level alignment and its mechanisms at a prototypical hybrid pn-junction comprising ZnO (n-type) and p-doped α -NPD, using photoelectron spectroscopy. The level alignment can be quantitatively described by the interplay of contact-induced band and energy level bending in the inorganic and organic component away from the interface, and the formation of an interface dipole. By adjusting the dopant concentration in α -NPD, the position of the frontier energy levels of ZnO can be varied by over 0.5 eV and that of α -NPD by over 1 eV. The tunability of this pn-junction's energy levels evidences the substantial potential of the hybrid approach for enhancing device functionality.

HL 41.2 Thu 15:15 H31

Orientation of antiphase boundaries in GaP on Si(001) — ●PASCAL FARIN, MARIO DÄHNE, HOLGER EISELE, and ANDREA LENZ — TU Berlin, Berlin, Deutschland

Monolithic integration of III-V semiconductors on Si would dramatically lower the cost of optoelectronic devices as well as improve their performance. Due to its small lattice mismatch with Si, GaP is particularly suited. However, locally charged defects called antiphase boundaries strongly deteriorate the optoelectronic device performance. While growth conditions that limit the antiphase-domain size and density have already been found, the exact crystalline orientation of the two-dimensional antiphase boundaries remains unclear. Their orientation is related to the net doping introduced into the crystal.

In this work, antiphase boundaries are investigated in detail by means of cross-sectional scanning tunneling microscopy (XSTM) on two perpendicular cleavage surfaces of the same sample. It is shown, how it is thereby possible to determine the exact orientation of the antiphase boundaries and their shares of the entire antiphase domain surface in order to finally estimate the net doping caused by the antiphase boundaries.

We thank Prof. K. Volz *et al.* for providing the sample and we acknowledge support by the DFG, project LE 3317/1-2.

HL 41.3 Thu 15:30 H31

Strain study of piezotronic ZnO microstructures utilising X-ray nanodiffraction techniques — PHILIPP JORDT¹, STJEPAN HRKAC², NIKLAS WOLFF³, MONA MINTKEN³, ●CHRISTINA KRYWKA⁴, RAINER ADELUNG³, LORENZ KIENLE³, OLAF MAGNUSSEN¹, and BRIDGET MURPHY¹ — ¹Institut für Experimentelle und Angewandte Physik, Kiel University, Germany — ²UC San Diego, CA, USA — ³Technische Fakultät, Kiel University, Germany — ⁴Zentrum für Material- und Küstenforschung, Helmholtz-Zentrum Geesthacht, Germany

Combining piezoelectric/piezotronic and magnetostrictive materials is one promising approach to design bio magnetic field sensors to detect magnetic signals from the human body. To achieve the extreme sensitivity of less than 100 pT required for medical applications, is a challenge. Piezotronic readout is possibility to increase the limit of detection. For piezotronic, the strain induced piezoelectric potential causes additional charges at the metal-semiconductor interface resulting in a change of height and width of the Schottky barrier. The charge carrier transport across the metal-semiconductor contact is therefore dependent on the piezoelectric charges, which can be controlled by the applied strain or vice versa. For this experiment we used ZnO micro wires with diameters between one and 100 microns. During the

experiment we collected the current voltage curves of the sample and simultaneously applied a mechanical stress while observing key Bragg reflections. This nanofocus diffraction experiment provided unique spatially resolved lattice deformation during piezotronic measurements.

HL 41.4 Thu 15:45 H31

Non-percolative dielectric films based on conductor-insulator hybrid material systems — ●MARKUS WIESINGER, TILL WELZEL, AYLIN GELLE, and MARTIN STUTZMANN — Walter Schottky Institut and Physics Department, TUM, Am Coulombwall 4, 85748 Garching b. München, Germany

The application of new hybrid materials for e.g. small floating gate MOSFETs or high power devices is motivated by novel properties of hybrid dielectric layers such as enhanced and tunable dielectric constants, the capability to store and retain charge for long time or the ability to screen high electric fields. In this study, we explore approaches to produce a polyimide-nanoparticle-based hybrid thin film, which has a tunable dielectric constant. We put our focus on suppressing percolation effects in the films and enhance interface polarization at the internal boundaries. This is achieved by carefully choosing different materials and systematically changing the processing conditions. The dielectric and electrical properties of our films are investigated using impedance spectroscopy and DC-conductivity measurements. The results will be discussed in terms of the nanoparticles utilized, the processing conditions and the resulting structure of the material.

HL 41.5 Thu 16:00 H31

In-Situ Patterning of IBC SHJ Solar Cells with Efficiencies Exceeding 20 % — ●PHILIPP WAGNER^{1,2}, DIMITRI BELOSTOTSKI¹, JOHANN-CHRISTOPH STANG¹, BERND STANNOWSKI³, BERT STEGEMANN², and LARS KORTE¹ — ¹HZB, Institute Silicon Photovoltaics, Kekuléstraße 5, D-12489 Berlin — ²HTW Berlin, Wilhelmshofstraße 75a, D-12459 Berlin — ³HZB, Institute PVcomB, Schwarzschildstraße 3, D-12489 Berlin

Silicon represents the predominant material for solar cell fabrication owing to its excellent electrical properties and abundance. Its predicted theoretical efficiency potential is 29.4 % [1]. Within Silicon-based technologies, the interdigitated back contacted silicon heterojunction (IBC SHJ) solar cell represents the recently most successful approach with an efficiency record of 26.7 % [2], almost entirely exploiting the abovementioned potential. However, hitherto established contact preparation of such solar cells by photolithography is elaborate, time-consuming, and cost-intensive, rendering their implementation in industrially fabrication challenging. Here, we report on our recent progress in developing an easy and potentially industrially viable fabrication process for IBC SHJ solar cells using in-situ shadow masks during PECVD, yielding efficiencies exceeding 20 %. Detailed device characterisation as well as strategies to further improve passivation quality and reduce resistive losses are presented to close the yet present performance gap between these devices and their photolithography-based counterpart.

[1] A. Richter *et al.* IEEE J. Photovoltaics 3(4), 1184-1191 (2013).

[2] M. A. Green *et al.* Prog. Photovolt. Res. Appl. 25, 668-676 (2017).

15 min. break

HL 41.6 Thu 16:30 H31

Cubic tin sulfide nanocrystals: growth mechanism unfolded by organic ligands adsorption — ●ELAD SEGEV^{1,2}, RAN EITAN ABUTBUL^{1,2}, URI ARGAMAN¹, YUVAL GOLAN^{1,2}, and GUY MAKOV^{1,2} — ¹Department of Materials Engineering, Ben-Gurion University of the Negev, Beer-Sheva 84105, Israel — ²Ilse Katz institute for Nanoscale science and Technology, Ben-Gurion University of the Negev, Beer-Sheva 84105m Israel

Novel metastable cubic phase was recently discovered in tin monosulfide and monoselenide systems. Surface energy calculations and experimental studies indicate that this cubic phase is stabilized by specific ligands adsorption on the surface. The ab-initio computations with adsorbed ligands show lower surface energies for the cubic phase and for the orthorhombic phase than for the pristine surfaces. It is shown that Cl bonds are replacing the missing Sn-S bonds on the surface in the cubic structure. We observe that high ligand concentration reach-

ing a full surface coverage enables the cubic nanoparticles to stabilize while for the same concentration the ORT nanoparticles collapse.

HL 41.7 Thu 16:45 H31

Optical *in situ* spectroscopy during MOCVD-preparation of GaAs_{1-x}P_x surfaces — •AMMAR TUMMALIEH, AGNIESZKA PASZUK, OLIVER SUPPLIE, ALEXANDER HEINISCH, PETER KLEINSCHMIDT, and THOMAS HANNAPPEL — Institute for Physics, University of Technology, Ilmenau, Germany

Multi-junction solar cells comprising GaAsP top absorbers with Si bottom cells enable photovoltaic conversion efficiencies above 40%. However, monolithic epitaxial integration of GaAsP with As contents between 50%-75% on Si requires to overcome a significant lattice mismatch. Commonly, this is achieved with GaAsP graded buffers where the As/P ratio increases step-wise. Here, such GaAs_{1-x}P_x buffers ($x \leq 0.5$) were grown on GaP(100) substrates by metalorganic chemical vapor deposition. The entire process was monitored *in situ* with reflection anisotropy spectroscopy (RAS), an optical surface sensitive technique, in order to yield a better understanding of the interface preparation. To further resolve the origin of the RA spectra and the atomic structure of the surfaces, selected samples were transferred to ultra-high vacuum surface-sensitive tools. The atomic structure depends on processing routes: While GaAsP surfaces annealed under H₂ at 500°C exhibit (2x4) surface reconstruction and are V-rich, annealing at 700°C leads to Ga-rich surfaces. We also find that the GaAs_{1-x}P_x stoichiometry can be quantified empirically during growth via the stoichiometry-depending energy shift of the E₁ interband tran-

sition of GaAsP.

HL 41.8 Thu 17:00 H31

Single atomic layer removal via mechanochemical reactions — •LEI CHEN¹, SEONG H. KIM², and LINMAO QIAN¹ — ¹Southwest Jiaotong University, No. 111, Erhuan Road, Chengdu, Sichuan, China — ²N349, MSC, Pollock Road, University Park, Pennsylvania, USA

Nanomanufacturing process with an ultra-high precision is of paramount importance for new development of nanoelectronics with unique functionalities. Here, we demonstrate a mask-less and chemical-free nanolithography process for regio-specific removal of atomic layers on 2D material and crystalline materials surfaces via shear-induced mechanochemical reactions. Since chemical reactions involve only the topmost atomic layer exposed at the interface, the removal of single atomic layer is possible and the crystalline lattice or structure beneath the processed area remains intact without subsurface structural damages. There are two mechanochemical wear processes depending on materials. For the materials which can react with the counterface, such as graphite or single crystalline silicon, the atom-by-atom removal process is that the first atomic layer is removed preferentially through the formation and dissociation of interfacial bridge bonds. Differently, for other material, like CaF₂, the stress-enhanced chemical reaction with surrounding water results in the formation of softening layer on the outermost surface which can be preferentially removed under mechanical interaction. This study advances research toward nanofabrication with single atomic layer precision, opening new opportunities for advanced nanoelectronics with new functionalities.