HL 17: Interfaces and surfaces

Time: Monday 15:00–17:00 Location: H15

HL 17.1 Mon 15:00 H15

Photoluminescence spectroscopy of singlelayer MoS_2 — •Gerd Plechinger, Stefanie Heydrich, Johannes Schmutzler, Jonathan Eroms, Dieter Weiss, Christian Schüller, and Tobias Korn — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany

Complementary to the gapless material graphene, the transition-metal dichalcogenide MoS_2 is a promising two-dimensional layered semiconductor for future ultrathin nanoelectronic and optoelectronic devices. Subnanometer thickness, large bandgap in the visible range and ultrafast carrier dynamics make it interesting for devices like transistors, ultrafast optical switches or photovoltaic applications.

Our monolayer MoS_2 flakes were prepared by the well-known mechanical cleavage method. With a μPL experimental setup, we can perform photoluminescence spectroscopy at temperatures from 4 K up to room temperature. Under different external influences like temperature, magnetic fields or circular polarisation of the exciting laser light, we investigated the behavior of the A and B excitons, arising from transitions from the spin-orbit split valence band to the conduction band at the K-point of the Brillouin zone. Thereby, we could gather information about charged and neutral excitons and a possible valley polarisation. Furthermore, we could produce monolayer regions out of few-layer flakes via intense focussed laser radiation.

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HL 17.2 Mon 15:15 H15

Optical properties of single-layer, double-layer, and bulk MoS2 — •Alejandro Molina-Sánchez[1], Ludger Wirtz[1], and Kerstin Hummer[2] — [1]University of Luxembourg, Luxembourg — [2]University of Vienna, Vienna, Austria

The rise of graphene has brought attention also to other layered materials that can complement graphene or that can be an alternative in applications as transistors. Single-layer MoS2 has shown interesting electronic and optical properties such as as high electron mobility at room temperature and an optical bandgap of 1.8 eV. This makes the material suitable for transistors or optoelectronic devices [1]. We present a theoretical study of the optical absorption and photoluminescence spectra of single-layer, double-layer and bulk MoS2. The excitonic states have been calculated in the framework of the Bethe-Salpeter equation, taking into account the electron-hole interaction via the screened Coulomb potential. In addition to the step-function like behaviour that is typical for the joint-density of states of 2D materials with parabolic band dispersion, we find a bound excitonic peak that is dominating the luminescence spectra. The peak is split due to spin-orbit coupling for the single-layer and split due to layer-layer interaction for few-layer and bulk MoS2. We discuss the changes of the optical bandgap and of the exciton binding energy with the number of layers, comparing our results with the reported experimental data.

[1] See recent review: Nature Nanotechnology 7, 699 (2012).

HL 17.3 Mon 15:30 H15

Time and spatially resolved measurement of interface and bulk recombination of low bandgap multijunction solar cell material — •Anja Dobrich[1], Klaus Schwarzburg[1], and Thomas Hannappel[1,2,3] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin — [2]Technische Universität Ilmenau, Institut für Physik, Fachgebiet Photovoltaik, Ilmenau — [3]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, Erfurt

Triple junction III-V compound semiconductor solar cells are today's most efficient photovoltaic devices with conversion efficiencies >41%. A next generation multijunction cell with four or more junctions and optimized bandgaps is expected to break the present record efficiency surpassing the 50% mark. For this purpose, we developed a GaInAsP/GaInAs tandem cell lattice-matched to InP, which could be utilized as a low bandgap part of a well-established high bandgap GaInP/GaAs tandem cell. Since one of the most important properties of solar cell absorber materials is the lifetime of minority carriers, double heterostructures with the low bandgap GaInAs absorber embedded between InP barriers were grown, for photoluminescence measurements. We investigated the effect of different preparation routes for the GaInAs/InP interface on the lifetime, interface recombination velocity and its lateral interface homogeneity. The preparation routines were varied in order to initiate a lateral homogenous layer growth and to form the interface as sharp as possible, which is of major importance for the performance of thin device structures such as quantum well structures or tunnel junctions in multijunction solar cells.

HL 17.4 Mon 15:45 H15

Surface characterization of MOVPE prepared Si(111) substrates for III-V nanowire solar cells — •Weihong Zhao[1,2], Agnieszka Paszuk[1,2], Matthias Steidl[1,2], Sebastian Brückner[1,2], Anja Dobrich[2], Johannes Luczak[2], Peter Kleinschmidt[1,3], Henning Döscher[1,2], and Thomas Hannappel[1,2,3] — [1]Technische Universität Ilmenau, Institut für Physik, Fachgebiet Photovoltaik, D-98684 Ilmenau — [2]Helmholtz-Zentrum Berlin, Institut für Solare Brennstoffe und Energiespeichermaterialien, D14109 Berlin — [3]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, D99099 Erfurt

III-V nanowires grown on Si(111) substrates by metal-organic vapor phase epitaxy (MOVPE) enable a promising new solar cell concept meeting the demands of high-quality-low-cost photovoltaics. GaP buffer layers grown on Si(111) substrates represent suitable quasi-substrates since GaP is almost lattice-matched to Si. Apparently, preparation of atomically flat Si (111) surfaces is an essential step as a precondition for adjacent GaP heteroepitaxy. However, little is known about preparation and surface properties of Si(111) surfaces in MOVPE enviroment. We used in situ RAS to monitor the Si (111) surface during preparation in MOVPE. A contamination-free transfer system enabled us to study the MOVPE prepared surfaces with numerous UHV based surface science tools. A dedicated wet-chemical pretreatment is crucial to obtain atomically flat Si(111) surfaces. It is shown that our preparation in a hydrogen ambient results in a monohydride terminated (1x1)-reconstructed Si(111) surface.

HL 17.5 Mon 16:00 H15

From surface dimers to Si—P bonds at the GaP/Si(100) heterointerface — •Oliver Supplie[1,2], Sebastian Brückner[1,3], Henning Döscher[1,3,4], Peter Kleinschmidt[1,5], and Thomas Hannappel[1,4,5] — [1]Helmholtz-Zentrum Berlin, Institut für Solare Brennstoffe — [2]Humboldt-Universität zu Berlin, Institut für Physik — [3]TU Ilmenau, Institut für Physik, Fachgebiet Photovoltaik — [4]NREL, Golden, CO, USA — [5]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, Erfurt

Dimerized (100) surfaces of cubic crystals often exhibit characteristic reflection anisotropy (RA) spectra, as reported for both monohydride [1] and As [2] terminated Si(100), as well as for P-rich GaP(100) [3]. This allows in situ control during metalorganic vapor phase epitaxy which is essential, in particular, directly before III-V nucleation since preparation routes strongly vary with offcut and desired surface termination. Given the polarity of the GaP film and the dimer orientation of the substrate prior to nucleation, a simplistic model [4] allows to conclude whether Si—III or Si—V bonds are preferred at the heterointerface. Since GaP polarity corresponds to orientation of P-dimers at the P-rich GaP/Si(100) surface, we can deduce the preferred bonding from in situ RA spectra only. We find that P-polar GaP was grown both on As-terminated Si(100) and H-terminated, B-type Si(100) while Ga-polar GaP grew on H-terminated A-type Si(100). In all three cases, Si—V bonds established preferentially.

[1] Brückner et al., *PRB* **86**:195310. [2] Kipp et al., *PRL* **76**:2810. [3] Töben et al., *Surf.Sci.* **494**:755. [4] Beyer et al., *JAP* **111**:083534.

HL 17.6 Mon 16:15 H15

Surface characteristics of polar InN layers grown by MOVPE, MBE and migration enhanced afterglow techniques. — •Daria Skuridina[1], Duc V. Dinh[1], Rolf Aidam[2], Michael Kneissl[1], and Patrick Vogt[1] — [1]Institute of Solid State Physics, Technische Universitaet Berlin, Hardenbergstr. 36, EW6-1, 10623 Berlin, Germany — [2]Department Epitaxy, Fraunhofer Institute IAF, Tullastr. 72, 79108 Freiburg, Germany

The surface morphology of an InN layer affects its optical and electrical properties and thus influences the efficiency of InN based devices. In this work we investigate the correlation between morphology, bonding configuration and preparation conditions for polar surfaces of InN layers grown by different growth techniques: metal-organic vapour phase

epitaxy (MOVPE), molecular beam epitaxy (MBE), and migration enhanced afterglow (MEAglow) that results in a growth of N-rich InN layers [1]. Morphology, atomic structure and symmetry of the InN surfaces were measured by scanning tunneling microscopy (STM) and low energy electron diffraction (LEED). Auger and X-ray photoelectron spectroscopy (XPS) were used for chemical composition analysis of the layers. InN surfaces were prepared under ultra-high vacuum conditions by annealing, significantly reducing surface contaminations. We find that the surface oxide bonding configuration differs for InN grown by MEAglow and the observed $(\sqrt{3}\times\sqrt{3})\mathrm{R}\,30°$ surface symmetry differs from the commonly observed (1×1) surfaces for InN grown by MBE and MOVPE. We will discuss the related atomic structure and bonding configuration.[1]K.S.A.Butcher, Phys.Stat.Sol. A 209, 41(2012)

HL 17.7 Mon 16:30 H15

AlGaN/GaN Enzyme-Modified Field-Effect Transistors for Analysis of Enzyme Functionality — •Gesche Mareike Müntze, Wladimir Schäfer, Kai Röth, Alexander Sasse, and Martin Eickhoff — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany

AlGaN/GaN high electron mobility transistors (HEMTs) are promising candidates for the application as transducers in biosensors. The chemical stability and biocompability of GaN surfaces as well as their high pH-sensitivity serve as the basis for this application. By covalent immobilization of enzymes on the gate area of an AlGaN/GaN HEMT one obtains an enzyme-modified field-effect transistor (EnFET) with the type of enzyme defining the specificity of the biosensor. Essential to this concept is the formation of an acid or a base as a product of the enzymatic reaction. The pH-change is detected by the AlGaN/GaN HEMT in terms of a change in the drain-source current I_{DS}.

Here, we report the preparation of penicillinase-modified as well as acetylcholinesterase-modified FETs (PenFETs, AcFETs) by a wet chemical process. The obtained EnFET response curves can be fitted by applying a kinetic model which is used to extract microscopic parameters representing both the enzymatic activity and the transistor/enzyme/electrolyte system.

Our results show that EnFETs based on AlGaN/GaN HEMT structures provide a suitable base not only for the realization of specific biosensors but also for analysis of the functionality of immobilized enzymes.

HL 17.8 Mon 16:45 H15

Silicon surface properties after irradiation with single femtosecond laser pulses under $\mathbf{SF_6}$ atmosphere — •Kay-Michael Günther[1], Hartmut Witte[2], Jürgen Blaesing[2], Alois Krost[2], Thomas Gimpel[3], Wolfgang Schade[1,3], and Stefan Kontermann[3] — [1]Clausthal University of Technology, EFZN, Am Stollen 19B, 38640 Goslar, Germany — [2]Otto-von-Guericke University Magdeburg, Institute for Experimental Physics, Universitätsplatz 2, 39106 Magdeburg, Germany — [3]Fraunhofer Heinrich Hertz Institute, Am Stollen 19B, 38640 Goslar, Germany

Irradiating a silicon surface with femtosecond laser pulses under a SF_6 atmosphere can lead to the incorporation of sulfur donors into the top layer. After several pulses on the same spot, the surface becomes roughened. Hence, with a single fabrication step, a pn-junction as well as a low reflecting surface can be created. This technique is already used to fabricate solar cells and photodetectors.

In this work, we investigate the properties of p-type silicon samples which are irradiated with a single pulse per spot. With X-ray diffraction (XRD) measurements, atomic force microscopy (AFM) and Nomarski microscopy images we show that the crystal quality of the material remains unchanged and that only the close surface region of the samples is structured by the laser. The sulfur incorporation is investigated by secondary ion mass spectroscopy (SIMS), Hall-effect measurement, photoluminescence spectroscopy as well as capacitance-voltage spectroscopy (CV) which indicates, that the incorporated sulfur atoms are partly electrically active.