HL 84: Heterostructures and Interfaces

Time: Friday 9:30–12:45 Location: POT 151

HL 84.1 Fri 9:30 POT 151

Recombination dynamics of excitons in (Ga,In)As/Ga(As,Sb) type-II heterostructures — •Sebastian Gies, Benjamin Holz, Christian Fuchs, Wolfgang Stolz, and Wolfram Heimbrodt — Department of Physics and Materials Science Center, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany

(Ga,In)As/Ga(As,Sb) heterostructures are a material system widely used as an active medium in IR-lasers. It is necessary to have profound knowledge about the basic relaxation and recombination processes to improve this material. We present a thorough study of these properties by continuous-wave (cw-) and time-resolved (TR-) photoluminescence spectroscopy (PL) at various temperatures. Therefore, we investigate (Ga,In)As/GaAs/Ga(As,Sb) type-II structures with GaAs interlayers of different thicknesses to modify the type-II transition. Upon changing temperature a complex interplay of relaxation, tunneling and thermal reactivation is found, that changes the PL spectra drastically. Furthermore, the TRPL reveals, that the relaxation of holes has a tremendous influence on the transients of the type-II PL. A rate-equation model is developed to quantify the relaxation.

HL 84.2 Fri 9:45 POT 151

Investigation of the growth of the organic semiconductor F4-TCNQ on inorganic substrates — •Hannah Schamoni, Michael Haugeneder, Martin Hetzl, Oliver Bienek, and Martin Stutzmann — Walter Schottky Institut und Physik-Department, Technische Universität München, Deutschland

The combination of organic and inorganic semiconductors is one promising approach towards new materials for applications like solar cells and light emitting devices, as they open up the possibility to benefit from the advantages of both material types. In order to identify the most promising hybrid systems, a detailed understanding of the properties of the organic/inorganic interface is essential. In this work, we focus on the growth of the small-molecule organic semiconductor 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ) by organic molecular beam deposition on various inorganic substrates like Si, diamond, graphene on Si or GaN nanowire arrays. We are able to confirm a Stranski-Krastanov growth mode of the organic layer on most substrates by means of AFM, REM and XPS measurements. The size, shape and density of the molecular clusters depend on the inorganic material, which we attribute to the differences in binding energy between F4-TCNQ and the various substrates. Furthermore, our data reveal monotonic dependencies of the density of the F4-TCNQ clusters on the diameter of the GaN nanowires and the spacing in between the nanowires, respectively.

HL 84.3 Fri 10:00 POT 151

A band-offset study on NiO/SnO_2 heterojunctions using X-ray photoelectron spectroscopy (XPS) — •Fabian Michel, Benedikt Kramm, Martin Becker, Robert Hamann, Angelika Polity, Detlev M. Hofmann, and Martin Eickhoff — Justus-Liebig Universität, Gießen, Deutschland

The band discontinuities of NiO/SnO_2 pn-heterojunctions were evaluated by X-ray photoelectron spectroscopy. The heterojunctions were produced by ion beam sputtering. Using the common method of E.A. Kraut and J.R. Waldrop considering the position of the different core level signals and especially the related energy difference in the vicinity of the heterointerface the valence band and conduction band discontinuities of NiO/SnO_2 were investigated. For that the band gaps of the fabricated heterojunctions were determined via UV-VIS spectroscopy. A qualitative analysis of the interfacial chemical state by estimating the modified Auger parameter and the relative concentrations of the photoelectron signals using depth profiling via in situ Ar^+ ion etching was done. We also investigated the challenging Ni 2p signal by decomposing the line structure and the satellite structure. Results will be discussed with respect to other metal oxide heterojunctions such as NiO/ZnO, NiO/TiO and more.

HL 84.4 Fri 10:15 POT 151

$NiSi_2$-Si interfaces as building blocks for reconfigurable field-effect transistors: from the atomic structure to device characteristics — •Florian Fuchs[1,2,3], Jörg Schuster[2,4], and Sibylle Gemming[1,2,3] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Dresden, Germany — [2]Center for Advancing Electronics Dresden (cfaed), Dresden, Germany — [3]Institute of Physics, Technische Universität Chemnitz, Chemnitz, Germany — [4]Fraunhofer Institute for Electronic Nano Systems (ENAS), Chemnitz, Germany

The electron transport across metal-semiconductor interfaces is crucial for the functionality of reconfigurable field-effect transistors, which can be switched between electron and hole current. Devices were already fabricated experimentally, however, a profound understanding of the underlaying mechanism is not yet available.

This study focuses on the $NiSi_2$-Si interface, which is studied using the NEGF formalism. Based on the calculated transmission spectra, the transfer characteristic of a reconfigurable transistor is obtained using a simplified approach. Even though this model strongly simplifies the electrostatic environment in a transistor, very good agreement with experimental devices is demonstrated. The impact of strain on the device characteristic is studied as well. It is shown that the magnitude of electron and hole current can be altered successfully. They can also be tuned to be symmetric, which fits to experimental observations. Finally, new insight into the device functionality is gained based on our calculations of the work functions and effective masses of the isolated $NiSi_2$ and Si.

HL 84.5 Fri 10:30 POT 151

Iron-based Nitrogen doped Graphene Aerogels Derived from Seaweed Waste as Electrocatalysts for Efficient Electrochemical Energy Conversion and Storage — •Long Liu[1], Huaping Zhao[1], Rui Xu[1], Huanming Zhang[1], Yi Wang[1], Dongjiang Yang[2], and Yong Lei[1] — [1]Institut für Physik & IMN MacroNano, 98693 Ilmenau, Germany — [2]School of Environmental Science and Engineering, 266071 Qingdao, China

Advanced electrocatalysts are critical towards boosting the performance of electrochemical energy storage and conversion devices (e.g., lithium ion batteries, fuel cells). Here, we report our recent achievement about preparing bulky hierarchical Fe-based nanoparticles (NPs)/N-doped graphene aerogels (NGAs) through seaweed-derived biomass conversion strategy as highly-efficient electrocatalysts for electrochemical energy storage and conversion applications. The as-prepared unique Fe2N core-shell/NGAs exhibit highly desirable performance in oxygen reduction reaction (ORR), which is superior to costly commercial Pt/C electrocatalysts. Meanwhile, when transforming Fe2N core-shell / NGAs into Fe2O3 hollow nanoparticles (HNPs) / NGAs via the nanoscale Kirkendall effect, the as-obtained HNPs/NGAs display excellent energy storage performance in lithium ion batteries with high specific capacity, excellent rate capability and good cycle stability. These results demonstrate a sustainable approach to synthesize efficient and multifunctional electrocatalysts based on seaweed waste for electrochemical energy storage and conversion applications.

HL 84.6 Fri 10:45 POT 151

Charge Transport in Hexathiophene - Silicon Hybrid Systems — •Felix Eckmann, Hannah Schamoni, and Martin Stutzmann — Walter Schottky Institut und Physik Department, Technische Universität München, München, Deutschland

Hybrid structures containing organic and inorganic semiconductors are attractive material systems for applications such as light emitting devices and solar cells due to their potential of combining the high mobility and stability of inorganic semiconductors with the organic semiconductors' low production cost and flexibility. In order to gain insight into the fundamental electronic properties of such structures' interfaces, a model system containing a hexathiophene thin film deposited by organic molecular beam deposition onto variously doped silicon substrates has been chosen for thorough investigation. Current - voltage as well as capacitance - voltage measurements have been performed in order to compare different contacting methods to the thin film, such as Au lift-off float-on and Hg-droplet contacts. Our data yields good agreement to space charge limiting current theory, showing strong diode characteristics with rectification ratios of up to four orders of magnitude, a switch in forward direction as well as significantly varying barrier heights from n- to p-type substrates.

Coffee Break

HL 84.7 Fri 11:30 POT 151

Magnetic quantum ratchet effect in CdTe and Cd(Mn)Te quantum wells with dual grating top gate structure — •Philipp Faltermeier[1], Jan Unverzagt[1], Stefan Hubmann[1], Alexander Pfaller[1], Zbigniew Adamus[2], Grzegorz Karczewski[2], Thomasz Wojtowicz[2], Vasily. V. Bel'kov[3], Leonid Golub[3], Eougenious Ivchenko[3], Grigory Budkin[3], Vyacheslav Popov[4], Denis V. Fateev[4], Dieter Weiss[1], and Sergey D. Ganichev[1] — [1]University of Regensburg, Regensburg, Germany — [2]Institute of Physics, Polish Academy of Sciences, Warsaw, Poland — [3]Ioffe Institute, St. Petersburg, Russia — [4]Institute of Radio Engineering and Electronics (Saratov Branch), Saratov, Russia

We report on the observation of terahertz radiation induced magnetic-ratchet effects in CdTe and (Cd,Mn)Te quantum well structures superimposed with lateral superlattice. The in-plane potential was tuned by applying gate voltages. Irradiating the QW at normal incidence while applying a magnetic field B along the growth direction we observed that the terahertz-induced ratchet current exhibits sign-alternating $1/B$ periodic oscillations. The magnitude of the oscillations was by orders of magnitude larger than the ratchet photoresponse at zero magnetic field. The oscillation period corresponds to that of the Shubnikov-de-Haas effect. Our results reveal the existence of magnetic ratchet effects characterized by magnetic quantum photocurrent oscillations caused by Landau quantization and giant Zeeman effects in diluted magnetic heterostructures.

HL 84.8 Fri 11:45 POT 151

Spectroscopic studies of buried GaP/Si(100) heterointerfaces — •Oliver Supplie[1], Oleksandr Romanyuk[2], Toma Susi[3], Matthias M. May[1,4], and Thomas Hannappel[1] — [1]TU Ilmenau, Institute of Physics, D — [2]Institute of Physics, Academy of Sciences of the Czech Republic, Prague, CZ — [3]Vienna University, Institute of Physics, AU — [4]Department of Chemistry, Cambridge University, UK

Pseudomorphic virtual GaP/Si substrates are attractive for III/V-on-Si integration for microelectronics, photovoltaics, and water-splitting applications. Adequate preparation of the GaP/Si(100) heterointerface is of particular interest since its atomic and electronic structure highly impacts crystal quality. Here, we study the formation of the GaP/Si(100) heterointerface *in situ* during preparation in metalorganic vapor phase epitaxy by means of reflection anisotropy spectroscopy and develop a dedicated nucleation sequence, which yields about 2 nm thin GaP layers on Si(100) with atomically well-ordered surfaces free of antiphase disorder, as evidenced by low energy electron diffraction [1]. Furthermore, we apply photoelectron spectroscopy (PES) on very thin GaP nucleation layers to conclude on the chemical structure of the heterointerface [1]. Density functional theory (DFT) calculations of chemical shifts caused by interfacial bonds support our findings of Si-P bonds being present at the interface [2]. With DFT, we also find interface states in the common band gap above the VBM [2]. Their predicted dispersion is anisotropic and provides distinct features for further experimental PES-based investigation [2]. [1] Supplie et al., *JPCL* 6, 464 (2015). [2] Romanyuk et al., *PRB* 94, 155309 (2016).

HL 84.9 Fri 12:00 POT 151

The importance of interface step configurations in the GaP/Si(111):As system: Towards a growth model for twin domain formation — •Christian Koppka, Lars Winterfeld, Matthias Steidl, Agnieszka Paszuk, Peter Kleinschmidt, Erich Runge, and Thomas Hannappel — TU Ilmenau, Institute of Physics, D-98693 Ilmenau, Germany

V-III epitaxy on (111) oriented semiconductors is an increasingly relevant topic for innovative optoelectronic devices. In particular, the combination of (111) oriented epilayers with the growth of nanowire-based structures is a subject of intense research. However, the (111) orientation often leads to the formation of rotational twins. Despite the potential negative effects on the optoelectronic properties of such devices, this growth defect is rarely taken into account so far. Recently, we demonstrated the importance of the twin suppression in GaP/Si(111) virtual substrates for the quality of VLS grown GaP nanowires (1). Besides the nucleation conditions (T_{nuc}, t_{nuc}, V/III ratio, etc.), the substrate misorientation has a decisive influence on the twin domain formation. For an atomistic understanding of the twinning process, DFT calculations on the GaP/Si(111):As interface, the twin boundary as well as nucleation at steps were performed. In addition to thermodynamic conditions, kinetic monte carlo simulations should also consider kinetic influences and confirm the experimentally determined trends.

(1) C. Koppka et al., Crystal Growth & Design (2016)

HL 84.10 Fri 12:15 POT 151

Ultrathin Magnetite in Fe_3O_4/MgO super-lattices – resolving the origin of an enhanced, thin film magnetic moment — Ozhet Mauit[1,2], •Karsten Fleischer[1], Cormac Ó Coileáin[1], Daniel S. Fox[1], Christopher M. Smith[1], Gulnar Sugurbekova[2], Hongzhou Zhang[1], and Igor V. Shvets[1] — [1]School of Physics and CRANN, Trinity College Dublin, The University of Dublin, Ireland — [2]National Laboratory Astana, Nazarbayev University, Astana, Kazakhstan

The electrical, crystallographic and magnetic properties of ultra-thin magnetite (Fe_3O_4) have been studied in detail, by employing superlattice structures of Fe_3O_4/$MgFe_2O_4$ and Fe_3O_4/MgO on a variety of substrates. By careful analysis of their properties, the influence of substrate stoichiometry, Fe_3O_4 thin film thickness, antiphase boundaries on the magnetic properties can be separated. In particular, the controversial enhanced magnetic moment in ultra-thin films (<5 nm) was found to be related to the substrate stoichiometry, specifically the migration of oxygen vacancies into the Fe_3O_4 thin films. The multilayer concept can be employed with many other such systems and offers new methods of tuning the properties of thin magnetic oxides.

HL 84.11 Fri 12:30 POT 151

Spilling of electronic states in Pb quantum wells on Si(111)-Au surface — Mieczysław Jałochowski[1], •Krisztián Palotás[2,3], and Mariusz Krawiec[1] — [1]Marie Curie-Skłodowska University, Lublin, Poland — [2]Budapest University of Technology and Economics, Budapest, Hungary — [3]Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia

Energy-dependent apparent step heights of two-dimensional ultrathin Pb islands grown on the Si(111)6x6-Au surface have been investigated by a combination of scanning tunneling microscopy, first-principles density-functional theory and particle-in-a-box model calculations [1]. The apparent step height shows thickness- and energy-dependent oscillatory behaviors, which are directly related to the spilling of electron states into the vacuum exhibiting a quantum size effect. This has been unambiguously proven by extensive first-principles scanning tunneling microscopy and spectroscopy simulations. An electronic contribution to the apparent step height is directly determined, which can reach values as high as the half of the atomic contribution at certain energies. The applicability of the particle-in-a-box model to the spilling of electron states is also discussed.

[1] M. Jałochowski et al., Phys. Rev. B 93, 035437 (2016)