HL 30: Heterostructures, interfaces, and surfaces

Time: Wednesday 15:00–17:30 Location: EW 202

HL 30.1 Wed 15:00 EW 202

Band offset of Ga(N,As,P)/GaP heterostructures on silicon for optoelectronic integration — •Sebastian Gies[1], Florian Dobener[1,2], Robin C. Döring[1], Sarah Karrenberg[1], Khakaber Jandieri[1,3], Peter Ludewig[3], Kerstin Volz[1], Wolfgang Stolz[1,3], Sangam Chatterjee[2], and Wolfram Heimbrodt[1] — [1]Faculty of Physics and Materials Sciences Center, Philipps-Universität Marburg, Germany — [2]Institute of Experimental Physics I, Justus-Liebig-University Giessen, Germany — [3]NAsP$_{III/V}$ GmbH, Marburg, Germany

Nowadays, realizing laser diodes for the optoelectronic integration on silicon is a big challenge. The quaternary, direct-gap semiconductor Ga(N,As,P) is a suitable candidate for this purpose as it can be grown pseudomorphically on silicon and laser operation at low temperatures has already been demonstrated. To further optimize the Ga(N,As,P) heterostructures profound knowledge of the band offset is important. We present a thorough study of the Ga(N,As,P)/GaP band offset based on the conjunction of experiment and theory. Using PLE spectroscopy the transition energies of the Ga(N,As,P)-QW are revealed. These are modeled by a QW-calculation taking strain and the N-induced band anti-crossing into account. Therefore, it is possible to uniquely determine the band offset with very high precision.

HL 30.2 Wed 15:15 EW 202

First Principle Calculations of Interlayer Electronic Excitations in MoS2-WS2-MoSe2 van der Waals Trilayer Semiconductor — •Anders Christian Riis-Jensen and Kristian Sommer Thygesen — Technical university of Denmark, Department of Physics

van der Waals bonded heterostructures based on transition metal dichalcogenides or other 2D materials, represent an ideal playground for studying light-matter interactions at the nano-scale, and for benchmarking first principles excited state calculations against well defined experiments. Here we combine many-body perturbation theory with classical electrostatic models to calculate the electronic structure of the trilayer MoS2-WS2-MoSe2. The band alignment and interlayer excitons obtained using different self-energy approximations (with and without vertex corrections) and pseudopotentials (norm conserving and ultrasoft) are compared and discussed in relation to recent experimental results.

HL 30.3 Wed 15:30 EW 202

Hole carrier profiles at the surface of p-type Ge measured by low-energy muon spin spectroscopy — •Thomas Prokscha[1], Kim Chow[2], Elvezio Morenzoni[1], Zaher Salman[1], Evelyn Stilp[1,3], and Andreas Suter[1] — [1]LMU, Paul Scherrer Institut, 5232 Villigen, Switzerland — [2]University of Alberta, Edmonton, T6G 2E1, Canada — [3]Physics Institute, University of Zurich, 8057 Zurich, Switzerland

Macroscopic transport measurements and modelling are usually used to determine the charge carrier profiles across semiconductor interfaces. A local probe technique, capable of detecting the variation in carrier concentration, offers the unique possibility of measuring carrier profiles and manipulation directly without the need of model assumptions. Here we use for the first time the low-energy μ^+ beam at PSI with tunable energies in the keV range to investigate charge carrier profiles and their manipulation by illumination in commercial p-type Ge wafers at varying mean implantation depths from 10 nm to 150 nm. In p-type Ge with doping levels of 10^{15} cm^{-3} and 10^{16} cm^{-3} we observed a depletion of holes in the top 150 nm and 50 nm, respectively. The depletion zone can be persistently removed by illumination with blue light due to filling of empty surface acceptor states with photo-generated electrons [1]. By illumination with red light the photo-generated electrons have not sufficient energy to overcome the surface barrier of about 1 eV [1], and a dynamic equilibrium concentration of holes is observed, which increases as a function of depth.

[1] T. Proksch a et al., Sci. Rep. 3, 2569 (2013).

HL 30.4 Wed 15:45 EW 202

NiSi$_2$-Si interfaces and their role in tunneling based field-effect transistors: from the atomic structure to device characteristics — •Florian Fuchs[1,2,3,4], Sibylle Gemming[1,2,3], and Jörg Schuster[2,4] — [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 field-effect transistors (FETs) built from such contacts. By using a multiscale simulation approach we simulate single-gate FETs and so called reconfigurable FETs, where the latter design allows switching between electron and hole conduction by applying a second gate electrode. Our simulation approach combines NEGF-DFT modeling of the contact physics and a compact model to describe the device switching.

Our transistor model consists of a silicon channel sandwiched between two $NiSi_2$ contacts. We systematically apply strain and vary the crystal orientation. It is demonstrated that strain has, depending on the crystal orientation, a very different influence on the ratio between electron and hole current. These differences are compared with the change of the effective mass and the work function of the isolated materials. We show that the properties of the isolated materials cannot explain the discovered modification of the current alone and that the interface chemistry needs to be taken into account as well.

HL 30.5 Wed 16:00 EW 202

Spectroscopic examination and theoretical modelling of fluorescence spectral diffusion of CdSe/CdS dotrods — •Sven-Hendrik Lohmann, Philip Harder, Felix Bourier, Christian Strelow, Tobias Kipp, and Alf Mews — Institute für Physikalische Chemie ,Universität Hamburg, Grindelallee 117, 20146 Hamburg, Deutschland

Here we investigate the photoluminescence properties, more specifically the spectral diffusion, of individual chemically-synthesized CdSe/CdS nanoparticles, which consist of a spherical core enclosed by an elongated shell. Time- and energy-resolved photoluminescence data were collected at low temperature to analyze the spectral diffusion of the emission. The observed correlation between the energy and the decay time of the emission was used to develop a theoretical model, which includes migrating surface charges to describe the fluorescence jittering. Our initial model calculations already show a good agreement with our experimental studies.[1] In the next step, the model was refined by the incorporation of strain effects and the geometric parameters as well as different material compositions were investigated in respect to spectral diffusion.

[1] S.-H. Lohmann, C. Strelow, A. Mews, T. Kipp, ACS Nano 2017, DOI 10.1021/acsnano.7b05303.

15 min. break.

HL 30.6 Wed 16:30 EW 202

Fluorescence behaviour of semiconductor nanoparticles in vicinity of plasmonic metals — •Simon Schneider, Phillip Witthöft, Jannik Rebmann, Tobias Kipp, Christian Strelow, and Alf Mews — Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg, Germany

Interactions of plasmonic metal nanoparticles with semiconductor nanoparticles greatly influence the fluorescence behaviour of the latter. If introduced to a plasmonic resonant system, the rate of spontaneous emission can be enhanced (Purcell effect). Here, the distance between the metal- and semiconductor nanoparticles, as well as the geometry of the system, has a huge influence on the fluorescence behaviour of the whole system, i.e. direct contact of the two parts leads to complete fluorescence quenching. We control the distance between plasmonic metals and CdSe/CdS semiconductor dot-in-rod (DR) structures on a nanometer scale using a silica shell around the DRs as a dielectric spacer and investigate the effect of attached plasmonic metals (Ag & Au) on the fluorescence behaviour of the DRs. By using different geometries (i.e. spherical nanoparticles or nanorods) we can tune the spectral overlap as well as the dispersion of the electric field generated through the surface plasmon resonances, thereby influencing the fluorescence behaviour of the system.

HL 30.7 Wed 16:45 EW 202

Tracing dark exciton dynamics with optical bistable exci-

ton polaritons in planar microcavities — •Daniel Schmidt[1], Bernd Berger[1], Manfred Bayer[1], Christian Schneider[2], Sven Höfling[2], and Marc Assmann[1] — [1]Technische Universität Dortmund, 44227 Dortmund, Deutschland — [2]Technische Physik, Universität Würzburg, 97074 Würzburg, Deutschland

In the quickly thriving field of quantum computation exists a demand in systems that can be derived by using quantum mechanical methods. To fulfill such demands, various research has been done on exciton polaritons in semiconductor microcavities that arise due to the strong coupling of cavity photons and quantum well excitons. Furthermore, their ability to be reconfigured by controlling them all-optically makes them even more promising candidates. Another striking feature of exciton polaritons is the nonlinear polariton-polariton interaction. At high pumping densities these interactions may induce various phenomena, such as Bose-Einstein condensation, superfluidity or optical bistability. The latter is created by using slightly off-resonant CW excitation that generates a blueshift of the lower polariton branch, resulting in a hysteresis of the input-output behavior of the exciton polaritons. Utilizing this behavior, we use an additional short far off-resonant laser pulse to perturb the bistable system, enabling access to the dynamics of the lower polariton branch. Here, these dynamics show surprisingly long recovery times, which hints the presence of a reservoir of dark excitons involved in this process.

HL 30.8 Wed 17:00 EW 202

Exceptional Carrier Diffusion on CdTe Surfaces Revealed by 4D Electron Microscopy — •Ahmed M. El-Zohry, Basamat S. Shaheen, Jun Yin, Boon Ooi, Osman M. Bakr, and Omar F. Mohammed — King Abdullah University of Science and Technology

To further develop any real-world-energy devices, light light-triggered charge carrier dynamics near the surface of the absorber layers need to be visualized in space and time. Such spatial and dynamical information can only be accessed using the one of-a-kind technique of scanning ultrafast electron microscopy. Here, we clearly demonstrate not only that charge transport on material surfaces behaves very differently from that of the bulk, but also the surface orientation can control the overall charge carrier dynamics. More specifically, in CdTe single crystal with orientation of (110), we found that shows a the diffusion coefficient at surfaces of 3-4 order of magnitude higher than in bulk. The detected charges for the first time can move up to ~ 60 nm within 6 nanosecond time scale. Moreover, the X-ray photoelectron spectroscopy experiments and Density functional theory (DFT) calculations show that the surface diffusion process relay mostly on the crystal orientation and termination, in which other crystal with (211) orientation, highly tends to form ultrathin-oxidative layers that in turn suppress the charge transport through formation of mid surface-trap states

HL 30.9 Wed 17:15 EW 202

Template-Assisted Fabrications of Regular Arrays of Nanostructures for Sensitive Gas-Sensing — •Shipu Xu, Huaping Zhao, Yang Xu, Rui Xu, Huanming Zhang, and Long Liu — Institut für Physik & IMN MacroNano (ZIK), Technische Universität Ilmenau, 98693, Ilmenau, Germany

Sensitive gas-sensing is a constant pursue for the development of gas sensors. Herein we show a gas sensor formed by a regular array of nanostructures to efficiently fulfill sensitive gas-sensing, where the regular array is prepared by template-assisted methods. The morphologies of the gas-sensors involve regular arrays of nanopores and nanorods, which are respectively prepared from the templates of colloidal monolayer and anodic aluminum oxide. An optimized sensitivity of the gas-sensor is achievable by adjusting structure parameters of the gas sensors: (i) the pore size for the nanoporous-film-based sensor and (ii) the nanorod length for the nanorod-array-based sensors. In a detection of ethanol gas, the optimized sensitivity of the SnO2 porous film and the SnO2 nanorod array can be characterized by a low detection limit at a ppm level. Base on the above, we confirm that the regular arrays of nanostructures prepared by template-assisted methods can realize the sensitive gas-sensing.