# HL 76: Heterostructures

Time: Thursday 9:30–11:00 Location: EW 202

HL 76.1 Thu 9:30 EW 202

**Nanowire heterojunction devices with tunable light emission** — •Martin Hetzel, Alois Lugstein, and Emmerich Bertagnolli — Institut für Festkörperelektronik, TU Wien, Floragasse 7, 1040 Wien

The results of synthesis as well as the electrical and optical characterization of a heterojunction device with tunable light emission, based on silicon and germanium nanowires and epitaxially grown on GaAs and InAs, are presented. Nanowire growth was performed by means of a VLS process in a LPCVD reactor with the assistance of either catalytic gold seed particles or a thin gold layer. Both silicon and germanium nanowires with a length of a few microns and a diameter of about 100nm are realized. The results depend strongly on the substrate, for which highly p- and n-doped GaAs as well as highly n-doped InAs are used. After growth, thin layers of aluminium oxide and indium tin oxide (ITO), respectively, are deposited on the surface, thus forming a wrapped gate around the nanowires. Then the samples are coated with photoresist which completely encapsulates the nanowires. Consecutively, the nanowire tops are revealed by an O2/SF6 reactive-ion etch, while optical lithography is used to define top contacts consisting of ITO or gold, respectively. Electrical measurements of individual nanowires as well as of nanowire ensembles reveal characteristic diode-like behavior in dependance on growth epitaxy, substrate type and nanowire material. Optical measurements with a tunable monochromatic light source are discussed as well. It is shown that dependent on wavelength and the applied gate voltage, nanowires can be stimulated to light emission, thus enabling tunable heterojunction devices.

HL 76.2 Thu 9:45 EW 202

**High quality MgZnO/ZnO Quantum wells on polar and non-polar Substrates** — •Jan Zippel, Gabriele Benndorf, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany

ZnO has promising properties for the application in blue and ultraviolet light-emitting diodes. An increase in the internal quantum efficiency can be achieved by the growth of quantum well heterostructures. The quality of the interfaces and the control of the growth mode is necessary to achieve efficient heterostructures. Here, we present the growth of MgZnO/ZnO quantum wells heteroepitaxially as well as homoepitaxially by pulsed-laser deposition (PLD). Adopting the strategy of fairly low growth temperatures proposed in [1], we grow ZnO quantum wells on commercially available *a*-sapphire substrates in a layer by layer growth mode showing reflection high energy electron diffraction (RHEED) oscillations over the whole quantum well thickness. In the case of homoepitaxially grown MgZnO/ZnO quantum wells, we focus on non-polar ZnO substrates to avoid the quantum confined Stark effect observable in polar MgZnO/ZnO structures. Quantum confinement in MgZnO/ZnO heterostructures grown on non-polar *m*-plane ZnO substrates as well as on non polar *a*-plane ZnO substrates is presented. Additionally, ZnO thin films grown by an interval PLD approach on *c*-plane ZnO substrates showing smooth surfaces and RHEED oscillations over the whole layer are presented. [1] S. Sadofev et *al.*, Appl. Phys. Lett **87**, 091903 (2005).

HL 76.3 Thu 10:00 EW 202

**Control of the population decay time in submonolayer-stacks by spatial coupling to Stranski-Krastanow-QDs** — •Thomas Switaiski[1], Jan-Hindrik Schulze[2], Tim David Germann[2], André Strittmatter[2], Udo W. Pohl[2], Dieter Bimberg[2], and Ulrike Woggon[1] — [1]Inst. f. Optik und Atomare Physik, TU Berlin, Germany — [2]Inst. f. Festkörperphysik, TU Berlin, Germany

Superlattices of submonolayer depositions (SML-stack) based on InAs/GaAs provide high power conversion efficiencies and low threshold current densities when used as an active medium in laser diodes. In addition, these SML-stacks offer controllable tuning parameters.

Here, an approach to introduce an additional parameter to control the properties of a SML-stack is presented. We investigated the impact of coupling between a SML-stack and a Stranski-Krastanow (SK) grown quantum dot layer, as this coupled nanostructured system offers further parameters to control the decay dynamics. The studied samples contain one layer of InGaAs-SK-QDs, which is overgrown with the matrix material GaAs of a defined thickness d, followed by an InAs/GaAs-SML-stack. The presence of the energetically lower SK-QDs introduces an additional, nonradiative decay channel to the carriers inside the SML-stack. Hence, the decay time for the SML-luminescence is dependent on the vertical distance between the two different nanostructures.

We present time-resolved photoluminescence measurements and a model of a conventional rate equation system to simulate the observed data and to approximate the coupling time constant of the SML-stack to the SK-QDs.

HL 76.4 Thu 10:15 EW 202

**Strain relaxation in metamorphic InAlAs buffers** — •Boris Landgraf, Slobodskyy Taras, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

Modulation-doped high-mobility InAs heterostructures are of current interest owing to the small effective mass and strong spin-orbit coupling [1]. The heterostructures are prepared on molecular beam epitaxy grown virtual substrates strain engineered to match the lattice constant of the electronically active layers. The virtual substrates contain metamorphic buffer layers to compensate for the lattice mismatch. Recent developments in the design of the metamorphic buffers have made possible high-quality epitaxial InAs heterostructures.
This talk will be about the strain relaxation in metamorphic $In_xAl_{1-x}As$ buffers with and without an underneath grown AlAs/Gas superlattice. The structure of the virtual substrate was analyzed using high-resolution x-ray diffraction. Pole figures were collected to characterize the strain relaxation and twist in the metamorphic buffer layers, AlAs/GaAs superlattice and GaAs substrate. Our results indicate that an AlAs/GaAs superlattice in the virtual substrate is essential for strain relaxation in these virtual substrates.

[1] S. Löhr et al., Highly anisotropic transport in shallow InGaAs heterostructures, Physical Review B 67, 045309 (2003)

HL 76.5 Thu 10:30 EW 202

**Analysis of the oxygen vacancy induced metallic state in $SrTiO_3$** — •Juan Shen, Hunpyo Lee, Harald O. Jeschke, and Roser Valentí — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt am Main

Strontium titanate ($SrTiO_3$) is one of the typical perovskite oxides and has been considered for use in oxide electronics. Recently, high carrier mobilities on the fractured bare (001) surface have been found, and the source of the 2D electron gas (2DEG) at the surface is still not clear. Oxygen vacancies are assumed to be one of the origins for the conductivity. By using density function theory (DFT), we investigate the electronic structure of $SrTiO_3$ surfaces in the presence of different oxygen vacancy concentrations both in SrO and in $TiO_2$ terminated (001) slabs. We find that the conductivity is caused by the extra electrons due to the oxygen vacancy which are transferred to Ti 3*d* states. In this talk we will discuss our results in comparison with available experimental measurements.

HL 76.6 Thu 10:45 EW 202

***Ab-Initio* Investigation of graphene based one-dimensional superlattices** — •Lars Matthes[1,2], Karsten Hannewald[1], and Friedhelm Bechstedt[1] — [1]Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Dipartimento di Fisica, Università di Roma "Tor Vergata", via della Ricerca Scientifica 1, 00133 Rome, Italy

Since the two-dimensional material graphene was rediscovered in 2004 by Geim et al. there has been a strong interest in tailoring its properties in order to achieve a broad usability in manifold applications. Furthermore, due to massless electrons appearing in graphene it is also a sandbox for theoretical physicists for testing basic physical theories of high energy physics in a solid state system.
Here we present first-principles studies of electronic and structural properties of various graphene-based one-dimensional superlattice including modifications of pristine graphene by means of hydrogen adsorption, substitution of carbon atoms with boron-nitride as well as a heterostructure including the very recently discovered silicene. [1]

We discuss the occurrence of an electronic band gap in these systems, while we focus in particular on the interesting case of graphene-silicene superlattices which provides insights to the physics of heterostructures consisting of materials where both may contain massless Fermions and a vanishing electronic gap around the Fermi-energy. Finally, we also discuss the importance of the 1D interface between those 2D crystalss.

[1] B. Lalmi et al., Applied Physics Letters 97, 223109 (2010)