HL 98: Focus Session: Functionalization of Semiconductors III

Organizers: Kerstin Volz, Sangam Chatterjee (Universität Marburg), Michael Dürr (Universität Giessen)

Time: Friday 9:30–11:45 Location: H16

HL 98.1 Fri 9:30 H16

MOVPE growth of InGaAs quantum dots in functionalized semiconductor structures — •Matthias Paul, Jan Kettler, Caterina Clausen, Katharina Zeuner, Fabian Olbrich, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und funktionelle Grenzflächen, Universität Stuttgart and Research Centers SCoPE and IQST, Allmandring 3, 70569 Stuttgart

InGaAs semiconductor quantum dots (QDs) have been studied as sources for single photons and entangled photon pairs with regard to applications in quantum computation and communication. In that regard, the tunability of the QD emission wavelengths and the control of the area density together with the benefits of a solid state system offer a high degree of integration into photonic devices. We present the growth of low density InGaAs QDs on GaAs substrates for wavelengths ranging from below 900 nm to above 1300 nm by metal-organic vapor-phase epitaxy (MOVPE). Single-photon characteristics and radiative decay cascades are demonstrated in correlation measurements. The site-controlled growth of QDs on patterned GaAs substrates promises deterministic implementation into devices and easy addressability of individual QDs. An important step towards quantum computation with photonic integrated circuits is the realization of emitters and detectors on one chip, e.g., based on InGaAs QDs and GaAs waveguides. In addition, the integration of an optical excitation source allows for a compact device design without an electric field or current at the position of the QDs. Finally, the QDs are embedded in resonator structures to increase the extraction efficiency and study coupling phenomena.

HL 98.2 Fri 10:00 H16

Temperature-stable large-bandwidth directly modulated 1.5 μm quantum dot lasers — Saddam Banyoudeh, •Alireza Abdollahinia, and Johann Peter Reithmaier — Technische Physik, Institute of Nanostructure Technologies and Analytics, University of Kassel, Germany

Within the last decade, semiconductor quantum dot (QD) structures have interested notably both fundamental physics and optoelectronic device applications specially QD lasers operating at 1.5 μm, significant for optical fiber communication [1]. Self-assembled semiconductor QDs formed via the Stranski-Krastanov growth mode have provided a robust active medium for optoelectronic devices like lasers [2], essentially needing a base of high QD density with a homogeneous size distribution, preferably round shaped, resulting in properties such as high temperature stability, reduced threshold current, increased spectral and differential gain, and higher modulation bandwidth [3]. Recently we showed improvement in the QD epitaxy by reduction of the inhomogeneous size distribution [4]. In this work recent enhancements for broad area (BA) and ridge waveguide (RWG) lasers show a high modal gain of 14.5 cm^{-1} per QD layer with a temperature-insensitive threshold current density exhibiting T_0 values of 125 K and 152 K for BA and RWG lasers, respectively, with remarkable improvements in the small signal modulation bandwidth of more than 16 GHz.

[1] J.P. Reithmaier et al., J.Phys.D 38, 2088 (2005) [2] D. Gready et al., PTL 24, 809 (2012) [3] K. Akahane et al., PTL 22, 103 (2010) [4] S. Banyoudeh et al., JCG 425, 299 (2015)

HL 98.3 Fri 10:15 H16

Nitrogen incorporation in GaAs using DTBAA, a novel N precursor with no direct C-N bond — •Eduard Sterzer[1], Andreas Beyer[1], Lennart Duschek[1], Lukas Nattermann[1], Benjamin Ringler[2], Bernhard Leube[2], Andreas Stegmüller[2], Ralf Tonner[2], Carsten von Hänisch[2], Wolfgang Stolz[1], and Kerstin Volz[1] — [1]Material Sciences Center and Faculty of Physics — [2]Material Sciences Center and Faculty of Chemistry, Philipps-Universität Marburg, Germany

III/V semiconductors containing small amounts of N are discussed in the context of solar cell and laser applications. MOVPE growth of these alloy is typically complicated as a large excess of the conventional N precursor (UDMHy) is required in the gas phase to incorporate even small amounts of N. Furthermore, applications are hampered by significant C incorporation in the layers during growth, which either stems from the N precursor or the group III sources. Our novel N precursor DTBAA contains no direct C-N bond, which could reduce the C incorporation. We used this molecule - together with TEGa and, in some experiments, also with TBAs and TMIn - in low temperature Ga(NAs) and (GaIn)(NAs) growth. We observed around 10 times higher N incorporation efficiency in Ga(NAs) compared to UDMHy. For (GaIn)(NAs) growth we didn't observe the decrease of N incorporation with higher In amount as reported for UDMHy in the literature. These studies underline the great potential of DTBAA for the growth of dilute nitride III/V alloys. Support of the DFG in the framework of GRK 1782 "Functionalization of Semiconductors" is greatfully acknowledged.

30 min. Coffee Break

HL 98.4 Fri 11:00 H16

GaN-on-Si(hkl) epitaxy: physics and chemistry — •Andre Strittmatter and Armin Dadgar — Otto-von-Guericke Universitaet Magdeburg

GaN epitaxy on Si substrates is governed by the atomic arrangement on the Si surface and by chemical processes during growth. Thermal stresses, mechanical strain, and a chemical instability of the Si surface are severe problems which need to be controlled throughout the growth. In order to obtain device-quality material certain measures have to be taken in order to achieve stable growth regimes and single phase, highly crystalline layers. GaN layers with specific orientations can be obtained if Si substrates with proper suface orientations are chosen and special preparation steps are applied to these kind of substrates. We will compare the special requirements of GaN growth on Si for surface orientation.

HL 98.5 Fri 11:30 H16

Atomic-scale investigation of photovoltaic GaN/Si(111) hetero-interfaces using photoexcited scanning tunneling microscopy and spectroscopy — •Fei-Man Hsiao[1], Yen-Chin Huang[2], Bo-Chao Huang[3], Philipp Ebert[4], and Ya-Ping Chiu[5] — [1]Dept. of Physics, National Sun Yat-sen University, Kaohsiung 80424, Taiwan — [2]Dept. of Physics, National Cheng Kung University, Tainan 70101, Taiwan — [3]Institute of Physics, Academia Sinica, Taipei 11529, Taiwan — [4]Peter Grünberg Institut, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [5]Dept. of Physics, National Taiwan Normal University, Taipei 11677, Taiwan

Direct observation of the light response across high-efficiency GaN/Si(111) solar cell heterojunctions was spatially resolved at atomic scale by cross-sectional scanning tunneling microscopy and spectroscopy. By employing a laser with a wavelength of 405 nm at the interface, electron/hole pairs are expected to be primarily generated at the Si side. However, the analysis reveals changes of the tunnel currents at both sides of the hetero-interface under illumination, indicating the transport of excited carriers through the interface. This observation was verified by band alignment calculations: While excited electrons can pass the interface due to the flat alignment of the conduction bands, excited holes do not have sufficient energy to overcome the valence band discontinuity.