HL 73: Devices

Time: Thursday 9:30–11:15 Location: H15

HL 73.1 Thu 9:30 H15

Does Scaling help making HEMTs faster? — Sabbir Ahmed[1], Kyle David Holland[1], Navid Paydavosi[1], Christopher Martin Sinclair Rogers[1], Ahsan Ul Alam[1], Neophytos Neophytou[2], •Diego Kienle[3], and Mani Vaidyanathan[1] — [1]Department of Electical and Computer Engineering, University of Alberta — [2]Institute for Microelectronics, Technical University of Vienna — [3]Theoretische Physik I, Universität Bayreuth

The scaling-down of channels has been the basis to design faster transistors. Particularly III-V high-electron-mobility transistors (HEMTs) have been favored for terahertz applications thanks to their low-effective mass. However, experimentally it is known that the unity-current gain and power-gain cut-off frequencies (f_T and f_{max}) of HEMTs exhibit the tendency to saturate with shorter channel lengths and thus become insensitive to scaling. In this talk we employ a self-consistent, quantum-mechanical NEGF solver to quasi-statically extract the f_T of intrinsic III-V devices, focusing on InGaAs and GaN HEMTs with channel lengths of 50 nm down to 10 nm. We show that the non-scaling behavior of HEMTs is a result of short-channel effects (DIBL) leading to a weaker quantum confinement, so that the subbands are positioned lower in energy resulting in a larger-than-expected charge modulation and gate capacitance, respectively. It is also shown that the InGaAs HEMTs have faster f_T at long gate lengths, but as a consequence of their lower effective mass, they experience a more rapid f_T saturation than the GaN HEMTs, such that the two devices have a comparable f_T at very short gate lengths down to 10 nm.

HL 73.2 Thu 9:45 H15

Structural and magnetic properties of iron on modulation-doped (001) GaAs and on modulation-doped InAs heterostructures — •Boris Landgraf, Taras Slobodskyy, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

We study hybrid structures comprising a ferromagnetic metal layer on III/V compound heterostructures in view of spintronic applications [1]. While iron on modulation-doped (001) GaAs is a well established system [2], corresponding experiments of iron on InAs-HEMTs are not appeared so far. InAs is of high interest because of the low Schottky barrier and strong spin-orbit coupling.

In this talk, I will give an account of the growth and strain relaxation of iron on modulation-doped (001) GaAs and on inverted modulation-doped InAs heterostructures investigated with in-situ reflection high-energy electron diffraction (RHEED). Furthermore, we employed high-resolution X-ray diffraction and magneto-optical Kerr measurements to investigate structural as well as magnetic properties of these structures.

[1] S. Datta, B. Das, „Electronic analog of the electro-optic modulator“, Apllied Physics Letters 56, 665-667 (1990)

[2] X. Lou, C. Adelmann, S. A. Crooker, E. S. Garlid, J. Zhang, K. S. M. Reddy, S. D. Flexner, C. J. Palmstrøm, and P. A. Crowell, „Electrical detection of spin transport in lateral ferromagnet-semiconductor devices“, Nature Physics 3, 197-202 (2007)

HL 73.3 Thu 10:00 H15

Interrelation between the Charge Transport and the Electronic Structure of Transparent Printed Metal Oxide Semiconductors — •M. Häming[1,2], A. Issanin[1,3], P. Pacak[1,2], W. Jägermann[3], and K. Bonrad[1,2] — [1]Merck-TU-Darmstadt Laboratories, Darmstadt, Germany — [2]Merck KGaA, Darmstadt, Germany — [3]Materials Science Department, TU Darmstadt, Germany

Printed Indium-Zinc-Oxide (IZO) and Indium-Gallium-Zinc-Oxide (IGZO) semiconductor thin films have rapidly become of high interest due to recent observations of a surprisingly high field effect mobility (μ > 10 cm^2/Vs) in printed IZO and IGZO thin film transistors (TFTs) which opens up the opportunity for high-performance transparent printed electronics. The charge transport and the electronic structure of a systematic series of solution processed IZO thin films with high field effect mobility has been studied with particular focus at the aspects of doping and the energy position of the charge transport states. A consistent picture of the interrelation between the charge transport properties and the electronic structure can be developed by correlating the data from TFT and four-point probe measurements with UV/VIS transmission spectroscopy and photoelectron spectroscopy data.

HL 73.4 Thu 10:15 H15

A novel bottom-up approach for single photon emitters based on self-aligned quantum dots — •Jan-Hindrik Schulze, Waldemar Unrau, David Quandt, Tobias Heindel, Tim Germann, Ole Hitzemann, André Strittmatter, Stephan Reitzenstein, Udo Pohl, and Dieter Bimberg — Institut für Festkörperphysik, Technische Universität Berlin

Low-cost single or entangled photon sources are basic components of future semiconductor based quantum communication systems. We present a method for fabricating electrically driven single photon sources based on site-controlled quantum dots (QD). The QD positioning is induced by a buried stressor consisting of an oxide aperture which simultaneously self-aligns the current path in the pin-diode structure to the QD site. Due to the long range impact of the buried stressor this approach allows to embed QDs in defect-free matrix material leading to excellent optical properties comparable to Stranski-Krastanow QDs grown on planar surfaces. Moreover, the entire process relies only on conventional photolithographic processes compatible to mass production. Devices exhibit electroluminescence spectra of single QDs featuring linewidths of excitonic recombinations down to 25 μeV (resolution limited). The fine-structure splitting of the excitonic ground state could be measured to be (84 $\pm$ 2) μeV. Also electrically driven anti-bunching measurements confirm single photon emission with g^2(0) = 0.05.

HL 73.5 Thu 10:30 H15

Cathodoluminescence spectroscopy and electron-beam induced current mapping of quantum devices — •Manuel Gschrey, Tuan Minh Do, Sven Rodt, Waldemar Unrau, David Quandt, Jan-Hindrik Schulze, Tim Germann, André Strittmatter, Dieter Bimberg, and Stephan Reitzenstein — Insititut für Festkörperphysik, Technische Universität Berlin

Electrically-driven single-photon sources (SPSs) are key components for future quantum communication systems. For the further development of cavity-enhanced quantum-dot (QD) based SPSs, the spatial and spectral control of the QDs, as well as the design of the current path through the device, are of utmost importance. We report on high-resolution cathodoluminescence (CL) spectroscopy and electron-beam induced current (EBIC) mapping of novel electrically driven SPSs. The SPSs are fabricated by an self-alignment process where an oxide aperture defines not only the current path through the device, but also initiates the site-controlled growth of single QDs aligned to the aperture, which provide true single photon emission with $g^{(2)}(0) = 0.05$. The combination of CL spectroscopy and EBIC mapping under variation of the applied bias voltage allows us to prove the small size and high quality of the oxide aperture, as well as the spatial position of the emission lines of single QDs within the active layer of the device.

HL 73.6 Thu 10:45 H15

d-DotFET: Using locally strained silicon for mobility enhancement in MOSFET devices — •Jürgen Moers[1,2], Julian Gerharz[1,2], and Detlev Grützmacher[1,2] — [1]Peter Grünberg Institut 9 (PGI-9), Forschungszentrum Jülich, D-52425 Jülich, Germany — [2]JARA -Fundamentals of Future Information Technology (JARA-FIT)

In MOSFET devices strained silicon is regarded as material to improve device performance due to enhanced mobility. In the d-DotFET approach we use ordered Ge dots to facilitate locally strained silicon layers. The growth sites of the Ge dots, which serve as local pseudosubstrate for the subsequently grown Si, are defined by template assisted self assembly: the Ge dots grow on prepatterned sites only. By integrating the MOSFET on top of this locally strained layer the strain can be utilized to improve device performance. The applied strain in the Si layer can be larger as in the planar case, because the Ge content in the dots is larger than possible in normal blanket epitaxy of SiGe-layers. Transistors with gate length between 60 *nm* and 1 *μm* were processed with different gate width ranging from 60 *nm* to 180 *nm*. In comparison to transistors fabricated on the same chip, but without strained layer, the drain current enhancement is up to

35%. In devices where the Ge-dot is not removed the drain current increase is 22.5%, showing that removing the Ge dot further increases performance. In conclusion exploiting locally strained silicon in the d-DotFET concept offers an alternative route to get higher strain and hence improved device performance in MOSFET applications.

HL 73.7 Thu 11:00 H15

Electrostatic Doping in III-V Nanowire Tunnel FETs — •Thomas Grap and Joachim Knoch — Institute of Semiconductor Electronics RWTH University, D-52074 Aachen

Tunnel FETs (TFETs) have attracted a great deal of attention due to their potential superior off-state performance which would enable a substantial reduction in power consumption of highly integrated circuits. In order to improve the TFET performance, a nanowire (NW) device layout with ultrathin diameter and wrap-gate architecture with high-k gate dielectrics is proposed. Of special interest are III-V semiconductors, since they offer a low effective mass and a small band gap. As a result, in such a device structure electronic transport is one-dimensional (1D). Due to the particular band profile (p-i-n) excellent screening of the gate action on the source is mandatory in order to obtain a steep source-channel p-n junction. However a large doping concentration increases the Fermi-Level in source - due to a 1D transport and a low density of states of the III-V NW - limiting the inverse subthresholdslope of the TFET to 60mV/dec. As an alternative to the conventional doping, we successfully designed various device layouts using a triple-gate structure to electrostatically dope the NW. This allows us to adjust the screening and the Fermi-Level independently. We will show simulations performed for different TFET device geometries discussing the advantages of electrostatic doping over conventional doping with respect to the TFET performance. First experimental results on the proposed device layouts will be presented as well.