HL 73: Devices

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

HL 73.1 Thu 9:30 H15

Does Scaling help making HEMTs faster? — SABIRR AHMED1,
KYLE DAVID HOLLAND1, NAVEED PAYDAVASH2, CHRISTOPHER MARTIN
SINCLAIR ROGERS3, AHSAN UL ALAM1, NEOPHTIOS NEOPHYTOU2,
DIEGO KIENLE1, and MANI VADIVANATHAN1 — 1Department of
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The scaling-down of channels has been the basis to design faster tran-
sistors. Particularly III-V high-electron-mobility transistors (HEMTs) have
been favored for terahertz applications thanks to their low-
effect mass. However, experimentally it is known that the unity-
current gain and power-gain cut-off frequencies (fT and fmax) 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-continuously ex-
tract the fT 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 sub-
bands are positioned lower in energy resulting in a larger-than-expected
cutoff frequency, channel inversion, and gate capacitance, respectively. It is also shown that the InGaAs HEMTs have faster fT at long gate lengths, but as a conse-
quence of their lower effective mass, they experience a more rapid
fT saturation than the GaN HEMTs, such that the two devices hav-
eseparable fT 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 hetero-
structures — BORIS LANDGRAF, TARAS SLOBODSKY, CHRIST-
IAN HEYN, and WOLFGANG HAHN — Institut für Angewandte
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We study hybrid structures comprising a ferromagnetic metal 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
reported in literature 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-
electron electron diffraction (RHEED). Furthermore, we employed high-
resolution X-ray diffraction and magnetic-optical Kerr measurements
to investigate structural as well as magnetic properties of these struc-
tures.

[1] Datta, B. Das, „Electronic analog of the electro-optic modula-
S. Reddy, S. D. Flexner, C. J. Palmstrom, and P. A. Crowell, „Elec-
trical detection of spin transport in lateral ferromagnet-semiconductor

HL 73.3 Thu 10:00 H15

Interrelation between the Charge Transport and the Electric
Structure of Transparent Printed Metal Oxide Semiconductors — M. HÄMNING1,
A. ISSAMNI2, P. PAKCAR1,2, W. JÄGERMANN3, and K. BONRAD1,2 —
Merck-TU Darmstadt Laboratories, Darmstadt, Germany — 1Merck KGaA, Darmstadt, Germany —
3Materials 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
(\(\mu > 10 \text{ cm}^2/\text{Vs}\)) in printed IZO and IGZO thin film transis-
tors (TFTs) which opens up the opportunity for high-performance trans-
parent 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 fo-
cus 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 de-
veloped by correlating the data from TFT and four-point probe mea-
surements 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, WALDE-
MAR UNRAU, DAVID QUANDT, TOBIAS HENDSEL, TIM GERMANN, OLE
HITZEMANN, ANDRE STRITTMATTER, STEPHAN RETZENSTEIN, UD
O HENNINGSSEN, DIETER BIMBERG, JÜRGEN MOERS — Institut für Festkörperphysik, Techni-
ische 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 (QDs). The QD position-
ing is induced by a buried stressor consisting of an oxide aperture which
simultaneously self-aligns the current path in the pin-diode structure
between the QDs.

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 production process relies
only on conventional photolithographic processes compatible to mass
production. Devices exhibit electroluminescence spectra of a single QDs
featuring linewidths of excitonic recombinations down to 25 \(\mu\)eV
(resolution limited). The fine-structure splitting of the excitonic ground
state could be measured to be \(84 (\pm 2) \mu\)eV. 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 GSCHEUREY, TUAN MINH DO, SYEN RODT, WALDEMAR UNRAU,
DAVID QUANDT, JAN-HINDRIK SCHULZE, TOBIAS HENDSEL, ANDRE
STRITTMATTER, DIETER BIMBERG, STEPHAN RETZENSTEIN —
Institut 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 aper-
ture, which provide pure single photon emission with \(g^2(0) = 0.05\). The
site-controlled growth of CL spectroscopy and EBIC mapping under varia-
tion 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 en-
hancement in MOSFET devices — JÜRGEN MÖHRS1,2, JULIAN
GERHARZ1,2, and DETLEV GRÜTZMACHER1,2 — 1Peter Grünberg
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2JARA -Fundamentals of Future Information Technology (JARA-
FIT)

In MOSFET devices strained silicon is regarded as material to im-
prove 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 pseu-
dodesubstrate for the subsequently grown Si, are defined by template
assisted self assembly: the Ge dots grow on prepatterned sites only.

In 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 \(\mu\)m 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
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.

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.