HL 42: Devices

Time: Wednesday 9:30–12:00 Location: EW 015

HL 42.1 Wed 9:30 EW 015

Charging dynamics of a floating gate transistor with site-controlled quantum dots — •Patrick Maier[1], Fabian Hartmann[1], Monika Emmerling[1], Christian Schneider[1], Sven Höfling[1,2], Martin Kamp[1], and Lukas Worschech[1] — [1]Technische Physik, Physikalisches Institut, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]present address: SUPA, School of Physics and Astronomy, University of St. Andrews, St. Andrews, KY16 9SS, UK

Quantum dots can serve as floating gates when positioned in close vicinity to a transistor channel. We have used templates in combination with regrowth techniques by means of molecular beam epitaxy to position single InAs quantum dots in a GaAs based quantum wire. The floating gate properties were studied in terms of transport measurements. By sampling of different gate voltage sweeps for the determination of charging and discharging thresholds, it was found that discharging takes place at short time scales of microseconds, whereas several seconds of waiting times within a distinct negative gate voltage range were needed to charge the quantum dots. Such quantum dot structures have the potential to implement logic functions comprising charge and time dependent ingredients such as counting of signals or learning rules.

HL 42.2 Wed 9:45 EW 015

Charge transition levels of oxygen, lanthanum and fluorine related defect structures in bulk hafniumdioxide (HfO2): an ab initio investigation. — •Roman Leitsmann[1], Florian Lazarevic[1], Rolf Öttking[2], Ebrahim Nadimi[3], and Philipp Plänitz[1] — [1]AQcomputare GmbH, 09125 Chemnitz, Germany — [2]Institute of Physics, Illmenau University of Technology, 98693 Illmenau, Germany — [3]K. N. Toosi University of Technology, Faculty of Computer and Electrical Engineering, 14317-14191 Tehran, Iran

Intrinsic defect structures and impurity atoms are one of the main source of leakage current in metal-oxide-semiconductor devices. Using state of the art density functional theory we have investigated oxygen, lanthanum, and fluorine related defect structures and possible combinations of them. In particular we have calculated their charge transition levels in bulk m-HfO2. The obtained results are able to explain the experimentally observed reduction of the trap density after NF3 treatment [1].

[1] M. Drescher et al., J. Vac. Sci. Technol. accepted (2014).

HL 42.3 Wed 10:00 EW 015

Resonant tunnelling structures to improve the erase time in memory devices based on quantum dots — •Ismail Firat Arikan[1,2], Tobias Nowozin[1], Dieter Bimberg[1], and Nurten Oncan[2] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany — [2]Department of Physics, Faculty of Science, Istanbul University, 34134 Vezneciler, Istanbul, Turkey

We develop a memory device based on self-assembled quantum dots (QDs) called QD-Flash in order to combine the advantage of both DRAM and Flash Memory, i.e. non-volatility, fast write time (ns) and good endurance. While the write performance is promising, there is a trade-off for erasing performance: When the localization energy of the holes in the QDs is increased to further increase the storage time, the erase time also increases due to the increased tunnelling barrier. Implementing a superlattice structure, which allows resonant tunnelling as erasing mechanism, eliminates the trade-off between storage and erase time. In such a structure, it is possible to switch the transparency between very high and very low values by varying a bias voltage.

In this work, the concept of designing such a superlattice structure is presented. The structures are simulated using a One-Dimensional Poisson Solver and a Non-Equilibrium Green's Function Formalism. Results are presented.

HL 42.4 Wed 10:15 EW 015

Growth of $In_{0.5}Ga_{0.5}As/GaP$ quantum dots, manipulation of optical transitions by epitaxial means, and application in nano memory cells — •Gernot Stracke, Elisa Sala, Leo Bonato, Manuel Gschrey, Sven Rodt, Sören Selve, Tore Niermann, Christopher Prohl, Andrea Lenz, Holger Eisele, Andrei Schliwa, André Strittmatter, and Dieter Bimberg — Institut für Festkörperphysik, Institut für Optik und Atomare Physik und Zentraleinrichtung Elektronenmikroskopie, Technische Universität Berlin

InGaAs quantum dots (QDs) embedded in GaP have recently attracted attention for nano memory cells and monolithic integration of III/V-devices on silicon. A QD size- and strain- dependent transition from indirect to direct optical emission was predicted. Here we report on direct-gap $In_{0.5}Ga_{0.5}As/GaP(001)$ QDs grown by metalorganic vapor phase epitaxy with strong optical emission. To initiate the three-dimensional growth mode of $In_{0.5}Ga_{0.5}As$ on GaP, the GaP surface is covered with 2 monolayers (ML) of GaAs prior to InGaAs deposition. A second GaAs layer of 1-2 ML thickness grown on top of the QDs allows for improved strain relief of the QDs and results in a red-shift of QD luminescence from 722 nm to 843 nm, and an increase in luminescence intensity by more than one order of magnitude. The storage time of holes in $In_{0.5}Ga_{0.5}As/AlP$ QDs is determined by deep level transition spectroscopy to 230 s at room temperature, the highest value hitherto measured in QDs. Thus, QDs in a (Ga,Al)P matrix represent promising candidates for future nano memory devices.

Coffee break

HL 42.5 Wed 10:45 EW 015

High-resolution in-situ electron beam lithography for deterministic nanophotonic device processing — •Manuel Gschrey, Ronny Schmidt, Arsenty Kaganskiy, Sven Rodt, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, D-10623 Berlin

Advances in the field of quantum communication and computation using single semiconductor quantum dots (QDs) as emitters of single and indistinguishable photons rely crucially on the development of novel deterministic device technologies. As such, in-situ electron-beam lithography combines the benefits of high-resolution electron-beam lithography (EBL) and deterministic fabrication of nanostructures via convenient preceding luminescence mapping by cathodoluminescence [1]. For the application of this technique, a thorough understanding of the alignment accuracy, the writing resolution and the low temperature resist properties is inevitable. In this work we address these important points by a statistical analysis of our in-situ lithography technology platform. We find the the alignment accuracy is well below 50 nm and that circular mesas and wires with feature sizes down to 100 nm can be realized routinely. Moreover, studying the dose and temperature dependence of various common resists has revealed that polymethylmethacrylate (PMMA) is most suitable for 2D and 3D EBL at cryogenic temperatures.

[1] M. Gschrey et. al, APL 102, 251113 (2013)
[2] M. Gschrey et. al, J. Vac. Sci. Technol. B 32, 061601 (2014)

HL 42.6 Wed 11:00 EW 015

On the Photocurrent-Voltage Relations of Resonant Tunneling Photodetectors — •Andreas Pfenning[1], Fabian Hartmann[1], Fabian Langer[1], Sven Höfling[1,2], Martin Kamp[1], and Lukas Worschech[1] — [1]Technische Physik, Physikalisches Institut, Universität Würzburg and Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Am Hubland, D-97074 Würzburg, Germany — [2]SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

We present a study of the photocurrent-voltage relations and photogenerated charge accumulation dynamics of resonant tunneling diode (RTD) photodetectors. The RTDs are based on an AlGaAs/GaAs double barrier structure with a nearby and lattice matched GaInNAs absorption layer. The RTDs were studied for light sensing at the telecommunication wavelength λ=1.3 μm by means of electro-optical transport measurements. A strong nonlinear photocurrent-voltage relation was found and is attributed to three voltage dependent parameters: the quantum efficiency η(V), the mean lifetime of photogenerated and accumulated charge carriers τ(V) and the RTD's current-voltage characteristic in the dark I(V).

HL 42.7 Wed 11:15 EW 015

Ultraviolet photodiodes from visible-blind to solar-blind spectral range based on $(Ga_{1-x},In_x)_2O_3$ thin films — •Zhipeng Zhang, Holger von Wenckstern, Stefan Müller, Daniel Splith, Jörg Lenzner, Michael Lorenz, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstraße 5, 04103, Leipzig

We report on the fabrication of ultraviolet photodiode arrays based on Si-doped $(Ga_{1-x},In_x)_2O_3$ thin films [1] having a monotonous lateral variation of the indium content x from 0 to 0.8 as determined by energy-dispersive X-ray diffraction spectroscopy. The wavelength-selectivity of the device from visible-blind to solar-blind spectral range is realized by using a continuous composition spread approach [2,3] for pulsed-laser deposition. We ablate a single but segmented target consisting of semicircular segments of In_2O_3 and Ga_2O_3 both containing 0.1 wt.% SiO_2 in addition.

The structural properties of the thin film are investigated by spatially resolved X-ray diffraction measurements revealing phase separation for $x > 0.2$. The photoresponse of the photodiodes is determined from a metal-semiconductor-metal structure at room temperature. The onset of the absorption was tuned from 4.8 to 3.2 eV with increasing indium content within a single 2 inch wafer sample.

[1] H. von Wenckstern et al., Semic. Sci. Technol., accepted (2014)
[2] H. von Wenckstern et al., CrystEngComm. **15**, 10020 (2013)
[3] Z. Zhang et al., IEEE J. Sel. Top. Quantum Electr. **20**, 3801606 (2014)

HL 42.8 Wed 11:30 EW 015

Stability of QD excited-state laser emission under simultaneous ground-state perturbation — •Yücel Kaptan[1], André Röhm[2], Bastian Herzog[1], Benjamin Lingnau[2], Holger Schmeckebier[3], Dejan Arsenijević[3], Vissarion Mikhelashvili[4], Oliver Schöps[1], Mirco Kolarczik[1], Gadi Eisenstein[4], Dieter Bimberg[3], Ulrike Woggon[1], Nina Owschimikow[1], and Kathy Lüdge[2] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Berlin, Germany — [2]Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany — [3]Institut für Festkörperphysik, Technische Universität Berlin, Berlin, Germany — [4]Technion Institute of Technology, Faculty of Electrical Engineering, Haifa, Israel

State of the art in optoelectronic devices based on In(Ga)As-quantum dots (QDs) is the primary use of the energetically lowest bound QD state, the ground state (GS). Using also excited states (ES) may provide additional functionalities. We investigate QD ES lasers and provide conclusions for the realization of multi-state QD devices. We study the impact of GS amplification on simultaneous ES lasing via time-resolved emission measurements and find that a depopulation of the QD GS is followed by a drop in ES lasing intensity, strongly depending on wavelength of the depletion pulse and injection current. Numerical simulations based on laser rate equations reproduce the experimental results by taking into account the different dynamics of lasing and non-lasing QD subensembles within the inhomogeneously broadened spectrum [1]. [1] Y. Kaptan et al., Appl. Phys. Lett. 105, 191105 (2014)

HL 42.9 Wed 11:45 EW 015

25 Gb/s phase modulation with 1.3 μm semiconductor optical amplifiers based on InAs quantum dots — •Anissa Zeghuzi[1], Holger Schmeckebier[1], Mirko Stubenrauch[1], Christian Meuer[2], Christian-Alexander Bunge[3], and Dieter Bimberg[1] — [1]Technische Universität Berlin — [2]Fraunhofer Heinrich-Hertz-Institut Berlin — [3]Hochschule für Telekommunikation Leipzig

The number of components and thus costs in optical networks, e.g. in PON, can be significantly reduced by merging modulators and amplifiers. Since the real and the complex part of the susceptibility are decoupled in QD devices, the phase can be changed individually. The phase modulation is realized by means of the direct modulation induced change of current density, resulting in a change of effective refractive index of the ridge waveguide. The SOAs are driven in the QD ground state saturation regime with a high suppression of amplitude modulation. Therefore no patterning occurs in contrast to on-off- keying modulation scheme. Thus amplitude modulation was limited to 6 Gb/s, but phase modulation up to 25 Gb/s is demonstrated without any additional electrical pre- or post-processing (BER $< 10^{-9}$). Furthermore modulation of 20 Gb/s bit rate is achieved at a small cw input power of only - 11 dBm.