HL 70: Poster Session: Devices; Preparation and characterization; C/diamond; Si/Ge

Presenters are kindly asked to be near their posters at least 17:00–18:00 or to leave a note at the poster indicating a time period of availability for discussions. — Beverages will be served starting at 18:00.

Time: Wednesday 16:00–20:00 Location: Poster A

HL 70.1 Wed 16:00 Poster A

Solution processed doped zinc oxide field-effect transistors on flexible substrates — •Florian Mathies[1,2], Sebastian Hietzschold[1,2], Wolfgang Kowalsky[1,2,3], Uli Lemmer[4], and Norman Mechau[2,4] — [1]Kirchhoff-Institut für Physik, Universität Heidelberg, Germany — [2]InnovationLab, Heidelberg, Germany — [3]Institut für Hochfrequenztechnik, Technische Universität Braunschweig, Germany — [4]Light Technology Institute, Karlsruhe Institute of Technology, Germany

In order to build efficient printed inorganic electronic devices, solution processable semiconductors and adequate fabrication techniques are required. Metal oxides have been considered a promising material because of their excellent electrical performance and stability, in addition to good solubility and printability. In this work, soluble zinc oxide precursor systems doped with aluminium or tin (AZO, ZTO) are used to fabricate field-effect transistors (FETs) in top- and bottom gate configuration. The bottom gate FETs are prepared on top of thermally oxidized doped silicon wafers. For the top gate configuration flexible glass-substrates with a polymer dielectric were used. The characteristics of the devices are found to be strongly affected by material- and process parameters which correlate to differences in the layer morphology and the charge carrier concentration.

HL 70.2 Wed 16:00 Poster A

Optimization of (Mg,Zn)O-based thin-film transistors with high-k WO_3 dielectric gates — •Anna Reinhardt, Michael Lorenz, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Semiconductor Physics Group

Recently, room-temperature deposited tungsten trioxide (WO_3) was demonstrated to be an advantageous high-k gate dielectric for transparent metal-insulator-semiconductor field-effect transistors (MISFETs) with large on/off-current ratios and low gate-voltage sweeps [1].

We present our results on the optimization of WO_3-gated thin-film transistors deposited on (Mg,Zn)O-channel material by pulsed-laser deposition. The gate dielectric thickness was varied in order to minimize the subthreshold slope and leakage currents. Furthermore, results on the reduction of the (Mg,Zn)O-channel thickness and its impact on the turn-on voltage will be presented. In combination with Pt as gate metal normally-off transistors were realized. In addition, we investigated the long-term stability of the transfer characteristics of unpassivated devices in comparison to passivated transistors.

[1] M. Lorenz *et al.*, Adv. Mater. **23**, 5383-5386 (2011)

[2] M. Lorenz, A. Reinhardt *et al.*, Appl. Phys. Lett. **101**, 183502 (2012)

HL 70.3 Wed 16:00 Poster A

Comparison of ZnO-based JFETs, MESFETs and MISFETs — •Fabian J. Klüpfel, Friedrich L. Schein, Michael Lorenz, Heiko Frenzel, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Linnéstr. 5, 04103 Leipzig

We compare the device characteristics of field-effect transistors (FETs) based on ZnO. From the same ZnO thin film, junction FETs with $ZnCo_2O_4$-based gates, metal-semiconductor FETs with reactively sputtered Pt Schottky contacts and metal-insulator-semiconductor FETs with WO_3 as gate insulator were fabricated. By using a common thin film for the channel, the influence of the different gate architectures on the device performance can be distinguished from other fabrication-induced factors. Similar operation voltages for all FET types support the comparability of the devices. The transistors were characterized electrically by dc measurements at room and elevated temperatures and by frequency-dependent measurements. It was found, that the transfer curves of all devices exhibit a shift towards positive gate voltages with increasing temperature. This is in contrast to other semiconductors, e.g. InGaZnO or a-Si, and is attributed to the ZnO channel material. Several differences in the device characteristics were observed, which make the device types suitable for different fields of application.

HL 70.4 Wed 16:00 Poster A

Transparent, highly rectifying p-CuI/n-ZnO heterojunctions — •Friedrich-Leonhard Schein, Holger von Wenckstern, and Marius Grundmann — Institut für Experimentelle Physik II, Abt. Halbleiterphysik, Universität Leipzig, Germany

We investigated the wide bandgap ($E_g = 3.01\,\mathrm{eV}$ [1]) p-type semiconductor γ-copper(I)-iodide (CuI) [2] as an alternative candidate to p-type transparent semiconducting oxides like SnO [3] or $ZnCo_2O_4$ [4]. Our method to transform dc-sputtered Cu into CuI is easy to handle and uses temperatures below 120 °C. Hall-effect measurements of these CuI films on glass substrates revealed a hole mobility of about $6\,\mathrm{cm^2/Vs}$, a hole density of $5 \times 10^{18}\,\mathrm{cm^{-3}}$ and a resistivity of $0.2\,\Omega\mathrm{cm}$. Atomic force microscopy and optical transmission measurements will be discussed.

Heterostructures consisting of p-CuI and pulsed-laser deposited n-ZnO were fabricated on a-sapphire substrates and characterized electrically. The diodes showed rectification ratios $I_{on}/I_{off} > 10^7$ at $\pm 2\,\mathrm{V}$. Capacitance-voltage and temperature-dependent current-voltage measurements were analyzed to obtain a clear understanding of the diode characteristics.

[1] B.-L. Zhu and X. Z. Zhao, Phys. Status Solidi A **208**, 91 (2011).

[2] K. Bädeker, Annalen der Physik textbf327, 749 (1907)

[3] E. Fortunato *et al.*, Appl. Phys. Lett. **97**, 052105 (2010).

[4] F.-L. Schein *et al.*, IEEE Electron Device Lett. **33**, 676 (2012).

HL 70.5 Wed 16:00 Poster A

Synthesis of single crystalline Cu2O nanowires for electrochemically-gated PMOS transistors — Suneeti Purohit[1], •Anna Stösser[1], Robert Kruk[1], Subho Dasgupta[1], and Horst Hahn[1,2] — [1]INT, Karlsruhe Institute of Technology, D-76344 Eggenstein-Leopoldshafen, — [2]Joint Research Laboratory Nanomaterials, TU Darmstadt, Petersenstr. 32, D-64287 Darmstadt

One-dimensional nanomaterials such as nanorods or nanowires (NWs) are very attractive for various nanoelectronic devices. Cuprous oxide (Cu2O), a well-known p-type semiconductor with a band gap of 2 eV, has cubic crystal structure and is a very good candidate for conversion of solar energy into electrical or chemical energy; optoelectronic or light-emitting devices and as well as for catalysis. We present a low-cost, large scale solution-phase synthesis of single crystalline cuprous oxide NWs that shows very high aspect ratio. Synthesis has been done with hydrothermal treatment of Cu(Ac)2 and pyrrole at 250°C for 5hr. The powder X-ray diffraction (XRD) confirms cubic cuprite structure. Scanning electron microscopy (SEM) images show smooth and straight NWs with minimal surface roughness. The length of most Cu2O NWs exceeds 100 *m, while the diameter varies between 100-150 nm. Fourier transformed infrared spectroscopy (FTIR) and High resolution transmission electron microscopy (HRTEM) has also been performed. Subsequently, the NWs are harvested and used to build low voltage operated, single-nanowire transistors that are gated with composite solid polymer electrolytes; detailed transistor characteristics will also be presented.

HL 70.6 Wed 16:00 Poster A

Narrow bandwidth ultraviolet photodetectors based on wide band gap semiconductors — •Zhipeng Zhang, Friedrich-Leonhard Schein, Holger von Wenckstern, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstraße 5, 04103, Leipzig

The integration of an optical filter layer allows fabrication of wavelength-selective, visible-blind ultraviolet photodetectors (PDs) based on (Mg,Zn)O-heterostructure being only sensitive in a defined, narrow spectral range [1]. Up to now, this was accomplished by growing the active layer of a backside detector on top of a buffer layer having a slightly higher band gap. In this contribution we demonstrate the potential of a novel device layout allowing to achieve much narrower bandwidth by the decoupling of the optical filter and the active layer.

Within this approach interdiffusion between the layers is avoided and carriers generated in the filter layer will not contribute to the photocurrent. The achieved bandwidth of this kind at 3.4 eV was 12 meV smaller than that of the previous design.

Furthermore, the properties of a p-$ZnCo_2O_4$/n-ZnO heterojunction [2] under illumination were investigated. This bipolar diode can be used as PD similar to the PDs described above. Additionally, such pn-junction can be used as visible-blind solar cells. A first wavelength selective PD with a bandwidth of 60 meV was realized.

[1]: Z. Zhang et al., Appl. Phys. Lett. **99**, 083502 (2011)

[2]: F-L. Schein et al., IEEE Electron Device Lett. **33**, 676 (2012)

HL 70.7 Wed 16:00 Poster A

Two-photon quantum well infrared photodetectors in the THz regime — •Carsten Franke[1], Harald Schneider[1], and Martin Walther[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Fraunhofer IAF Freiburg

Two-photon quantum well infrared photodetectors (QWIPs) are interesting nonlinear devices for autocorrelation measurements in the mid-infrared and THz-regime. Here, we present first results on two-photon THz-QWIPs with intersubband transition frequencies below 7 THz, based on the GaAs/AlGaAs material system with an aluminium content of 5% and below. We performed dark current measurements and observed large current discontinuities which can be attributed to impact ionisation. We also present photocurrent spectra which show, in addition to the expected intersubband transitions, evidence of further signatures related to optical-phonons.

HL 70.8 Wed 16:00 Poster A

Construction of a heterodyne nearfield optical microscope — •Jan Siebels, Jens Ehlermann, Lena Simone Fohrmann, and Stefan Mendach — University of Hamburg, Germany

Here we describe the technical realization of a phase-resolved scanning near field optical microscope. In general, the frequency of visible light oscillating between 384 THz and 789 THz is too fast to be detected directly with today*s electronics. In order to obtain information about the phase of light one can utilize heterodyne detection. In combination with a near field scanning optical microscope it is possible to directly detect the amplitude and phase of near field distribution on sample surfaces [1][2]. . The near-field microscopeis placed in one branch of a Mach-Zehnder like interferometer. The frequency of the laser beams within the two branches, i.e. reference and signal beam, is slightly shifted via acousto-optic modulators. As a result, the interference of the beams results in beating pattern which is demodulated with a Lock-in amplifier to retrieve amplitude and phase of the SNOM signal.

We gratefully acknowledge financial support of the Deutsche Forschungsgemeinschaft via the Graduiertenkolleg 1286.

[1] M.L.M. Balistreri, J. Korterik, K. Kuipers, and N. van Hulst, Phys. Rev. Lett. 85, 294 (2000)

[2] A. Nesci, R. Dändliker, and H.P. Herzig Optics Letters, Vol. 26, Issue 4, pp. 208-210 (2001)

HL 70.9 Wed 16:00 Poster A

Production and characterization of ZnO nanorods from various precursors for single- and multi-rod transistors — •Falk von Seggern[1,2], Subho Dasgupta[1], Robert Kruk[1], and Horst Hahn[1,2] — [1]Institute of Nanotechnology, Karlsruhe Institute of Technology (KIT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany — [2]TU Darmstadt and KIT Joint Research Laboratory Nanomaterials, , Petersenstr. 32, 64287 Darmstadt, Germany

There is still a large research interest for ZnO for many applications due to its relatively wide band gap (3.37 eV), its transparency, its high carrier mobility, the easy production and non-toxicity. We present different routes for bulk synthesis (in the gram range) of ZnO nanorods, which are later used for single, as well as multi-nanorod transistor fabrication. Starting from different precursors we vary the process parameters systematically in order to obtain nanorods in bulk amounts and with an optimum morphology for the field-effect device fabrication. Structural characterizations are performed on as-grown nanorods using XRD, SEM and EDX techniques. Initially, devices have been made by structuring with e-beam lithography (in order to define the passive structures) and tested for transistor characteristics thereafter. Further work is in progress to fabricate completely solution processed single or multi nanorod field-effect devices.

HL 70.10 Wed 16:00 Poster A

strain and temperature evaluation of electro-thermal actuators using raman spectroscopy — •pramodh srinivasa[1], evgeniya sheremet[1], raul rodriguez[1], alexey shaporin[2], ovidiu gordan[1], gianina schondelmaier[3], and dietrich zahn[1] — [1]Semiconductor Physics, Chemnitz University of Technology, Chemnitz, Germany — [2]Microsystems and Precision Engineering, Chemnitz University of Technology, Chemnitz, Germany — [3]Materials and Reliability of Micro-Technical Systems, Chemnitz University of Technology,Chemnitz, Germany

Strain and temperature changes in Micro-Electro-Mechanical Systems devices are key factors to determine the performance and reliability. Movable parts are the main components of MEMS actuators responsible for sensing and actuating. Upon applying a potential to the actuator,resulting current flow heats up the comb structures leading to strain and temperature effects in turn making them move and elongate. Optical techniques are adopted for quantifying strain and temperature in comparison to other techniques, as they are highly accurate, non-destructive, and non-invasive. Micro-Raman Spectroscopy is used in this work to estimate the temperature and localized strain based on the analysis of the shift in the position of the optical phonon. The excitation wavelength used is 632nm(HeNe laser)with a spectral resolution of 0.23cm-1. We report the characterization of electro-thermal actuators in idle and working conditions under different external temperature and potentials.Spatially resolved temperature and stress maps of different components of the device are discussed.

HL 70.11 Wed 16:00 Poster A

Simulated annealing of nanodiamonds in vaccum, oxygen and water vapor — •Moloud Kaviani, Peter Deák, Bálint Aradi, and Thomas Frauenheim — BCCMS University of Bremen TAB Building, Entrance 1 A, Level 3 The case of Tower 1 28359 Bremen

Biocompatible luminescent nanodiamonds (ND) have received considerable attention as markers in biophysics and nanomedicine. For these applications NDs should be produced as small as possible. Transmission electron microscopy studies have shown that NDs are polyhedra with a diamond core, partly covered by a shell of graphitic or amorphous carbon. Our goal is to estimate how small can NDs be to preserve the diamond core at elevated temperatures under various ambient conditions: in vacuum, in oxygen, and water vapor. We investigate the stability of diamond nanoparticles upon annealing as a function of the size and shape, with the help of molecular dynamics (MD) simulations, using the self-consistent density functional based tight-binding method (SCC-DFTB). Simulated isochronal annealing was carried out at 500K, 1000K, 1500K for 30ps with a linear ramp between the stages (for 10ps).The diamond core of cuboid and cuboctahedral clusters with as like as ˜250 atoms survives such short anneals. As accelerated MD at 5000K, as well as tests at 1500K for 250 ps indicate that they are likely to survive also longer annealing times. The primary effect of oxygen seems to be saturated threefold-coordinated surface carbon atoms and the etching of coordinated ones.The application process becomes somewhat quicker and stronger but about a ˜250 atom cluster still retains its diamond core in the longer run.

HL 70.12 Wed 16:00 Poster A

Determination of the Depth of Shallow Implanted NV Centers in Diamond by Confocal Microscopy and Statistics — •Andreas Häussler, Pascal Heller, and Fedor Jelezko — Institut für Quantenoptik, Universität Ulm, Albert-Einstein-Allee 11, 89081 Ulm, Germany

Nitrogen-Vacancy (NV) color centers in diamond are interesting candidates for magnetic sensing in solid state. However, to measure a magnetic field outside of the diamond, the NV probe has to be positioned close to the point of interest, i.e. near the surface of the diamond. For the sake of good sensitivity and precision, knowing the exact depth of a NV center below the surface is crucial.

In our work we use a simple confocal microscope and measure both the reflected light from the surface and the emitted light of the NV to determine the depth of the color center. A statistical evaluation of the data can then lead to a much higher precision than the point spread function of the microscope down to nanometer accuracy.

HL 70.13 Wed 16:00 Poster A

Influence of surface treatment on NV centers in diamond — •Lina Elbers[1], Aniela Scheffzyk[1], Daniel Laumann[1], Christian Klump[1], Sani Noor[1], Sébastien Pezzagna[2], Jan Meijer[2], and Ulrich Köhler[1] — [1]Experimentalphysik IV, AG Oberflächen, Ruhr-Universität Bochum — [2]RUBION, Ruhr-Universität Bochum

Color centers in diamond especially NV centers are practical single photon emitters due to RT operations and candidates for applications in quantum computing. The implantation of NV centers near the surface for a possible electrical addressing is still a problem. Therefore, we survey the influence of different surface and bulk treatments on the diamond and the NV centers. To purify the diamonds we reduced the amount of natural NV centers in optical grade diamonds by heating up to 1500 °C in hydrogen. The intensity of their luminescence could be reduced down to $\frac{1}{8}$. In one set of the experiments we deposited silicon on the diamond to test the influence on the luminescence spectra and the charge states. The spectra show that the Si only influences the overall intensities. The H-termination in contrast seems to be practical for the manipulation of the charge state. Hence the diamond surface was treated by an H_2 plasma under varying parameters until the diamond becomes conductive. HREELS and AFM measurements were made to test the surface after the plasma treatment. The influence of an Al_2O_3 passivation layer that was deposited by sputtering on the conductivity was investigated. Additionally, a UHV chamber is modified to implant directly under UHV conditions and to allow in situ spectroscopic access to the diamond samples.

HL 70.14 Wed 16:00 Poster A

Microwave Driven Nanoscopic Resolution of Two Neighbour Single NV Centres in Diamond: Micro-(wave)-scopy (MWS) — •Andreas Häussler[1], Luca Marseglia[1], Florian Striebel[1], Manfred Bürzele[1], Ressa Said[2], Pascal Heller[1], Philip Hemmer[3], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm, Germany — [2]Institut für Quanteninformationsverarbeitung, Universität Ulm, Germany — [3]Electrical and Computer Engineering, Texas A&M University, College Station, TX 77843, USA

The negatively charged Nitrogen Vacancy color center (NV) is a spin active defect in diamond with a long spin lifetime at room temperature. We aim to resolve two different NV centres separated by a distance in nanoscopic regime by exploiting Rabi oscillations of the spin of the NV centre which show a spatial dependence due to applied microwave fields. Therefore we fabricate a microwave circuit on the diamond, which will allow us to apply different high intensity microwave fields and gradients. Finally the relation between the Rabi oscillations and the microwave field of two NV centres close to each other can be used in order to compute the distance between them, with a resolution below 50 nm.

HL 70.15 Wed 16:00 Poster A

Entanglement of a pair of two nitrogen-vacancy centers — •Christian Osterkamp[1], Christoph Müller[1], Liam McGuinness[1], Takashi Yamamoto[2], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institut für Quantenoptik, Universität Ulm, Germany — [2]Japan Atomic Energy Agency, 1233 Watanuki-machi, Takasaki, Gunma, 370-1292, Japan

Entanglement is the most counter-intuitive state in the quantum mechanics and it is the main part of the most quantum information protocols. Entangled states can be also used to enhance magnetic field sensitivity. Here we report on experiments towards the creation of entanglement between two single electron spins associated to nitrogen-vacancy defect centers in diamond (NV). The NV is a very promising system as a solid state qubit as well as a nano-scale magnetic field sensor. The fluorescence of single NVs can be detected and its electron spin can be polarized, read-out and manipulated at ambient conditions. We produced a pair of coupled single NV centers by using nitrogen ion implantation in 12C enriched ultra pure single crystalline diamond. Both NVs show long electron spin coherence time T2 ~ 1 ms and a magnetic dipolar coupling of 55 kHz, corresponding to 13 nm distance between the spins. Using this system we will be able to create a variety of entangled states with reasonable fidelity.

HL 70.16 Wed 16:00 Poster A

Temperature and gate dependent electrical characterization of carbon nanotube networks — •Fabian Fritz[1,2], Michael Schnee[1,2], Marlou Slot[1,2], Robert Frielinghaus[1,2], Claus M. Schneider[1,2], and Carola Meyer[1,2] — [1]Peter Grünberg Institut (PGI-6), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA – Fundamentals of Future Information Technologies

Carbon nanotubes (CNTs) show outstanding electronic properties and therefore they are a promising material for future nanoelectronic applications. Their electrical transport behavior depends on the environment. Here, we investigate the influence of gate dielectrics and chemical functionalization on the transport properties of carbon nanotube networks.

Networks of single-walled CNTs of different densities are grown by means of chemical vapor deposition. The structure of the networks is characterized by atomic force microscopy and scanning electron microscopy. Electrical measurements have been conducted at room temperature and down to 4 K in a helium flow cryostat.

At low temperature, the networks show clear non-ohmic current-voltage characteristics, which is interpreted within the framework of two-dimensional variable range hopping. The influence of oxidation on the transport through the networks is investigated, since this is the first step for a chemical functionalization based on ligand exchange reaction. First results of magneto-transport measurements on chemically functionalized CNTs as well as gate dependent transport measurements are presented.

HL 70.17 Wed 16:00 Poster A

Carbon Nanotube spectroscopy in optical microcavities — •Thomas Hümmer[1,2], Hanno Kaupp[1,2], Matthias S. Hofmann[1], Jonathan Noe[1], Alexander Högele[1], Theodor W. Hänsch[1,2], and David Hunger[1,2] — [1]Ludwig-Maximilians-Universität München, Deutschland — [2]Max-Planck Institut für Quantenoptik, Garching, Deutschland

We use fiber-based Fabry-Perot optical microcavities [1] with mode volumes down to a few tens of wavelengths cubed and high quality factors up to 10^7 to study single-walled carbon nanotubes (SWCNTs). Very recent progress in the growth of freestanding narrow-diameter SWCNTs has demonstrated that this system can show exceptional fluorescence properties, including a strong optical dipole transition, single photon emission characteristics, and close to Fourier limited linewidth [2]. Placing nanotubes inside an optical microcavity promises ultimative sensitivity for absorption spectroscopy and strong Purcell enhancement of fluorescence emission. Harnessing the full tunability and open access of fiber-based microcavities allows us to address a variety of CNTs at different locations and wavelengths with a single cavity. We show first experimental results on cavity enhanced spectroscopy of individual SWCNTs and discuss the potential for cavity QED with this system.

[1] Hunger, Reichel *et al.*, NJP **12**, 065038 (2010)
[2] Hofmann, Högele *et al.*, arXiv: 1209.3429 (2012)

HL 70.18 Wed 16:00 Poster A

Ab-initio study of metal-decorated carbon nanotubes for interconnect and sensor applications — •Florian Fuchs[1], Christian Wagner[1], and Jörg Schuster[2] — [1]Center for Microtechnologies, Chemnitz University of Technology, Chemnitz, Germany — [2]Fraunhofer Institute for Electronic Nano Systems (ENAS), Chemnitz, Germany

Carbon nanotubes (CNTs) are promising candidates for novel applications in various technical fields. They are discussed as metallization layers in interconnect systems, thanks to their extraordinary electronical properties. Furthermore, the electromechanical sensitivity of CNTs can be used to construct new sensors. For all these various application fields, CNTs with suitable properties are required. Still, producing them in high purity is a challange and multiple approaches are being considered. One of the possibilities is to functionalize the CNTs in order to adjust their electronical properties.

We present the results of an ab-initio study of metal-decorated single walled CNTs (SWCNTs) based on density functional theory. The influence of different metals adsorbed on a semiconducting SWCNT are investigated and compared. We demonstrate that the decoration significantly changes the properties and that the choice of the metal is essential. Furthermore, the decorated SWCNTs are strained to judge their applicability for sensors. It is shown, that the electromechanical properties of SWCNTs are conserved and that the metal decoration can therefore be used to control the properties of SWCNTs for future sensors as well as for interconnect applications.

HL 70.19 Wed 16:00 Poster A

Untersuchungen zur Absorption von Thz-Strahlung durch einwandige Kohlenstoffnanoröhren — •Frieder Ostermaier[1], Hans-Georg von Ribbeck[2], Michael Mertig[1] und Lukas Eng[2] — [1]TU Dresden, Professur für Physikalische Chemie, Mess- und Sensortechnik, 01062 Dresden, Germany — [2]TU Dresden, Institut für Angewandte Photophysik, 01062 Dresden, Germany

Einwandige Kohlenstoffnanoröhren (SWCNT) kann man sich als Hohlzylinder vorstellen, die durch das Aufrollen von Graphen entstanden

sind. Je nach Richtung des Aufrollens kommt es zu Änderungen in der Bandstruktur im Vergleich zum halbmetallischen Graphen. Die Bandlücken sind z.T. sehr klein und weisen daher Absorptionsbanden im THz-Wellenlängenbereich auf, was sich ideal für sensorische Anwendungen im tiefen Infrarot anbietet. Bisherige Studien haben stets Netzwerke von SWCNT zur Messung der Absorption verwendet. Dabei findet eine Mittelung über viele SWCNT statt.

Um die Absorption im THz-Wellenlängenbereich an einzelnen SWCNT zu messen, wurden mit Hilfe der Dielektrophorese SWCNT zwischen Elektroden abgelegt, so dass Stränge aus einzelnen SWCNT entstanden. Zur Vermessung der Absorption wurde ein streuendes optisches Nahfeldmikroskop verwendet, welches den durchstimmbaren Freie-Elektronen Laser am Helmholtz-Forschungszentrum Dresden-Rossendorf als THz-Strahlungsquelle einsetzt.

Die Messungen legen eine selektive Absorption nahe. Kleine Bündel von SWCNT zeigen zudem eine höhere Absorption. Die Messungen fanden dabei an der Grenze des Signal-Rauschabstandes statt.

HL 70.20 Wed 16:00 Poster A

Thermoelectric measurements of strained silicon using electrical and optical methods — •Jiehong Jin, Markus Hagedorn, Beata Kardynal, Stephan Wirths, Dan Mihai Buca, Detlev Grützmacher, and Toma Stoica — Peter Grünberg Institut (PGI-9), Jülich-Aachen Research Alliance (JARA), Forschungszentrum Jülich, 52425 Jülich, Germany

Semiconductor nanowires (NWs) have been shown to greatly suppress phonon heat conduction without a significant decrease in the Seebeck coefficient or electrical conductivity. Variety of methods can be used for structure fabrication. Irrespective of the fabrication process the specific geometry of NWs renders the heat transport measurements difficult. In this work, NWs of strained silicon on insulator (SSOI) were defined using e-beam lithography with metallic lines for local heaters and thermoelectric contacts. Two different methods of measuring temperature along the NWs are compared. We measured the temperature as resistance change of the thin metal lines in contact with the NWs. We also used the temperature dependence of the Si-Si Raman vibration mode to measure the NWs temperature. Both techniques can be used as accurate thermometers. However, optical readout using micro-Raman scattering proved to be more flexible. Using this technique, the temperature change along the NWs can be monitored with a resolution of the order of laser wavelength. Importantly, since the Raman peaks of the strained Si NWs and the substrate are clearly separated, the parasitic heat transport into the substrate can be evaluated.

HL 70.21 Wed 16:00 Poster A

BCS-type condensate in the electron-hole plasma of silicon — •Dietrich Schneider, Dirk Semkat, and Heinrich Stolz — University of Rostock

Quantum condensation phenomena in highly excited semiconductors comprise, besides the Bose-Einstein condensate of excitons, also a BCS-type condensate of weakly correlated electron-hole pairs at very low temperatures and high densities, where excitons can no longer exist. The key quantity of the BCS condensate is the so-called gap function. We present theoretical results for this quantity based on a recent approach. The gap function modifies the single-particle spectrum of the carriers. These modifications are transformed in the usual way into alterations of the high-energy tail of the electron-hole pair luminescence spectrum. Therefore, the occurrence of BCS condensed electron-hole pairs, i.e., a nonzero gap function, should manifest itself in the luminescence spectrum. We present first experiments where the electron-hole plasma in silicon is captured in a stress-induced potential trap at temperatures below 100 mK. Results for the measured spectra are shown and compared to the theoretical predictions.

HL 70.22 Wed 16:00 Poster A

Analysis of the fabrication process of x-ray waveguides — •Sarah Hoffmann, Henrike Neubauer, Mike Kanbach, and Tim Salditt — Institut für Röntgenphysik, Universität Göttingen

Small sized x-ray sources as provided by x-ray waveguide channels are required for a multitude of applications such as high resolution spectroscopy, diffraction, microscopy and holography [1,2]. We report on a processing scheme which among other techniques involves e-beam lithography, reactive ion etching and Silicon wafer bonding [3], allowing for the fabrication of sub-100 nm sized waveguide channels [4]. Both waveguide geometry and material can be adapted to meet the requirements of a specific experiment, such as the x-ray energy (7.9-17.5 keV) or the desired source size, or the application of a reference beam in a holography setup. As the tunability of the optical properties provided by the waveguide, as the coherence of the beam, its divergence or the waveguide transmission, depends sensitively on the precise control over the several processing steps, an iterative process of diagnostics and optimization is essential. Thereby, the surface roughness of the channel walls could be identified as a key parameter in fabrication of high transmission x-ray waveguides. To study this attribute in detail, complementary methods like AFM, SEM and ellipsometry are employed in addition to x-ray analysis both at synchrotron and lab sources.

[1] A. Jarre et al., Phys. Rev. Lett. 94, 074801 (2005)
[2] C. Krywka et al., J. Appl. Cryst. 45, 85*92 (2012)
[3] A. Kohlstedt et al., Appl. Phys. A 91, 6*12 (2008)
[4] H. Neubauer et al., in preparation