# HL 12: "New" Materials and New Physics in "Old" Materials II

Time: Monday 11:45–14:00 Location: EW 015

HL 12.1 Mon 11:45 EW 015

**HAXPES investigation of vacuum evaporated $Bi_2S_3$ thin films** — •Sebastian ten Haaf[1], Benjamin Balke[2], Claudia Felser[2], and Gerhard Jakob[1] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]Institut für Anorganische Chemie und Analytische Chemie, Johannes Gutenberg-Universität, 55099 Mainz, Germany

In order to explore new absorber materials for photovoltaics, polycrystalline $Bi_2S_3$ thin films were prepared and investigated for their usability for solar cell fabrication.

Amorphous $Bi_2S_3$ thin films were deposited by thermal evaporation of bismuth trisulphide compound under ultra-high vacuum conditions on various substrates. An amorphous-to-crystalline transition could be observed after heat treatment in argon atmosphere at different temperatures.

The first measurements with hard X-ray photoelectron spectroscopy (HAXPES) on $Bi_2S_3$ were performed. Clear effects of annealing on valence band states could be observed, in addition to this, the thin films were characterized with regard to their optical and electrical properties as well as their morphology.

HL 12.2 Mon 12:00 EW 015

**Radial distribution function analysis of ultra low-k interlayer dielectric from electron diffraction** — •Pradeep Singh[1], Sven Zimmermann[2], Steffen Schulze[2,3], Stefan Schulz[1], and Michael Hietschold[1] — [1]Chemnitz University of Technology, Institute of Physics, D-09107 Chemnitz, Germany — [2]FraunhoferInstitute for Electronic Nano Systems (Fraunhofer ENAS), Dept. BEOL, D-09107 Chemnitz, Germany — [3]Chemnitz University of Technology, Center for Microtechnologies, D-09107 Chemnitz, Germany

The continuous scaling of transistor size towards deep submicron level needs an inevitable replacement of SiO2 with a low-k dielectric material. In this study we choose three different low-k dielectric materials to determine their structural arrangement by Selected Area Electron Diffraction (SAED). The SAED analysis for the local short-range ordering has been carried out with homemade software package BEUG having been developed in our group by S. Schulze. Using BEUG, it is possible to Fourier transform the diffracted intensity distribution ending up with the radial distribution function (RDF).The bond lengths calculated from RDF between the Si-O, O-O and Si-Si have a significant change in low-k materials as compared to the corresponding lengths in bulk amorphous SiO2. These changes in bond lengths have a reasonable impact on the binding energy of the corresponding elements. We observed an inverse relation between bond lengths and binding energies for the elements present in the materials. Further the local densities of the materials have also been derived from the RDF curve.

HL 12.3 Mon 12:15 EW 015

**Growth and Analysis of Fe and FeCo on GaAs** — •Tobias Nickel, Boris Landgraf, Sören Meyer, Taras Slobodskyy, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

The injection of highly spin-polarized electrons from ferromagnetic metals into semiconductor systems is an important part of spintronic applications. The main problem encountered when building such spintronic devices is the loss of spin-polarization of electrons at the metal/semiconductor interface [1]. This obstacle may be avoided by introducing a tunnel barrier between metal and semiconductor. We therefore investigate epitaxial growth as well as structural, magnetical, and electrical properties of ferromagnet/semiconductor hybrid systems. Here, we analyze the epitaxial growth of Fe and FeCo on GaAs(001) and on modulation-doped InAs heterostructures with and without a MgO layer in between. The MgO layer works as a tunnel barrier [2] for spin-injection into the semiconductor and as a diffusion-barrier to avoid intermixing at the interface.

[1] G. Schmidt et al., *Physical Review B* R4790-R4793 (2000).

[2] X. Jiang et al., *Physical Review Letters* 94, 1-4 (2005).

HL 12.4 Mon 12:30 EW 015

**Disorder-parameters in Ga(AsBi)** — •Christian Wagner[1], Sebastian Imhof[1], Alexej Chernikov[2], Martin Koch[2], Nico S. Köster[2], Kolja Kolata[2], Sangam Chatterjee[2], Stefan W. Koch[2], Xianfeng Lu[3], Shane R. Johnson[3], Dan A. Beaton[4], Thomas Tiedje[5], Oleg Rubel[6,7], and Angela Thränhardt[1] — [1]Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz, Germany — [2]Fachbereich Physik, Philipps-Universität Marburg, 35032 Marburg, Germany — [3]Department of Electrical Engineering, Arizona State University, Tempe, Arizona 85287-6206, USA — [4]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada — [5]Department of Electrical and Computer Engineering, University of Victoria, Victoria, British Columbia V8W 3P6, Canada — [6]Thunder Bay Regional Research Institute, Thunder Bay, Ontario P7A 7T1, Canada — [7]Department of Physics, Lakehead University, Thunder Bay, Ontario P7B 5E1, Canada

In recent years, Ga(AsBi) has been shown to be an interesting material for laser applications since its band gap can be varied over a wide frequency range. The growth process, however, is still challenging and carrier dynamics remains governed by hopping processes. We show that emission spectra and temporal behavior are well described by a two-scale disorder model (S. Imhof et al., Appl. Phys. Lett. 96, 131115 (2010), S. Imhof et al, Appl. Phys. Lett. 98 161104 (2011)) and discuss accessible parameters from measurements. Theory and experiment can be brought into agreement with physically meaningful parameters.

HL 12.5 Mon 12:45 EW 015

**Chemical Composition of Novel III/V-alloys** — •Tatjana Wegele, Vivien Vossebürger, Rafael Fritz, Kakhaber Jandieri, and Kerstin Volz — Faculty of Physics and Material Sciences Centre, Philipps-University Marburg, D-35032 Marburg

Low-priced and high-efficient solar cells are possible through combination of silicon technologies and III/V-ternary or -quaternary semiconductors. The conditions for high efficiency are a suitable band gap and high crystal quality. The latter implies good lattice-matching and consequently a specific chemical composition of III/V-alloys as well as the homogeneity of the distribution of the chemical constituents.

Cross-sectional dark-field transmission electron microscopy is a good opportunity to determine chemical composition using chemical sensitive reflections on the nanometre scale. For quantitative interpretations of these micrographs it has to be taken into account, that the chemical constituents, which have different covalent radius, induce a local strain and therefore impact the intensity of the respective dark-field image.

We study dilute ternary B- or N-containing compound semiconductors based on GaP and GaAs as well as novel quaternary alloys like (BGa)(AsP) and summarise the results of quantitative TEM imaging using chemical sensitive reflections in combination with structure factor calculation.

HL 12.6 Mon 13:00 EW 015

**Wachstum und Charakterisierung von verdünnt - stickstoffhaltigem (GaIn)(NAs) auf InP mittels MOVPE** — •Peter Ludewig, Katharina Werner, Wolfgang Stolz und Kerstin Volz — Fachbereich Physik und Wissenschaftliches Zentrum für Materialwissenschaften, Philipps-Universität Marburg

Aktuelle optoelektronische Bauelemente mit einer Emissionswellenlänge von 1,55um bestehen aus (GaIn)(AsP)/(GaIn)(AsP)-MQW Strukturen, abgeschieden auf InP Substrat. Die Energieeffizienz und thermische Stabilität dieser Bauelemente ist allerdings sehr gering und externe Kühlung notwendig.

Durch das Ersetzen der aktiven (GaIn)(AsP) Schicht aktueller Bauelemente durch verdünnt stickstoffhaltiges (GaIn)(NAs) kann eine höhere thermische Stabilität der Bauelemente erreicht werden.

Es wurden (GaIn)(NAs)/(GaIn)(AsP)-MQW Strukturen mittels metallorganischer Gasphasenepitaxie (MOVPE) auf InP-Substrat abgeschieden. Dabei wurden Wachstumstemperaturen von 450°C und 500°C verwendet. Die optischen wie strukturellen Eigenschaften wurden mittels Photolumineszenz-Spektroskopie sowie hochauflösender Röntgenbeugung (HR-XRD) und Transmissionselektronenmikroskopie (TEM) untersucht. Die Experimente zeigen, dass ein Stickstoffeinbau von bis zu 2% bei einem Indiumgehalt von ca. 40% erreicht werden kann. Mit steigender Stickstoffkonzentration ergibt sich eine Rotverschiebung der Emissionswellenlänge sowie eine Abnahme der integrierten Photolumineszenz-Intensität. HR-XRD wie TEM Untersuchungen weisen auf eine sehr gute Qualität der Schichten hin.

HL 12.7 Mon 13:15 EW 015

**Time-resolved photoluminescence and optical gain in Ga(NAsP) pseudomorphically grown on silicon** — Nektarios Koukourakis[1], Max Klimasch[1], •Nils C. Gerhardt[1], Martin R. Hofmann[1], Sven Liebich[2], Daniel Trusheim[2], Martin Zimprich[2], Kerstin Volz[2], Wolfgang Stolz[2], and Bernardette Kunert[3] — [1]Photonics and Terahertztechnology, Ruhr-University Bochum, Bochum, Germany — [2]Material Science Center and Faculty of Physics, Philipps-University Marburg, Marburg, Germany — [3]NAsP III/V GmbH, Marburg, Germany

The development of optoelectronic integrated circuits (OEICs) on silicon using the advanced complementary metal oxide semiconductor technology is one of the most important challenges in photonics today. However the realization of the key component, a reliable electrically pumped semiconductor laser grown on silicon, remains a huge challenge. The novel dilute nitride material Ga(NAsP) is a very promising candidate to fill this gap. Because of its direct nature and the capability for pseudomorphical growth on exactly oriented (001) silicon substrate Ga(NAsP) is perfectly qualified as an active material for lasers on silicon. Here we investigate the optical properties of Ga(NAsP) samples grown lattice matched on Si substrates using time-resolved photoluminescence and optical gain spectroscopy. The results indicate a significant impact of disorder-induced localization effects, which depends strongly on N content and growth conditions. However, optical gain measurements reveal high modal gain values at room temperature and demonstrate the suitability of Ga(NAsP) for laser devices on silicon.

HL 12.8 Mon 13:30 EW 015

**Graphene Solution-Gated Field Effect Transistors for Bioelectronics** — •Lucas Hess[1], Max Seifert[1], Michael Jansen[2], Vanessa Maybeck[2], Amel Bendali[3], Serge Picaud[3], Andreas Offenhäusser[2], Martin Stutzmann[1], Ian D. Sharp[1], and Jose A. Garrido[1] — [1]Walter Schottky Institut, TU München — [2]FZ Jülich — [3]Institut de la Vision, Paris

For medical applications in neuroprostheses as well as for fundamental research on neuron communication, it is of utmost importance to develop a new generation of electronic devices which can effectively detect the electrical activity of nerve cells. The relatively high electronic noise and the poor stability of silicon biosensors have motivated the search for more suitable materials. In this respect, the outstanding electronic and electrochemical performance of graphene holds great promise for bioelectronic applications.

Here, we report on arrays of graphene solution-gated field effect transistors (G-SGFETs) which can detect the electrical activity of electrogenic cells. G-SGFETs were fabricated using graphene films, which were grown by CVD on Cu and then transferred to insulating substrates where arrays of transistors were processed. We have investigated the ability of these transistors to detect the electrical activity of electrogenic cells. To this end, cardiomyocyte-like HL-1 cells have been cultured on G-SGFET arrays. Employing the transistors beneath, we were able to detect and resolve the action potentials generated by the cells. Our results clearly show that graphene transistors can outperform state-of-the-art devices for bioelectronic applications by far.

HL 12.9 Mon 13:45 EW 015

**Sensing with graphene solution-gated field effect transistors** — •Benno Blaschke, Lucas H. Hess, Max Seifert, Martin Stutzmann, and Jose A. Garrido — Walter Schottky Institut, Technische Universität München, Germany

Graphene based solution-gated field effect transistors (SGFETs) are promising candidates for high-sensitivity biosensors due to the outstanding electronic and chemical properties of graphene such as the high charge carrier mobility and the good biocompatibility. Sensors for various analytes as well as cell action potentials have already been realized based on graphene SGFETs.

In this work, an array of graphene SGFETs is fabricated on large-scale CVD-grown graphene using optical lithography. We present an electrical characterization of the graphene SGFETs and report on their long-term stability. Hall-effect measurements are performed to obtain more detail on the charge carrier density and mobility of the graphene under electrolytic gate.

In order to use graphene SGFETs for sensing applications, the influence of the electrolyte composition on the transistor needs to be investigated and understood. Therefore, the effect of pH and different ion species on the transistor current is analyzed. These experimental results are compared to a model describing the graphene-electrolyte interface.