DS 1: Application of Thin Films

Time: Monday 9:30–13:15 Location: CHE 91

DS 1.1 Mon 9:30 CHE 91

Lattice dynamics of epitaxial EuSi2 thin films and nanostructures — •Anja Seiler[1,2], Olga Bauder[1,2], Shyjumon Ibrahimkutty[1,2], Przemyslaw Piekarz[3], Daniel Merkel[4], Rudolf Rüffer[4], Tilo Baumbach[1,2], Michael Fiederle[5], and Svetoslav Stankov[1,2] — [1]Laboratory for Applications of Synchrotron Radiation, KIT, Germany — [2]Institute for Photon Science and Synchrotron Radiation, KIT, Germany — [3]Institute of Nuclear Physics, Polish Academy of Sciences, Poland — [4]European Synchrotron Radiation Facility, France — [5]Freiburg Materials Research Center, Germany

The continuous downscaling of the CMOS devices demands a constant search for new self-organizing nanostructures. The rare earth silicides became especially attractive due to their very low Schottky barrier of 0.3-0.4 eV on n-type silicon [1-3]. It is very well known that the finite material's sizes at the nanoscale significantly modify their thermoelastic properties. Therefore it is mandatory to get comprehensive understanding of the lattice dynamics in order to even tailor the properties at the nanoscale. Here we will present experimental data on in situ nuclear inelastic scattering [4] from 151Eu for the phonon density of states of EuSi2 thin films and nanoislands. The experimental results are compared with the ab intio calculations.

[1] G.L. Molnar et al., J. Appl. Phys. 90, 503 (2001). [2] M. Ieong et al., Mater. Today 9, 26 (2006). [3] N. Reckinger et al., Appl. Phys. Lett. 94, 191913 (2009). [4] S. Stankov et al., Chapter 1 in "Mössbauer Spectroscopy: Applications in Chemistry, Biology, Industry, and Nanotechnology" (2013)

DS 1.2 Mon 9:45 CHE 91

Properties of Sol-Gel derived Ge nanocrystals embedded in thin SiO_2 layers — •Ansgar Dominique Donner[1], Sebastian Knebel[1], Ivana Capan[2], Harald Rösner[1], Hartmut Bracht[1], and Gerhard Wilde[1] — [1]Institute of Materials Physics, WWU Münster, Münster, Germany — [2]Ruder Bošković Institute, Zagreb, Croatia

Besides a variety of potential applications in the field of optoelectronics, germanium (Ge) nanocrystals (NCs) are a widely-discussed alternative to poly-silicon (Si) floating gates in nonvolatile memory devices such as Flash or EEPROM, because they promise to be less sensitive to charge leakage and thus information loss. We have developed a highly scalable and cost-efficient wet-chemical sol-gel process for the synthesis of Ge NCs embedded in thin Si dioxide films. Using TEM and other techniques, we have studied these Ge NCs and find that their structural properties can be varied over a wide range by different compositions of the precursor material or different annealing conditions. In an attempt to realize non-volatile memory devices based on our sol-gel derived thin films with embedded Ge NCs, we have fabricated first MOSFET devices to characterize the charge storage behavior of these thin films involving Ge NCs as floating gate.

DS 1.3 Mon 10:00 CHE 91

Electrical resistivity of high-conductivity perovskite $SrMoO_3$ at microwave frequencies — •Arzhang Mani[1], Aldin Radetinac[1], Mohammad Nikfalazar[2], Sergiy Melnyk[2], Philipp Komissinskiy[1], Yuliang Zheng[2], Rolf Jakoby[2], and Lambert Alff[1] — [1]Institute of Material Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany — [2]Institut of Microwave Engineering, Technische Universität Darmstadt, Merckstraße 25, 64283 Darmstadt, Germany

Epitaxial $SrMoO_3$ thin films were grown on single crystal $GdScO_3$ (110) substrates using pulsed laser deposition (PLD). The lithography process of $SrMoO_3$ thin films for patterning the co-planar waveguide (CPW) structures is challenging due to the high oxygen affinity of $SrMoO_3$. However, successful patterning of $SrMoO_3$ electrodes for electrical measurements by means of lithography and wet etching was achieved. Making a comparison between the electrical resistivity of $SrMoO_3$ and $SrRuO_3$ as a common oxide electrode material, we show that $SrMoO_3$ exhibits a record-low DC resistivity of 27 $\mu\Omega$cm at room-temperature. Furthermore, $SrMoO_3$ exhibits an AC resistivity of 27 $\mu\Omega$cm in the range of 1-20 GHz, making it the best candidate for integration into all-oxide electronic devices for microwave applications.

DS 1.4 Mon 10:15 CHE 91

Rolled-up nanomembranes for field effect transistors and fluidic sensing applications — •Daniel Grimm[1,2], Cesar Bufon[1,2], Paola Atkinson[1], Dominic Thurmer[1], Franziska Schäffel[1], Sandeep Gorantla[1], Alicja Bachmatiuk[1], and Oliver Schmidt[1,2] — [1]Institute for Integrative Nanosciences, IFW Dresden, Germany — [2]Technische Universität Chemnitz, Material Systems for Nanoelectronics, Germany

In this work we demonstrate for the first time a three-dimensional free-standing metal oxide field-effect-transistor based on strained hybrid nanomembranes [1]. The fabrication process combines conventional device patterning with selective etching to form the three-dimensional rolled-up transistor (RUFET). Extremely small bending radii in the range of 5um can be achieved by taking advantage of the self-rolling technique. The hollow core of the as-produced RUFETs can be further explored foruidic sensing applications with a large sensitivity when feeding polar solvents through the tubes. By standard two-dimensional lithography, the Ohmic contacts, gate electrodes and Al2O3 dielectrics are defined on the surface of single-crystalline semiconducting multilayers. Upon selective etching of an underlying sacrificial layer, the complete planar transistor curls up so that the nanomembrane based channel bonds back onto the gate electrode. This rolled-up technique yields a substantial reduction of the device footprint and the as-produced RUFET can be driven in the depletion mode regime with gate-voltage swings around 160 mV/decade and on-off ratios being several orders of magnitudes. [1] D. Grimm et al., Nano Letters 13,213(2013)

DS 1.5 Mon 10:30 CHE 91

Metal Oxides and SURMOF-Hybrid material assemblies for Photonic and Optical Applications — •Engelbert Redel — IFG (Institut fuer Funktionelle Grenzflaechen)/KIT, Eggenstein-Leopoldshafen, Karlsruhe, DE

Porous hierarchical and photonic materials assemblies will be presented from a library of different metal oxide nanomaterials and hierarchical multilayer constructions. Potential applications of such materials will be presented, reaching from optical and tune able and porous 1D photonic crystals (PCs) to transparent and conductive oxides (TCOs) porous thin films, white light broad-band bragg reflectors as well as electrochromo-photonic switches. Furthermore the optical and dielectric properties of single porous SURMOF thin films as well as multilayered photonic SURMOF-Hybrid materials will be presented in terms of optical sensing.

1 a) E. REDEL, C. HUAI, M. RENNER, G. V. FREYMANN, G. A. OZIN SMALL 2011, 7, 3465-3471. b) E. REDEL, P. MIRTCHEV, C. HUAI, S. PETROV, G. A. OZIN ACS NANO, 2011, 5, 2861-2869.

2 E. REDEL, C. HUAI, S. PETROV, D. OMER, P. O'BRIEN, M. G. HELANDER, J.MLYNARSKI, G. A. OZIN, SMALL 2012, 8, 3806-3809.

3 E. REDEL, J. MLYNARSKI, J. MOIR, A. JELLE, C. HUAI, S. PETROV, M. G. HELANDER, F. C. PEIRIS, G. V. FREYMANN, G. A. OZIN Advanced Materials 2012, 24, OP265-OP269.

4 E. REDEL, Z. WANG, S. WALHEIM, J. LIU, H. GLIEMANN, C. WOELL, Appl. Phys. Lett. 2013, 103, 091903; doi: 10.1063/1.4819836

DS 1.6 Mon 10:45 CHE 91

Phonon Blocking in Multilayers produced by Pulsed Laser Deposition — •Florian Döring[1], Christian Eberl[1], Anna Major[1], Susanne Schlenkrich[1], Felix Schlenkrich[1], Martin Lüttich[2], Maria Mansurova[2], Benjamin Lenk[2], Sarah Hoffmann[3], Markus Münzenberg[2], and Hans-Ulrich Krebs[1] — [1]Institute for Materials Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]1st Institute of Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [3]Institute for x-ray physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Multilayer insulations are a modern high-technology approach for minimizing thermal transport, which is important for thermoelectric materials, thermal barrier coatings, solid state refridgerators and cryogenic applications. In these multilayer structures, the thermal conductivity can be reduced by an increasing number of interfaces between two materials with a high acoustic mismatch resulting in different phonon dispersion relations. Therefore, different types of multilayers, consisting of various metals (e.g. W, Ti, or Cu), oxides (e.g. ZrO2 or MgO) and

polymers (e.g. PC), were selected and pulsed laser deposited (PLD at 248 nm) with high quality and afterwards analysed by ultrafast pump-probe reflectivity measurements. Thereby we found fast phonon modes on ps time scales that indicate possible candidates for THz frequency band gap phononic metamaterials. In this contribution, the necessary steps for the fabrication of phononic metamaterials by PLD and first results of reflectivity measurements are discussed.

Coffee break (15 min)

DS 1.7 Mon 11:15 CHE 91

Multisegment-actuated micro-lenses based on ultrathin diamond membranes — •Johannes Fries[1], Verena Zuerbig[1,2], Wilfried Pletschen[1], Christoph E. Nebel[1], Oliver Ambacher[1,2], and Vadim Lebedev[1] — [1]Fraunhofer IAF, Freiburg, Germany — [2]IMTEK, University of Freiburg, Germany

The drawback of modern tunable micro-lenses based on polymers or silicon is the limitation in their mechanical and tribological properties. In order to overcome these limits, nanocrystalline diamond (NCD) elastic layers were combined with piezo-actuators made from aluminium nitride (AlN) or lead zirconate titanate (PZT). NCD thin films have excellent properties for manufacturing mechanically stable, ultrathin membranes, e.g. a high Young's modulus and an optical transparency from infrared to deep UV. In such ultrathin unimorph structures heavily boron-doped NCD layers (B:NCD) can serve as transparent front electrodes with conductivities up to 100 S/cm. Such bilayer structures were used to fabricate circular membranes. These unimorph membranes were tested towards their electrical, mechanical and optical properties. Finally, membrane-based multisegment piezo-actuated micro-lenses were fabricated. The performance of the micro-lenses was analyzed statically using white light interferometry and dynamically using laser Doppler vibrometry. Symmetric and asymmetric deflection of the lens surface was demonstrated by applying different voltages on each independent segment. These mirco-lenses can be used as focus and aberrations corrector in complex optical systems.

DS 1.8 Mon 11:30 CHE 91

Design, fabrication and performance of polymer actuators for on-chip variable focal length microlenses — •Christian Schirrmann, Boscij Pawlik, Kirstin Bornhorst, and Florenta Costache — Fraunhofer Institute for Photonic Microsystems IPMS, Dresden, Germany

We employed the finite element method (FEM) to simulate the electromecanical behavior of monolayer and multilayer bending actuators based on PVDF-TrFE-CFE (61.7%/29.8%/8.5%) terpolymer of high electrostrictive strain. The actuator geometry (i.e. radial shape), the actuator stack structure, the polymer layer thickness, as well as the electrode material were adjusted in order to improve the deflection characteristics of the actuator. For the actuator fabrication, a layer-by-layer process flow was developed, which included polymer and metallic electrode layers deposition, structuring and direct bonding. The analysis of the actuator performance by means of interferometric methods indicated that very large deflections could be obtained. Furthermore, the optimized terpolymer bending actuator was employed in the design of a microlens with electrically adjustable focal length. This microlens consisted of two microfluidic compartments sealed by an elastic lens membrane. Here, the integrated actuator played the role of a pump. The variable micro-lens chip geometry was optimized using 3D-FEM simulations and fabricated using planar microtechnology. For a microlens with 3 mm aperture diameter, we could achieve a tuning range in the refractive power between 0 and more than 20 dpt for fairly low operation voltages.

DS 1.9 Mon 11:45 CHE 91

Reduction via PLD: Growth of highly conductive $SrMoO_3$ thin films using various reducing atmospheres — •Aldin Radetinac, Arzhang Mani, Philipp Komissinskiy, and Lambert Alff — Institute for Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany

We have investigated the growth of $SrMoO_3$ by pulsed laser ablation out of a $SrMoO_4$ target. To stabilize $SrMoO_3$, one oxygen atom per formula unit has to be removed out of the material flux during the film growth. To achieve effective reduction, the atmosphere was varied from ultra high vacuum (10^{-9} torr) to Ar- and H_2+Ar mixtures. We show that laser pulse rate and gas flow have a high impact on the actual film quality for reductive film growth. Thus, thin films of metastable materials can be grown by pulsed laser deposition with their growth speed, microstructure, surface morphology and homogeneity controlled by the choice of growth parameters.

This work was supported by the DFG projects GRK 1037 (TICMO) and KO 4093/1-1.

DS 1.10 Mon 12:00 CHE 91

Work function tuning of pyrolytic carbon electrodes and integration in nanoelectronic devices. — •Andreas Krause[1], Andrew Graham[1], Thomas Mikolajick[1,2], and Walter M. Weber[1] — [1]namlab gGmbh, D-01187 Dresden — [2]Institut fuer Halbleiter- und Mikroelektronik IHM, TU Dresden

Pyrolytic carbon is an extraordinary material, which can be used as an electrode material for nanoelectronic device integration. The carbon layers have been grown by CVD below 900C. With a work function of 4.6 eV and high conformity, it poses a real alternative to standard TiN or other electrode materials. Composing of a polycrystalline mixture of graphite-like (sp^2) and amorphous (sp^3) carbon, it exhibits an metal ohmic behavior with $1.5\,m\Omega cm$. The amount of graphite-like (conductive) proportions can be changed with the annealing temperature and easily controlled with Raman spectroscopy. The work function of 4.6 eV has been tuned in our experiments with the introduction of nitrogen as dopant to the surface layer. [Aichmayr et al., 2007 IEEE Symposium on VLSI Technology] [A. Graham et al., J. Appl. Phys. 2010, 107(11)] [A. Graham et al., J. Appl. Phys. 2010, 108(10)]

DS 1.11 Mon 12:15 CHE 91

Dynamic Effects in the Power Spectral Density Determination of Multilayers with EUV Light — •Anton Haase, Victor Soltwisch, Christian Laubis, and Frank Scholze — Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin

The throughput of EUV lithography systems is presently strongly limited by the available radiant power at the waver level. Besides increasing the power of EUV sources, also the quality of the optical elements plays a key role. With state of the art multilayer mirrors the main cause of diminished reflectance is surface and interface roughness as well as interface diffusion. Both properties lead to diffuse scattering reducing the intensity of specular reflected light in the relevant EUV spectral range around 13.5 nm below the theoretical limit. The intensity distribution of diffusely scattered light provides information on vertical and lateral correlations of spacial frequencies of roughness through the appearance of resonant diffuse scattering (RDS) sheets. The study of off-specular scattering thus serves as a natural tool for the investigation roughness power spectral densities (PSD) of the interfaces. We found that dynamical scattering contributions from thickness oscillations (Kiessig fringes) lead to Bragg lines which intersect the RDS sheets. This causes strong resonant enhancement in the scatter cross section. Thus for power spectral density studies of multilayer interface roughness, resonant dynamical scattering can not be neglected. We considered the scatter enhancement by applying fully dynamic distored wave Born approximation to extract the power spectral density of roughness.

DS 1.12 Mon 12:30 CHE 91

Fabrication of Multilayer Zone Plates for hard x-ray point nano focusing — •C. Eberl[1], F. Döring[1], F. Schlenkrich[1], T. Liese[1], V. Radisch[1], M. Osterhoff[2], A. Robisch[2], A. Ruhlandt[2], S. Hoffmann[2], M. Krenkel[2], M. Bartels[2], M. Sprung[3], H.U. Krebs[1], and T. Salditt[2] — [1]Institut für Materialphysik — [2]Institut für Röntgenphysik, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [3]HASYLAB at DESY, Notkestr. 85, 22607 Hamburg, Germany

X-ray microscopy is due to the small wavelength and high penetration depth an auspicious technique for improved investigations of materials on nm-scale. For this, multilayer zone plates (MZP) with thin multilayers grown on wires are promising optical elements. Different materials such as W/Si, W/ZrO_2 and Ta_2O_5/ZrO_2 were used for the growth of high quality multilayers by pulsed laser deposition (PLD). They were investigated by X-ray reflectivity, transmission electron microscopy in cross-section and in-situ rate monitoring approving high accuracy in layer thickness as well as smoothness and well defined interfaces. In contrast to sputter deposition, where mostly cumulative roughness is observed, PLD shows smoothing effects, even on wires which is due to the energetic particle deposition. Only based on the knowledge of the underlying deposition processes high quality multilayers according to the zone plate law could be deposited onto a wire. Using these coated wires, highly precise MZP optics were fabricated by focused ion beam

(FIB) showing hard x-ray point focusing with unprecedented focal sizes of less than 5 nm.

DS 1.13 Mon 12:45 CHE 91

Interface investigation of ion-beam deposited Chromium/ Scandium multilayer mirrors — •Stefan Radünz[1,2], Alexander Guggenmos[1,2], Roman Rauhut[1,2], Bert Nickel[3], Sriram Venkatesan[4], Angela Wochnik[4], Christina Scheu[4], Eric M. Gullikson[5], Ferenc Krausz[1,2], and Ulf Kleineberg[1,2] — [1]LMU München, Fakultät für Physik, Garching, Germany — [2]MPQ, Garching, Germany — [3]CeNS, LMU München, München, Germany — [4]LMU München, Fakultät für Chemie, München, Germany — [5]CXRO, Lawrence Berkeley National Lab, Berkeley, USA

Highly reflective multilayer mirrors for beam steering, spectral shaping or as focusing elements for the water window spectral range, between the K-absorption edges of carbon and oxygen (284 eV and 543 eV, respectively) are of great interest for various applications like high-resolution microscopy, time-resolved (soft) x-ray spectroscopy or x-ray astronomy. Their demand for low-photon loss optics challenges the manufacturing process to create interfaces as perfect as possible due to the huge loss in reflectivity which arises from boundary imperfections. We present our achievements in minimizing the interface roughness of ion-beam deposited Cr/Sc multilayer mirrors by optimizing the kinetic energy of the utilized Krypton ions both in the deposition and the interface polishing process. The characteristics of our ion-beam polished nanolayers can be investigated using in-situ ellipsometry. Experimental results from measurements using X-ray reflectometry, spectral ellipsometry and XUV reflectrometry as well as TEM cross section images are shown and discussed.

DS 1.14 Mon 13:00 CHE 91

Wet-chemical Synthesis of $SrTiO_3$-Ruddlesden-Popper-Phases for photoelectrochemical Watersplittingg — •Diana Karsch, Doreen Eger, Erik Mehner, Hartmut Stöcker, and Dirk Meyer — TU Freiberg - Institut für experimentelle Physik

The photoinduced watersplitting promises a considerably simplification for the hydrogen production. Therefore the energy of photons, e.g. the sunlight, is used for splitting the water into its molecular components, Oxygen and Hydrogen. This is worked out by irradiation of light with a suitable wavelength to a semiconductor.

Thin films of $SrTiO_3$-Ruddlesden-Popper-Phases are produced by sol gel synthesis and are characterized due to phase content and morphology. For comparison of phase setup additionally one sample with stoichiometric relations is produced by ion beam implantation in a $SrTiO_3$ single crystal. The setup of crystalline phases in the film was investigated with *in-situ* X-ray diffraction.

The samples show delicate, spongy structures on the surface, which are visible by electron scanning microscopy. In addition to the RP-phases all samples have a relevant part of impurity phases. Further photoelectrochemical measurements with sol gel synthesized thin layers have been executed for the first time. The results show that the thin layer working electrodes are suitable for water splitting.