DS 39: Thin Film Applications

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

DS 39.1 Thu 9:30 CHE 91

Transport properties of nanostructured graphene — •Victor Aristov[1,2,3], Olga Molodtsova[1,4], Sergey Babenkov[1], Han-Chun Wu[5], Alexander Chaika[2], Dmitry Marchenko[6], Andrei Varykhalov[6], Alexei Zakharov[7], Yuran Niu[7], Alexei Preobrajenski[7], Denis Vyalikh[8], Barry Murphy[9], Sergey Krasnikov[9], and Igor Shvets[9] — [1]DESY, Hamburg, Germany — [2]ISSP RAS, Chernogolovka, Russia — [3]TU Bergakademie, Freiberg, Germany — [4]ITMO, Saint Petersburg, Russia — [5]BIT, Beijing, China — [6]BESSY, Berlin, Germany — [7]Max-lab, Lund, Sweden — [8]TU Dresden, Germany — [9]Trinity College, Dublin, Ireland

Trilayer graphene reveals unique electronic properties appealing for fundamental science and electronic technologies. We propose a simple method to open a charge transport gap and achieve a high on-off current ratio in Bernal-stacked trilayer graphene synthesized on vicinal SiC(001). Low-temperature measurements show that self-aligned, periodic nanodomain boundaries induce a huge charge transport gap of more than 1.3 eV at 10 K and 0.4 eV at 100 K. Our studies indicate the feasibility of creating electronic nanostructures using graphene on cubic-SiC/Si wafers.This work was supported by the RAS, RFBR grants No 17-02-01139 and No 17-02-01291.

DS 39.2 Thu 9:45 CHE 91

Co-doping of VO_2 with W and Sr for intelligent glazing — •Florian Kuhl, Angelika Polity, and Peter J. Klar — I. Physikalisches Institut, Justus Liebig University, Heinrich-Buff-Ring 16, DE-35392 Giessen, Germany

Vanadiumdioxide is a thermochromic material that undergoes a semiconductor-to-metal transition (SMT) at about 68 °C due to a phase change from monoclinic to rutile phase. At this transition the transmittance and reflectivity in the near infrared is decreased, thus it is an interesting material for intelligent window coatings for controling the temperature in buildings passively. But due to its transition temperature and optical properties, VO_2 thin films are not used for window coatings. Literature reports that the doping with tungsten will decrease the transition temperature and the doping with alkaline earth metals like Sr will enhance the optical properties.
We present our results on thin films that are co-doped with W and Sr in the rf sputtering process. With this method we can use both effects. On the one hand the transition temperature is reduced and on the other hand the optical properties can be improved so that the thin films show comparable properties to comercially available electrochromic window glazings. Furthermore we produced multi layer systems with anti reflective coatings to obtain coatings with enhanced properties for the use as intelligent glazings.

DS 39.3 Thu 10:00 CHE 91

SrZrO Interlayer — •Corinna Müller, Patrick Salg, Aldin Radetinac, Philipp Komissinskyi, and Lambert Alff — Technische Universität Darmstadt, Germany

We present SZO thin film utilized as a oxygen diffusion barrier grown by PLD. SZO is grown between BST and SMO in an all-oxide varactor to inhibit the oxidation of SMO. In the past STO has been used for this purpose but the performance was not optimized yet. SZO is very promising because of its very low oxygen diffusion constant in the range of $10^{-12} cm^2 s^{-1}$ compared to STO with $10^{-4} cm^2 s^{-1}$ [1],[2]. This work shows that SZO grows on top of SMO with very low oxygen partial pressure. Growth studies are performed with different parameters like laser fluence and substrate temperature. It could be shown that SZO is very invariant to these parameters. The problem of SZO is the big lattice constant compared to the substrate. Reciprocal space maps show that the resulting films relax instead of growing strained. To optimize this behaviour a mixture of STO and SZO is grown. The performance as an oxygen diffusion barrier is investigated with in-situ XPS studies. For that the SMO is capped with SZO and annealed under oxygen atmosphere.

[1] C. Nivot et al., "Oxygen diffusion in SrZrO3", Solid State Ionics, vol. 180, no. 17-19, pp. 1040-1044, 2009.
[2] T. Bieger et al., "Kinetics of oxygen incorporation in SrTiO3 (fe-doped): An optical investigation", Sensors and Actuators B: Chemical, vol. 7, no. 1-3, pp. 763-768, 1992.

DS 39.4 Thu 10:15 CHE 91

Sensor applications of indium tin oxide nano-columns formed by glancing angle deposition — •Kenneth Harris[1,2], Abebaw Jemere[1], Donghai Lin[1], Nora Chan[3], Véronique Balland[4], and Benoît Limoges[4] — [1]National Research Council Canada, National Institute for Nanotechnology, Edmonton, Canada — [2]Leibniz Institute of Polymer Research, Dresden, Germany — [3]Defense Research and Development Canada, Suffield, Canada — [4]Université Paris Diderot 7, Molecular Electrochemistry Laboratory, Paris, France

The glancing angle deposition (GLAD) technique can be used to fabricate nano-columnar structures with precisely-controlled shapes (including cylinders, helices, zig-zags and others) and in a wide variety of materials (including metals, oxides, ceramics and small-molecule organics). In this presentation, I will describe glancing angle deposition of the transparent conductor indium tin oxide (ITO), discussing deposition conditions and post-treatments to control electrical conductivity and transparency to visible light. Sensing applications of these GLAD-ITO structures will then be presented. Due to their large and accessible surface area, GLAD-formed structures can adsorb (or interact with) large quantities of analytes. With ITO-based sensors, both light transparency and electrical conductivity are also built into the materials system, allowing electrical and optical phenomena to be actively monitored during exposure to analytes of interest. Data from two representative GLAD-ITO sensing platforms will be presented: sensors for detection of bacterial surface proteins, and spectro-electrochemistry electrodes to observe the evolution of chemical redox reactions.

DS 39.5 Thu 10:30 CHE 91

Optical Investigation of Structural Disorder in Normal Spinel Ferrites in Relation to Magnetic Properties — •Vitaly Zviagin[1], Yogesh Kumar[1], Paula Huth[2], Israel Lorite[1], Annette Setzer[1], Daniel Spemann[3], Jan Meijer[1], Reinhard Denecke[2], Pablo Esquinazi[1], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1] — [1]Universtät Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, Germany — [2]Universtät Leipzig, Wilhelm-Ostwald-Institut für Physikalische und Theoretische Chemie, Linnéstr. 2, Germany — [3]Leibniz-Institut für Oberflächenmodifizierung e. V., Permoserstr. 15, Germany

We present an optical investigation of structural disorder in spinel ferrites grown at different temperatures and pressures on MgO (100) and $SrTiO_3$ (100) substrates by pulsed laser deposition. Optical transitions in the diagonal elements of the dielectric tensor, obtained by spectroscopic ellipsometry, were identified and related to the presence of Fe^{2+} and Fe^{3+} cations located at different lattice sites corresponding to disorder and inversion of the normal crystal structure. Procedures such as annealing and irradiation with Si ions were applied to induce disorder and to alter the crystal structure of the investigated thin films. A direct correlation between the overall magnetic response, measured by SQUID, and the presence of Fe^{3+} on the tetrahedral lattice sites has been found and can be explained by the ferrimagnetic order of the crystal due to the dominating nature of the oxygen mediated coupling between the tetrahedral and octahedral lattice sites.

DS 39.6 Thu 10:45 CHE 91

Nanostructured Freestanding Silicon Nitride Membranes for Field Electron Emission Based Detectors in Mass Spectrometry — •Stefanie Haugg, Chris Thomason, Christian Henkel, Robert Zierold, and Robert H. Blick — Institute of Nanostructure and Solid State Physics, Universität Hamburg, Hamburg, Germany

Freestanding nanomembranes can potentially be utilized in the detector unit of commercial time-of-flight (TOF) mass spectrometers because of their (i) quasi-dynamic mode of vibration or (ii) phonon-assisted field electron emission properties.[1]

Herein, rod-shaped nanostructures on freestanding silicon nitride membranes have been processed via a top-down approach using gold nanodots as hard mask for subsequent reactive ion etching. We show that geometrically enhanced field electron emission can be observed—in a emitter-grid-anode test setup connected to a transimpedance amplifier—on such nanostructured membranes compared to their planar counterparts.

Moreover, we employ microchannel plates for signal amplification

of field electron emission from our nanostructured membranes. This configuration offers the possibility to combine sample characterization with TOF mass spectrometry measurements without changing the setup.

[1] Park, J.& Blick, R. H. A silicon nanomembrane detector for matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS) of large proteins. Sensors 13 (2013)

DS 39.7 Thu 11:00 CHE 91

Nanoscale picosecond acoustic spectrometry of phononic superlattices — •Dennis Meyer[1], Henning Ulrichs[1], Florian Döring[2], and Hans-Ulrich Krebs[2] — [1]I. Physikalisches Institut, Universität Göttingen, Germany — [2]Institut für Materialphysik, Universität Göttingen, Germany

We show how the characteristics of acoustic resonances in metallic nano-cavities can be tailored by tuning the interplay with an underlying phononic crystal. For this purpose we exploit ultrafast optical excitation, which enables us to address a resonant surface mode with frequency around 180 GHz in a wedge-shaped tungsten thin film, grown on a MgO/ZrO_2 phononic crystal. The lifetime of the surface mode was found to vary between 60 and 250 ps, depending on the position on the wedge. Vice versa, one can also regard our results as a demonstration of a nanoscale acoustic spectrometry principle for investigation of the elastic wave band structure of a superlattice: a strong response of the surface layer only appears for frequencies inside an acoustic mini-band gap. By spatially moving the laser across the wedge, the first mini-band gap was mapped out. These results are in good agreement to a theoretical model of the system. In addition to these findings, we see an unexpected increase in frequency in the experimental data, when crossing the lower band-gap edge from above. We acknowledge financial support by the DFG within the CRC 1073 'Atomic scale control of energy conversion'.

15 min. break.

DS 39.8 Thu 11:30 CHE 91

Minimizing thermal conductivity in laser deposited multilayers — •Döring Florian and Krebs Hans-Urlich — Institut für Materialphysik, Universität Göttingen

Minimizing thermal conductivity is essential for modern applications in the field of thermal barrier coatings, thermoelectrics, cryogenics and space-applications. The reduction of thermal conductivity can be achieved by an increase of phonon scattering and phonon localization as well as by a reduction of phonon mean free path and velocity. These effects happen typically in materials with a high amount of interfaces and result in a thermal boundary resistance. Thus, the goals in order to minimize the thermal conductivity are on the one hand to maximize the interface density and on the other hand to maximize the thermal boundary resistance at each interface, which gives a high overall thermal resistance and thereby a low thermal conductivity. Those goals can be achieved by combining materials with a high acoustic mismatch in nanoscale multilayers. A prominent method for this purpose is pulsed laser deposition, which is a very versatile thin film method, allowing combining materials with very different properties such as metals, oxides and polymers and thus fabricating materials with a high density of interfaces between dissimilar materials that show a high thermal resistance. In this contribution, multilayers of W/polycarbonate and W/ZrO2 as well as measurements on their thermal conductivity, showing very low values, are presented. While the first material combination excels by a very high acoustic mismatch, the second material combination is outstanding in terms of thermal stability.

DS 39.9 Thu 11:45 CHE 91

Ion-beam-induced magnetic and structural phase transformation of fcc Fe thin films on different substrates — •Jonas Gloss[1], Michal Horký[1,2], Bernhard Ruch[1], Viola Křižáková[2], Lukáš Flajšman[2,3], Michael Schmid[1], Michal Urbánek[2,3], and Peter Varga[1,3] — [1]Inst. of Appl. Phys., TU Wien, AT — [2]Inst. of Phys. Engineering, Brno University of Technology (BUT), CZ — [3]Central European Inst. of Tech. BUT, CZ

It has been shown that 5-10 ML thick Fe films on Cu(100) have an fcc structure and are nonmagnetic at room temperature [1]. Ion beam irradiation of the fcc films causes a structural transformation from fcc to bcc as well as a magnetic transformation from nonmagnetic to ferromagnetic. To remove the 10-ML thickness limit of fcc Fe we alloyed it with 22% of Nickel to form the metastable fcc Fe [2]. To make use of the metastable films for magnonic crystals, we replaced the Cu(100) with two new alternative substrates H-Si(100) and C(100), which are also more suitable for applications and optical analysis. The first substitute is hydrogen terminated Si(100) with a Cu buffer layer. The as-grown $Fe_{78}Ni_{22}$ is corrugated, but metastable. The second successfully adapted substrate is undoped diamond C(001), on which metastable $Fe_{78}Ni_{22}$ films can be grown in 4-ML steps followed by post annealing.

[1] A.Biedermann, R.Tscheließnig, M.Schmid and P.Varga, Phys. Rev. Lett. **87** (2001) 086103

[2] J. Gloss, S. Shah Zaman, J. Jonner, Z. Novotny, M. Schmid, P. Varga, M. Urbánek, Appl. Phys. Lett. **103** (2013) 262405

DS 39.10 Thu 12:00 CHE 91

A Novel Approach to Monitor Surface Driven Photocatalysis Reactions at Titania-Organic Dye Interfaces — •Cenk Aktas, Muhammad Zubair Ghori, Mohammed Emami, Alexander Wahl, Oleksandr Polonskyi, Thomas Strunskus, and Franz Faupel — Institute for Materials Science, Chair for Multicomponent Materials, Faculty of Engineering, Christian-Albrechts-University of Kiel, Kaiserstraße 2, D-24143 Kiel, Germany

Titania is one of semi-conductor oxides which has been extensively studied in the past due to its high photocatalytic activity. On the other hand there is still a lack of knowledge in understanding mechanism of titania photocatalysis. Basically the degradation of an organic dye is monitored by time in terms of its optical absorption to analyse the photocatalytic activity. Most of these analyses are carried out in wet environment and there is relatively less study on characterisation of photocatalytic activity in gas or solid phase. While former gives an indirect measure, later may provide details of the surface reactions taking place directly at the titania-organic layer interface. This work covers a novel analytic approach to investigate details of the photocatalytic reaction at the titania surface using a dry test medium (organic dye in the form of a thin film). A comparative study between the wet and dry analysis approaches is also provided to understand the overall mechanism involved in the photocatalysis.

DS 39.11 Thu 12:15 CHE 91

The Effect of Surface Modification by Atomic Layer Deposition on the Field Emission Characteristic of Free-Standing Diamond Nanomembranes for Mass Spectrometry — •Christian Henkel, Chris Thomason, Stefanie Haugg, Robert Zierold, and Robert H. Blick — Institute of Nanostructure and Solid State Physics, Universität Hamburg, Hamburg, Germany

For mass spectrometry of large proteins, a nanomembrane based detector can be used for high-resolution measurements in the range > 100 kDa. Its efficiency is heavily influenced by the eletromechanical properties of the membrane in the detector unit.

As an improvement, zinc oxide is deposited on the surface of suspended diamond nanomembranes by means of atomic layer deposition. Electron field emission is measured as a function of the applied electric field for different cycle numbers in a home-made test setup at room temperature. The field emission characteristic is found to be highly dependent on the surface modification by ALD, possibly due to a change of the intrinsic electrical properties of the emitting material. Specifically, we found a decrease in work function as well as turn-on field of field emission for film thicknesses less than 1 nm, while thicker films lead to a huge increase of both.

Hereby, we prove that chemical surface modification by means of ultra-thin ALD coatings might lead to enhanced field emission properties of nanomembranes.

DS 39.12 Thu 12:30 CHE 91

A hybrid molecular beam epitaxy based growth method for large-area synthesis of stacked hexagonal boron nitride/graphene heterostructures — •Siamak Nakhaie[1], Joseph M. Wofford[1], Thilo Krause[1], Xianjie Liu[2], Manfred Ramsteiner[1], Michael Hanke[1], Henning Riechert[1], and J. Marcelo J. Lopes[1] — [1]Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany — [2]Department of Physics, Chemistry and Biology, Linköping University, SE-58183 Linköping, Sweden

Devices based on the graphene/hexagonal boron nitride (h-BN) materials system offer a host of potential advantages, including high speed, extremely low power consumption, and various novel functionalities. As a result, the large-area synthesis of this material has been extensively researched over the past few years using various crystal growth

techniques. In this contribution, we introduce a method for the production of h-BN/graphene heterostructures which allows both materials to form on the surface of the Ni substrate. We exploit the finite solubility of C in Ni by first saturating the metal film, then depositing a few-layer thick h-BN film from elemental B and N on the exposed Ni surface, and finally ramping the sample temperature down to controllably precipitate the C and form graphene at the interface between the h-BN and Ni. The resulting heterostructures are studied using various characterization techniques, such as UV and visible Raman spectroscopy, x-ray photoelectron spectroscopy and synchrotron-based grazing incidence spectroscopy to learn about their structural properties and quality.

DS 39.13 Thu 12:45 CHE 91

Phase transforming magnetocaloric Heuslers for multiferroic devices — •Yi-Cheng Chen[1,2], Parul Devi[1], Benedikt Ernst[1], Roshnee Sahoo[1], Ying-Hao Chu[2], Sanjay Singh[1], Gerhard Fecher[1], and Claudia Felser[1] — [1]MPI- CPfS, Dresden, Germany — [2]National Chiao Tung University, Hsinchu, Taiwan

Ni-Mn based magnetocaloric Heusler alloys show large resistance change at their magneto-structural (austenite-martesnite) phase transition. The martensite transition in these alloys is very much sensitive to the external pressure or strain and phase fraction of martensite can be easily tuned via strain. Therefore, a large resistance change can be realized in a magnetocaloric Heusler/Piezo heterostructure via the strain control of a ferroelectric substrate. We prepared the $Ni_2Mn_{1-x}In_x$ Heusler thin film on PMN-PT substrate using DC-magnetron sputtering and studied them using x-ray diffraction, EDX and magnetization measurements. The x-ray diffraction reveals a coexistence of austenite and modulated martensite phase at room temperature. The magnetization measurements show martensite transition over a broad temperature range as evident by the observed thermal hysteresis. Our future perspective is to obtain sharp austenite-martensite transition and to apply strain with electric field on this heterostructure film, which induces a change in the phase fraction and hence resistance that can be used as multiferroic devices .

DS 39.14 Thu 13:00 CHE 91

Growth and characterization of NbSe2 on Al2O3 (0001) using molecular beam epitaxy — •Avanindra Kumar Pandeya, Kai Chang, Amilcar bedoya Pinto, Ilya Kostanovskiy, and Stuart Parkin — Max Planck Institute of Microstructure Physics

The most common way to produce transition metal dichalcogenide (TMDC) thin films is via mechanical exfoliation, a method which is not well-suited to fabricate heterostructures with coherent interfaces or large-area thin film applications. Moreover, spintronic effects such as spin transfer torque are extremely sensitive to the quality of the heterointerface. Our approach is to use molecular beam epitaxy (MBE) to grow in-situ TMDC heterostructures and assess the layer and interface quality using in-situ characterization (RHEED, LEED, XPS and STM). Employing a two-step growth scheme, we achieved high-quality, single-crystalline NbSe2 layers on Al2O3 (0001) substrates. A superconducting transition was observed below 4K and is found to be driven by the carrier density in the metallic layers. The achievement of epitaxial, high-quality TMDC layers with high spin-orbit coupling opens up good prospects to realize an efficient spin transfer in TMDC/ferromagnet bilayers.