O 32: Semiconductor Substrates

Time: Tuesday 10:30–12:45 Location: GER 39

O 32.1 Tue 10:30 GER 39

Progress in local growth of III/V-semiconductor structures — •Christian Bruckmann, Jürgen Bläsing, Armin Dadgar, and André Strittmatter — Otto-von-Guericke-Universität Magdeburg, PF4120 Magdeburg, Germany

We recently developed a laser-assisted metalorganic vapor phase epitaxy (LA-MOVPE) for local growth of III/V-semiconductors[1]. The principle is based on local heating of a selected growth area by high-power laser radiation. Metalorganic precursors are fed into the reactor to the locally heated area so that the chemical reactions leading to island growth are confined within the heated area. Thereby, selective area growth can be done without full wafer heating which is advantageous for heteroepitaxy of crystalline materials and monolithic III/V device integration on Si. We report on optimum conditions for homoepitaxial GaAs growth, n- and p-type doping as well as AlGaAs/GaAs heterostructures. We discuss the proper choice of precursors and lateral homogeneity of ternary layers.

[1]M. Trippel et al., "Laser-assisted local metal-organic vapor phase epitaxy", Rev. Sci. Instrum. **93**, 113904 (2022)

O 32.2 Tue 10:45 GER 39

Post-synthesis of copper nitride monolayers from copper oxide films — •Mohammadreza Rostami[1], Biao Yang[1], Francesco Allegretti[1], Lifeng Chi[2], and Johannes V. Barth[1] — [1]Physics Department E20, Technical University of Munich, Garching, 85748, Germany — [2]Institute of Functional Nano & Soft Materials, Collaborative Innovation Center of Suzhou Nano Science and Technology, Soochow University, Suzhou 215123, P. R. China

Copper nitride (CuN) thin films represent insulating layers bearing promise for decoupling functional structures from a metallic copper substrate. [1] Although the nitrogen ion bombardment method was successfully applied for the in-situ preparation of CuN monolayers on Cu surfaces, the reduced domain size limits their application potential. [2] In this work, we have grown extended monolayer CuN films on Cu (111) surfaces by ammonia-mediated post-annealing of copper oxide (CuO) thin films. Structures and properties of CuN and CuO monolayers were characterized by scanning tunneling microscopy and low-energy electron diffraction. The element exchange of nitrogen with oxygen in the respective CuN and CuO layers on Cu (111) surfaces was evidenced by X-ray photoelectron spectroscopy. This oxidation-reduction two-step strategy provides a new approach to fabricate CuN buffer layers. [1] Z. Zhao et al, Adv. Electron. Mater. 2018, 4, 1700367 [2] H. Baek et al, Appl. Phys. Lett. 91, 253106 (2007)

O 32.3 Tue 11:00 GER 39

The role of mechanical strain in rare-earth silicide monolayers on Si(111) — •Kris Holtgrewe and Simone Sanna — Justus-Liebig-Universität, Gießen, Deutschland

Rare-earth silicide ($RESi_2$) nanostructures on silicon surfaces provide a very heterogeneous class of lower-dimensional metallic systems supported by a semiconducting substrate. The $RESi_2$ monolayer is a two-dimensional semimetal, which grows on Si(111) by self-organisation. While it has intensively been studied by experimental and theoretical works, there are major misunderstandings about the mechanisms which determine the morphological details of the monolayer. In particular, many previous studies state that mechanical strain is responsible for the structural differences between the $RESi_2$ monolayer on Si(111) (buckled Si honeycomb, vacancy-free), the $RESi_{2-x}$ bulk phase (flat Si honeycomb, vacancy-rich) and the AlB_2 structure (flat Si honeycomb, vacancy-free). This DFT work sheds light on the stability of the established structure model of the monolayer by a combined analysis of the structural details and the electronic band structure. It proves that the buckling of the covering Si honeycomb and the lack of Si vacancies are not due to mechanical strain, but due to charge balance. In this context, the monolayer is structurally more similar to the unstrained $CaSi_2$ structure than to the strained AlB_2 structure, which explains its stability. It is very likely that the misinterpreted role of mechanical strain is transferable to all $RESi_2$ nanostructures.

O 32.4 Tue 11:15 GER 39

Electronic and magnetic properties of ultrathin $FeBr_2$ films grown on Bi/Si(111) — •Shigemi Terakawa[1], Jiabao Yang[1], Shinichiro Hatta[2], Hiroshi Okuyama[2], Tetsuya Aruga[2], Niels Schröter[1], and Stuart Parkin[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Graduate School of Science, Kyoto University, Kyoto, Japan

Mono and a few layers of van der Waals (vdW) magnets are promising two-dimensional (2D) materials to fabricate heterostructures with topological materials to realize novel topological phases via proximity effects, such as the quantum anomalous Hall effect. $FeBr_2$ is a layered Ising antiferromagnet, where the magnetic moments are coupled ferromagnetically in a layer and antiferromagnetically between adjacent layers. We succeeded in the epitaxial growth of ultrathin $FeBr_2$ films using molecular-beam epitaxy on Bi/Si(111) substrate. We observed insulating band structures using angle-resolved photoelectron spectroscopy (ARPES). The valence band top is located at a flat band with a binding energy of 2 eV, which is ascribed to Fe 3d orbitals. At monolayer coverage, the Fe 3d flat band does not change but dispersive bands of Br 4p at 7-8 eV are largely altered due to the disappearance of inter-layer Br-Br coupling in the monolayer film. The monolayer film shows a strong moire pattern in low-energy electron diffraction (LEED), suggesting a strong coupling between the $FeBr_2$ and Bi films. We plan to discuss the magnetic properties of the $FeBr_2$ films from the results of XMCD experiments.

O 32.5 Tue 11:30 GER 39

In situ XPS Study on ultrathin Fe_xO_y Films on $SrTiO_3$ — •Pia Maria Düring, Timo Krieg, and Martina Müller — Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany

Oxide interfaces are emerging as one of the most interesting systems in condensed matter physics as they exhibit a multitude of physical phenomena such as 2D electron/hole gas, superconductivity, or the Spin Hall effect. One of the main processes that controls the physical properties is the oxygen exchange between the film and the substrate. The tunability of the oxygen transfer using different growth parameters opens up the possibility to unravel unexplored properties.

Using our UHV-MBE system, we grow high-quality ultrathin Fe-oxide films on $SrTiO_3$ substrates by systematically varying certain growth parameters. Performing in situ X-ray Photoelectron Spectroscopy and Low Energy Electron Diffraction enables the analysis of the electronic properties and crystalline structure of ultrathin Fe_xO_y films directly after the growth without any atmospheric contamination.

The present work discusses the effect of different growth temperatures, substrate annealing procedures, and film thicknesses of the Fe_xO_y films on the interfacial properties like oxygen vacancies. The results open up the possibility for the emergence of 2D electronic states at the interface by tuning such growth parameters.

O 32.6 Tue 11:45 GER 39

MOVPE of Stacked Quantum Dots Layers at 1250 nm Wavelength — •Ege Özmen, Armin Dadgar, and André Strittmatter — Otto von Guericke University, Magdeburg, Germany

LIDAR, light detection and ranging, is the technology to produce a 3D model of surroundings using semiconductor laser technology. In LIDAR, the return of laser pulses reflected from an object's surface is recorded in time. For optimum control of laser direction, a tightly bundled laser radiation is required. Since the light output from traditional semiconductor edge-emitting lasers is highly divergent, especially along the vertical axis, novel concepts for optical waveguides in laser diodes with lower output divergence have to be considered. Besides, as LIDAR operates in free space, a proper choice for laser wavelength has to be made. The current choice is around 905 nm wavelength which raises concerns about eye safety. Much better eye safety and therefore higher output powers could be realized if high-brilliance lasers operating at 1250 nm wavelength could be used. Here, we report on an optimization of MOVPE growth conditions to obtain up to 10-fold stacks of InGaAs quantum dots on a GaAs(001) substrate. We compare laser structures with 5-10 QD layers for static output characteristics.

O 32.7 Tue 12:00 GER 39

About the excitation of island growth orthogonal to the surface in the substrate Pb/Si(111)-(7x7) — •Paul Philip Schmidt, Lea Faber, and Regina Hoffmann-Vogel — Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam-

Golm, Germany

With the increasing miniaturization of systems, the phenomena of surface diffusion is becoming more and more relevant. Pb shows anormaly fast mass transport on Si(111)-(7x7) [1,2]. For this system island growth and the behaviour of the wetting layer must be taken into account in order to understand the physical processes at the surface. We investigate the growth of the islands. Si was cleaned by rapid heating to 1200°C. Pb was deposited on the sample by evaporation at room temperature or liquid nitrogen temperature (120K). We create local imbalances of Pb to draw conclusions about diffusion and selectively trigger island growth at individual islands. While we measure the topography with non contact atomic force microscopy, we simultaneously determine the local work function difference with Kelvin probe force microscopy. Our experiments show an energy barrier before ring growth occurs. Once atoms have reached an existing island, ring growth around occurs quickly. In experiments where we do not force this the islands hardly show any growth perpendicular to the surface. Part of the Pb comes from the restructuring of the island, which initially shrinks in the xy-direction.

[1] M. Hupalo et. al. Phys. Rev. B, 23, 235443 (2007)
[2] K. L. Man et al. Phys. Rev. Lett., 101 226102 (2008)

O 32.8 Tue 12:15 GER 39

Solution-Synthesized Extended Graphene Nanoribbons Deposited by High-Vacuum Electrospray Deposition — •Sebastian Scherb[1], Antoine Hinaut[1], Xuelin Yao[2], Alicia Götz[2,3], Samir H. Al-Hilfi[2], Xiao-Ye Wang[2], Yunbin Hu[2], Zijie Qiu[2], Yiming Song[1], Klaus Müllen[2,3], Thilo Glatzel[1], Akimitsu Narita[2], and Ernst Meyer[1] — [1]Department of Physics, University of Basel, Basel, Switzerland — [2]Max Plank Institute for Polymer Research, Mainz, Germany — [3]Department of Chemistry, Johannes Gutenberg University Mainz, Mainz, Germany

Solution-synthesized graphene nanoribbons (GNRs) can facilitate various interesting structures or functionalities, like non-planarity and thermo-labile functional groups, which can be difficult to access via on-surface synthesis [1,2]. However, their deposition and thus study on surfaces remains challenging.

Here, we show high-vacuum electrospray deposition (HVESD) of well-elongated solution-synthesized GNRs on metallic and non-metallic surfaces in UHV. Thereby, we compare three distinct GNRs, exhibiting different average lengths, functional groups, and edge structures. nc-AFM studies at room temperature combined with Raman spectroscopy allow the characterization of individual GNRs and confirm their chemical integrity [3].

[1] Narita et al. Nature Chemistry 6 (2014).
[2] Narita et al. Chemical Science 10 (2019).
[3] Scherb et al. accepted in ACS Nano.

O 32.9 Tue 12:30 GER 39

Ultra-thin Noble Metal Films on Superconductors — •Christian von Bredow, Philip Beck, Lucas Schneider, Jens Wiebe, and Roland Wiesendanger — Department of Physics - University of Hamburg, Hamburg, Germany

Magnet-superconductor hybrid systems involving Rashba-split surface states proximitized by a superconducting substrate are promising platforms for the realization of topological superconductivity [1,2,3]. To that end, a large gap of the superconductor, strong spin-orbit coupling, and a high surface quality that allows for the manipulation of individual magnetic atoms using the tip of a scanning tunneling microscope are strongly desired. In order to engineer a system with the desired properties we investigate the growth and surface-state dispersion of thin noble metal films on the (110)-surface of the elemental superconductor with the highest critical temperature, niobium. Starting from a few monolayer thickness, we observe the well known quasiparticle interference of the Shockley (111) surface state. Bias-dependent data is used to extract the layer-thickness dependence of the band bottom and the effective electron mass.

[1] A. C. Potter et al., Phys. Rev. B 85, 094516 (2012).
[2] A. Palacio-Morales et al., Science Advances 5 eaav6600 (2019)
[3] T. Tomanic et al., Phys. Rev. B 94, 220503 (2016).