HL 50: HL Poster IV

Time: Thursday 19:00–21:00 Location: Poster B

HL 50.1 Thu 19:00 Poster B

Geometry-induced effect on magnetoresistance in open superconductor microtubes — Roman Rezaev[1,2], Ekaterina Smirnova[1], Evgeniy Posenitskiy[1], Evgeniy Levchenko[1], and •Vladimir Fomin[3] — [1]Tomsk Polytechnic University, Tomsk, 634050, Russia — [2]Moscow Engineering Physics Institute, Moscow, 115409, Russia — [3]Insitute for Integrative Nanosciences, IFW Dresden, Dresden, D-01069, Germany

Superconductor order parameter is analyzed numerically in an open superconductor Nb microtube in an applied magnetic field orthogonal to the tube axis in the presence of a transport current flowing from one to the other bank of the cut. An open microtube manifests significantly different behavior of magnetoresistance due to the vortex motion as compared to the planar membrane of the same dimensions. The magnetoresistance in an open tube as a function of the magnetic field reveals an expressed geometry-induced peak. A three-fold increase of the magnetoresistance in its peak value at 7.5 mT is revealed numerically in an ultrathin Nb tube of radius 500 nm and length 5 μm. This non-monotonic behavior is presumably due to the occurrence of a phase slip line in the area with small absolute values of the normal-to-the-surface magnetic field component, when the quasi-stationary pattern of vortices changes from single to double chains in each half-turn. The effect is promising for design of novel superconductor switching based detectors. The work was partially supported by the Federal Targeted Program of the Russian Federation (agreement no. 14.578.21.0198) and by the COST Action MP1201 Nanoscale Superconductivity.

HL 50.2 Thu 19:00 Poster B

Soft Microrobots with Adaptive Geometry — •Mariana Medina Sánchez — Leibniz Institute for Solid State and Materials Research , Helmholtzstrasse 20, Dresden, Germany

The creation of soft microrobots able to adapt and move in complex environments has attracted the attention of scientists over the world. These microrobots with adaptive geometry could potentially move in complex environments, through small cavities, and in viscoelastic fluids in a very efficient way as many microorganisms and cells do. Here an overview of the existing materials and technologies that can be used to create such smart microrobots will be given, as well as the strategies to perform novel soft microrobots with dynamic geometry and collective behaviour will be highlighted.

HL 50.3 Thu 19:00 Poster B

Functional renormalization group approach to interacting three-dimensional Weyl semimetals — Anand Sharma, •Arthur Scammell, Jan Krieg, and Peter Kopietz — ITP Goethe Universität, Frankfurt am Main, Deutschland

We study quasiparticle properties due to long-range Coulomb interaction in clean threedimensional Weyl semimetals using a functional renormalization group (FRG) approach. The Coulomb interaction is represented via a bosonic Hubbard-Stratonovich field which couples to the fermionic density. We derive truncated FRG flow equations for the fermionic and bosonic self-energies and for the three-legged vertex with two fermionic and one bosonic external leg. We consider two different cutoff schemes - cutoff in fermionic or bosonic propagators - in order to calculate the renormalized quasiparticle velocity and the dielectric function for varying number of Weyl nodes, charge neutrality points with nondegenerate chiralities, and the bare effective dimensionless interaction strength. If we approximate the dielectric function by its static limit, our results for the velocity and dielectric function are in good agreement with the nonperturbative method of Abrikosov and Beneslavskii [Sov. Phys. JETP 32, 699 (1971)] which exhibits slowly varying logarithmic divergence for small momenta. Moreover, we extend their result for any given number of nodes and finite frequency by evaluating the renormalized velocity in the presence of dynamic screening and calculate the wavefunction renormalization factor.

HL 50.4 Thu 19:00 Poster B

Spectral imaging for deterministic positioning of quantum dots in photonic devices — •Magdalena Moczala-Dusanowska, Lukasz Dusanowski, Christian Schneider, and Sven Höfling — Technische Physik, Wilhelm Conrad Röntgen Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

In this contribution a method for deterministic fabrication of micropillar cavities with centered bright quantum dots will be presented. By combining a low-temperature micro-photoluminescence with a wide-field sample illumination a full position resolved emission spectral maps have been recorded. It allowed for registering positions of quantum dots in respect to the alignment marks, making feasible deterministic fabrication of the different kinds of photonic structures including micropillar cavities by utilizing the high-yield e-beam lithography.

HL 50.5 Thu 19:00 Poster B

Towards ultra broadband photon pairs using PZT material — •Stephane Clemmen — Université Libre de Bruxelles, Bruxelles, Belgium

PZT materials have a strong second order nonlinear response. This allows using short crystal and relaxes the phase matching condition therefore allowing broadband spontaneous down conversion.

HL 50.6 Thu 19:00 Poster B

Investigation of 3D-printed phase waveplates for THz beam shaping — •Jan Gospodaric[1], Stefan Rotter[2], Christian Huber[3], Dieter Suess[3], and Andrei Pimenov[1] — [1]Institute of Solid State Physics, Vienna University of Technology, 1040 Vienna, Austria — [2]Institute for Theoretical Physics, Vienna University of Technology, 1040 Vienna, Austria — [3]Faculty of Physics, University of Vienna, 1090 Wien, Austria

Additive manufacturing with 3D-printers has gained significant attention in the recent years due to its versatility, accessibility and generally because it presents a quick, easy-to-use and affordable technique to produce complex and high-precision structures. The layer height resolution of 3D-printers (up to 0.1 mm) and high transparency of the polymers used in 3D-printers are suitable for printing devices that manipulate electromagnetic radiation in the THz region — a frequency range that recently gained a lot of attention. Here we present a way of calculating, designing and fabricating a THz waveplate that phase modulates an incident THz beam (λ=2.14 mm) in order to create a predefined intensity profile of the optical wavefront on the distant image plane. The calculation was performed for two distinct target intensities with the use of the Gerchberg-Saxton algorithm. Resulting phase modulating profiles were used to model two elements, which were printed out of polyactide (PLA) with a commercially available 3D-printer and then tested in an optical experimental setup, which showed good agreement with the preliminary theoretical predictions.

HL 50.7 Thu 19:00 Poster B

Receiver Module for Free-Space Single-Photon QKD using Solid-State Quantum-Light Sources — •Timm Kupko, Stephan Reitzenstein, and Tobias Heindel — Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany

High modulation bandwidth and high purity of single-photon states make InAs/GaAs based quantum dots an ideal light source for free space quantum-key-distribution (QKD) [1]. For such systems, we developed a receiver module with passive basis choice for polarization-encoded QKD via the BB84 protocol. The module consists of off-the-shelf optics, four APD detectors and time-tagging electronics.
Many attacks are known for trusted-device QKD systems. With this knowledge, we investigate the susceptibility of our receiver for spatial-side-mode channel attacks [2][3], a subgroup of faked state attacks exploiting detection efficiency mismatches.
We conduct experiments to estimtate the influence of the angle of incidence on the detection efficiencies and how countermeasures like spatial filtering can prevent such attacks.
[1] T. Heindel et al., New J. Phys. 14, 083001 (2012)
[2] M. Rau et al., IEEE J. Quantum Electron. 21, 660905 (2015)
[3] S. Sajeed el al., Phys. Rev. A 91, 062301 (2015)

HL 50.8 Thu 19:00 Poster B

Droplet epitaxy growth and characterization of InAs QDs — •David Fricker[1,3], Zheng Zeng[1,3], Detlev Grützmacher[1,2,3], Mihail Ion Lepsa[2,3], and Beata Kardynal[1,3] — [1]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, Germany — [2]Peter Grünberg Institute (PGI-10), Forschungszentrum Jülich, Germany —

[3]JARA - Fundamentals of Future Information Technology, RWTH Aachen University, Germany

Self-assembled InAs quantum dots have been successfully applied in a number of devices for quantum information processing and communication, starting from single photon emitters and detectors to spin-photon interfaces. Droplet epitaxy represents an interesting alternative to the well -known Stranski-Krastanow growth mode of QDs permitting a high degree of control over the shape, size and density and avoiding the wetting layer which can be detrimental for spin-photon interfaces. Here, we report on the MBE growth of InAs QDs using droplet epitaxy method. The InAs QDs have been grown on GaAs (100) substrates. We have investigated the growth conditions for optimum size and density of the QDs. Their morphological and structural characteristics have been obtained using different microscopy methods. Preliminary results regarding optical characterization will be presented as well.

HL 50.9 Thu 19:00 Poster B

Effects of crystal annealing on the spin coherence time in silicon carbide — •Daniel Klenkert[1], Christian Kasper[1], Georgy V. Astakhov[1], Ingo Lederer[2], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Bavarian Center for Applied Energy Research (ZAE Bayern), 97074 Würzburg

The silicon vaccancy defect (V_{Si}) in silicon carbide (SiC) has recently emerged as a topic of research interest because of its coherent properties. The V_{Si} center forms a $S = 3/2$ system, which can be extensivly controlled by infrared and microwave radiation. Additonally, the V_{Si} defect shows spin coherence times on the order of several hundred microseconds at room temperature. Therefore the use of this defect in quantum sensing and quantum computing applications seems realistic. The defects are usually created by irradiation, which in turn impairs the coherent properties.
In this study, we examine the effects of crystal annealing on the spin-lattice relaxation time T_1 and the spin-spin relaxation time T_2 of the V_{Si} defect. The silicon vaccancy is stable and, in contrast to some other crystal defects, can only be anneald at high temperatures. This gives rise to the hope, that annealing at lower temperatures yields a better orderd crystal with longer coherence times.

HL 50.10 Thu 19:00 Poster B

Defect-affected Current in Silicon Carbide: Towards Photoelectric Spin Readout — •Michael Hollenbach[1], Christian Kasper[1], Dimitrij Poprygin[1], Andreas Sperlich[1], Makino Takahiro[2], Takeshi Ohshima[2], Georgy V. Astakhov[1], and Vladimir Dyakonov[1,3] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]National Institutes for Quantum and Radiological Science and Technology (QST, formerly Japan Atomic Energy Agency), Takasaki, Japan — [3]Bavarian Center for Applied Energy Research (ZAE Bayern), 97074 Würzburg

Silicon carbide (SiC) is a extremely versatile wide bandgap semiconductor for high-power and high-temperature electronics and is envisioned to be employed in solid-state quantum information systems. At present, the optical readout of the atomic-scale defects, localized within the bandgap, is typically based on confocal mircroscopy. In this study, we intend to introduce an alternative detection method, allowing the direct light induced photoelectric readout of the silicon defects (V_{Si}) in SiC.
Furthermore, of key intertest is the electrical characterization of 4H-SiC diodes with varying spatial distribution of Si-vacancies, introduced by electron and neutron irradiation. By analyzing current-voltage-characteristics as well as optically and electrically detected magnetic resonance (ODMR, EDMR) of active V_{Si} centers, we determine an irradiation/voltage threshold to optimize diodes with suitable quantity of V_{Si} for magnetic field sensing applications.

HL 50.11 Thu 19:00 Poster B

Towards an Optical Interface to Spin Qubits in GaAs — •Zheng Zeng[1], Arne Ludwig[2], Eva Gross[1], Hendrik Bluhm[3], and Beata Kardynał[1] — [1]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, D-52425 Jülich, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [3]JARA-Institute for Quantum Information, RWTH Aachen University, D-52074 Aachen, Germany

Connecting quantum information processors over long distances would enable quantum networks and more complex quantum computing architectures. Spin qubits in GaAs/AlGaAs gate-defined quantum dots (GDQDs) have been demonstrated to be promising scalable qubits. Since GaAs is a direct band gap material, a coherent transfer of information between a spin qubit and a photon qubit is in principle possible but cannot be achieved directly using GDQDs. We pursue an approach where an InAs self-assembled quantum dot (SAQD) facilitates a coherent transfer of a energy encoded photon qubit into a singlet-triplet spin qubit. We briefly analyse the device operation principle and conditions necessary to achieve high fidelity transfer. We will report on our progress on device fabrication with an emphasis on the alignment between the quantum dots and incorporation of back gates for tuning the electric field in the device.

HL 50.12 Thu 19:00 Poster B

Accurate Optical Alignment of Self-assembled Quantum Dots with Gate-defined Quantum Dots — •Eva Gross[1], Arne Ludwig[2], Zheng Zeng[1], Detlev Grützmacher[1], and Beata Kardynał[1,3] — [1]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [3]JARA - Fundamentals of Future Information Technology, RWTH Aachen University, Germany

InAs self-assembled quantum dots (SAQDs) are widely used in various quantum devices for quantum information processing with photons. In many of these applications an alignment of the SAQDs with other elements of the device is crucial to the device operation. Here we explore optical methods to locate SAQDs which can be used as pre-processing steps in device fabrication. The method should be compatible with processing of hybrid devices in which SAQDs and gate defined quantum dots in GaAs/AlGaAs are tunnel coupled. In this presentation we will compare two different photoluminescence based approaches. In both cases, alignment features are used to determine the position of the QDs. In the first method, the imaging process is realized directly by an EMCCD camera. SAQDs and alignment markers are selectively illuminated with light sources of different wavelengths. In the second approach, photoluminescence spectra at different positions of the sample are recorded while a focused spot of laser light is scanned across it.

HL 50.13 Thu 19:00 Poster B

Spin Lifetime and Magnetoconductance in Wurtzite Semiconductor Nanowires — •Paul Wenk[1], Michael Kammermeier[1], John Schliemann[1], Florian Dirnberger[2], and Dominique Bougeard[2] — [1]Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Deutschland — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Deutschland

This study is motivated by our experiments on catalytically grown wurtzite semiconductor nanowires, where spin densities are optically excited homogeneously along the nanowire axis [1]. Recently, we carried out these measurements by systematically changing the wire width. Here, a theoretical analysis of the width dependent D'yakonov-Perel' spin relaxation in these wires is presented, which is due to spin-orbit coupling in the diffusive regime. It is shown that the motional narrowing differs significantly from the case in zincblende wires [2,3]. Moreover, by taking into account an external electric and magnetic field magnetoconductivity corrections (*weak (anti-)localization*) are calculated, going also beyond the diffusive regime by following Ref. [4].

* * *

[1] S. Furthmeier *et al.*, Nat. Commun. **7**, 12413 (2016)
[2] S. Kettemann, PRL **98** 176808 (2007)
[3] M. Kammermeier *et al.*, arXiv:1709.02621 (2017)
[4] P. Wenk *et al.*, PRB **83** 115301 (2011)

HL 50.14 Thu 19:00 Poster B

Topological spintronic devices based on $BiSbTeSe_2$ flakes — •Patrick Janoschka, Fan Yang, Zhiwei Wang, Alexey Taskin, and Yoichi Ando — Institute of Physics II, University of Cologne

Topological insulators belong to a new class of quantum materials in which a strong spin-orbit coupling leads to a band inversion and therefore, to gapless surface states with helical spin texture. Due to the spin-momentum locking, the topological surface states are promising for spintronic applications.

A big obstacle in spintronic-device fabrication is to reach a high spin-polarization detection efficiency. Because of the conductivity mismatch between the topological insulator and the ferromagnetic (FM)

spin detector, the detection efficiency is usually low.

In this poster we present the approach of solving the conductivity mismatch with an Al_2O_3 tunnel barrier grown by atomic layer deposition (ALD) between the $BiSbTeSe_2$ flake and the FM spin detector. With this technique we are able to reach a spin-polarization detection efficiency of up to 36% and the current-induced spin polarization was reproducibly observed in many devices.

HL 50.15 Thu 19:00 Poster B

Effect of Exchange-correlation functional on spin-admixture parameter calculated from first principles — •Uday Chopra[1,2], Shambhawi Pandey[2,3], Sergei Egorov[4], Jairo Sinova[1], and Erik R. McNellis[1] — [1]Institute for Physics, Johannes Gutenberg University, Mainz, Germany — [2]Graduate School Materials Science in Mainz, Germany — [3]Department of Chemical Engineering, Indian Institute of Technology Roorkee, India — [4]Department of Chemistry, University of Virginia, USA

Organic semiconductors (OSC) are known to have a small spin-orbit coupling (SOC) and this has strong implications in their spintronic properties. It has been shown that SOC can be characterised by mixing of up- and down-spin states and is expressed by the spin-admixture parameter, γ^2[1]. This parameter governs the probability of a spin-flipping as the polaron hops between different sites in the OSC. Since for most OSC, transport is described by hopping mechanism, the spin-relaxation time is very sensitive to γ^2 therefore it becomes important to determine the parameter with high accuracy. We present a method for calculation of spin-admixture in organic semiconductors from first-principles on the level of Density Functional Theory. In this work, we use a methodical procedure to obtain precise values of γ^2 and demonstrate the effect of exchange-correlation functional on the parameter. Moreover, we generalise this approach under the Unrestricted DFT. We also find that γ^2, strongly depends on the delocalization error of the functional and tends to decrease as the functional becomes more localized. [1] Z. G. Yu, Phys. Rev. B. 85, 115201, 2012.

HL 50.16 Thu 19:00 Poster B

Structural and spin transport studies of Co_2FeSi/MgO/GaAs heterostructures — •Georg Hoffmann, Manfred Ramsteiner, and Jens Herfort — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

Lateral spin valve (SV) structures allow the investigation of spin generation in semiconductors (SC) as well as spin transport and detection within one device. Regarding the spin-polarized contacts, Heusler alloys, such as Co_2FeSi (CFS), are of particular interest because of their possible half-metallic behavior. However, the properties of CFS/SC hybrid structures are often deteriorated by the diffusion of Fe and Co into the SC material. MgO interlayers at the CFS/SC interface have the potential to prevent the Fe and Co diffusion and to act as spin-filtering barriers. We studied CFS/MgO/GaAs hybrid structures with different MgO layer thicknesses (0 to 2.1 nm) grown by molecular beam epitaxy (MBE). The structural and magnetic properties of the CFS contact layers (20 nm thickness) were characterized by x-ray diffraction and superconducting-quantum-interference-device magnetometry. For the evaluation of the spin generation and transport, SV devices were processed and investigated by using a nonlocal SV arrangement. The SV measurements reveal an enhanced spin generation efficiency and an increased spin diffusion length in the GaAs transport channel with respect to CFS/GaAs reference structures. These results demonstrate the benefit of MgO interlayers for the performance of lateral SV structures with CFS contacts.

HL 50.17 Thu 19:00 Poster B

Simulation of Spin Transport with Spatially Varying Transport Parameters — •Daniel Schiermeier, Stefan Hartl, Tobias Völkl, Dieter Weiss, and Jonathan Eroms — Institute of Experimental and Applied Physics, University of Regensburg, Regensburg, Germany

Spin transport properties of graphene devices are typically determined from Hanle spin precession measurements by using an analytical solution of the Bloch equation, which assumes infinitely long transport channels and uniform parameters. We investigate the influence of spatially varying parameters on the measured Hanle curves by finite element simulations using Comsol Multiphysics. To this end, we developed a model considering electric currents and spin transport properties, e.g., spin lifetime anisotropy. Thus we are able to simulate spin transport in suspended graphene, to investigate background signals originating from Hall effect due to pinholes within tunnel barriers and to explore the influence of a finite flake size and non-magnetic reference electrodes. We demonstrate that in case of uniform spin transport parameters one can overestimate the extracted spin lifetimes from Hanle measurements. In contrast, if one graphene region in a non-local spin valve device exhibits a comparatively short spin lifetime, by, e.g., contact-induced spin dephasing or lower mobility graphene parts directly connected to a suspended region, this will also affect the spin lifetime extracted in any other region, which becomes underestimated. Furthermore, we simulate normal and inverse spin Hall effect in WSe_2 graphene heterostructures to optimize our sample fabrication.

HL 50.18 Thu 19:00 Poster B

Higher order noise spectra of continuous quantum measurements — •Daniel Hägele and Fabian Schefczik — Fakultät für Physik und Astronomie, Ruhr-Universität Bochum, Bochum, Germany

Quantum physics does not allow for a perturbation free measurement. Nevertheless, experimental methods like spin noise spectroscopy gain important information about a quantum system by weakly probing the system with a laser beam yielding a detector output $z(t)$. The noise spectrum $S_z(\omega)$ of z consists of a constant laser shot noise background and an additional contribution that reveals some dynamical properties of the quantum system. We show that additional information can be obtained from $z(t)$ if also higher order spectra are evaluated. Treating continuous quantum measurements within a stochastic master equation approach, we recently derived the all-order continuous quantum noise formula (CQNF) which expresses $z(t)$ without approximations in terms of multiple convolutions of white Gaussian noise, the system propagator $\mathcal{G}(t)$, and the observable A in dependence on the measurement strength β [1]. Quantum mechanical expressions for the third order bispectrum and the fourth order trispectum follow. The power of higher order noise spectroscopy is demonstrated by calculating fourth order spectra for the indium electron donor in the semiconductor ZnO. The strong coupling of the electron spin to the 9/2 indium nuclear spin leads to a rich dynamics that leaves characteristic fingerprints in higher order quantum noise spectra.
[1] D. Hägele, https://arxiv.org/abs/1611.02077

HL 50.19 Thu 19:00 Poster B

Fabrication of bulk-insulating topological insulator nanowires — •Matthias Rössler, Dingxun Fan, Andrea Bliesener, Zhiwei Wang, Alexey Taskin, and Yoichi Ando — Institute of Physics II - University of Cologne

With proximity-induced superconductivity, bulk-insulating topological insulator nanowires are expected to serve as a robust platform for realizing Majorana bound states. When exploiting their non-Abelian exchange statistics, these could enable realizations of topological quantum computation schemes. In previous reports, however, finite bulk transport contribution yet showed potential for improvements. To tackle this issue, we have been performing fabrication and optimization of bulk-insulating nanowires through two different approaches:

1) Naturally grown $(Bi_{1-x}Sb_x)_2Te_3$ and Bi_2Te_2Se nano-wires prepared by a vapor-solid method.

2) Nanowires etched from bulk-insulating exfoliated $Bi_{2-x}Sb_xTe_{3-y}Se_y$ nanoribbons or MBE-grown $(Bi_{1-x}Sb_x)_2Te_3$ thin films.

By using chemical wet etching, nano-ribbons with a diameter of down to 100 nm have been prepared. Magneto-transport measurements have been carried out to characterize their properties such as carrier density and mobility. Once bulk-insulating topological insulator nanowires have been obtained, they will be utilized for studying proximity-induced superconductivity.

HL 50.20 Thu 19:00 Poster B

Topological Weyl semimetals of $Bi_{1-x}Sb_x$ alloys — •Yu-Hsin Su, Wujun Shi, Claudia Felser, and Yan Sun — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

Investigation on variety atomic composition and arrangement of bismuth antimony $Bi_{1-x}Sb_x$ alloys by making use of first-principle calculation has been accomplished and analysed. Firstly, the bulk of pure Bi and Sb have also been individually identified their topological invariant Z_2 which shows Bi is topological trivial while Sb is topological non-trivial. As increasing the concentration of Sb (increase x), the topological phase will be anticipated more significantly. When x is larger than 0.5 in $Bi_{1-x}Sb_x$ alloys, it shows strong 3D topological insulator phase confirmed in previous research. Surprisingly, in our investigation, at particular concentrations x=0.5 and x=0.83 with specific inversion symmetry broken elemental arrangement, topologi-

cal properties of weyl semimetal have been manifestly demonstrated from the emergence of Fermi arc. The Weyl semimetal phase provides a reasonable explanation for the current transport study of BiSb alloy with the violation of Ohm's law [Nature Materials 16, 1096 (2017)]. This work shows that the plenty of topological phases in BiSb alloys depend on the collaboration of the elemental composition and their specific arrangement.

HL 50.21 Thu 19:00 Poster B

MBE grown ultrathin and magnetically doped topological insulator films — •Andrea Bliesener[1], Gertjan Lippertz[1,2], Fan Yang[1], Alexey Taskin[1], and Yoichi Ando[1] — [1]Institute of Physics II, University of Cologne, Germany — [2]Instituut voor Kern- en Stralingsfysica, KU Leuven, Belgium

Topological insulators (TIs) belong to a new class of quantum materials in which a strong spin-orbit coupling leads to a band inversion and, as a consequence, to a symmetry-protected gapless metallic state on the surface. Time-reversal symmetry breaking by magnetic doping opens a energy gap at the Dirac point. This kind of gapped topological insulator has been reported to show new quantum phenomena, including the quantum anomalous Hall effect (QAHE).

To observe these kind of novel quantum phenomena, fabrications of thin-film devices are required which allows for tuning the Fermi level across the Dirac point. It is necessary to improve growth conditions for the ternary compound $(Bi_{1-x}Sb_x)_2Te_3$ such that the composition between n-type Bi_2Te_3 and p-type Sb_2Te_3 can be almost perfectly compensated. Decreasing the thickness of the MBE grown films, reduces the bulk-to-surface ratio and leads to TI samples where the surface transport is dominating. Doping ultrathin films with V or Cr allows to obtain the ferromagnetic state, which opens a gap in the surface states, leading to the QAHE at low temperatures.

In this contribution we report our efforts to grow ultrathin $(Bi_{1-x}Sb_x)_2Te_3$ films and to increase the T_c of V-doped samples.

HL 50.22 Thu 19:00 Poster B

Chemical and structural defects in magnetically doped topological insulators — •Jakub Šebesta, Pavel Baláž, and Karel Carva — Charles University, Faculty of Mathematics and Physics, Department of Condensed Matter Physics, Ke Karlovu 5 121 16 Praha 2, Czech Republic

The basic way to change physical properties of TI consists in doping the compound by magnetic atoms, which disturbs by magnetic field the time-reversal symmetry guaranteed uncommon surface properties. Besides, the non negligible influence on conductive surface states rests in the presence of defects of crystal structure, e.g. point defects, stacking faults, twinning planes which appear in real conditions [1]. The aim of the work is studying physical properties of TI under the influence of the above mentioned structural defects and magnetic atoms in well known bismuth chalcogenides as Bi_2Se_3 or Bi_2Te_3 [2], using electronic structure calculation and the simulations of the magnetization dynamic. Ab-initio calculations based on layered TB-LMTO+CPA method have been employed to obtain the dependence of surface states, energetic gap or magnitudes of exchange interactions on presented defects. Furthermore we used the results from ab-initio calculation to simulate the magnetic behavior of magnetic atoms in non-zero temperatures, where we calculated ordering temperatures of magnetically doped compounds. The obtained results are compared with experimental results as well.

[1] D. Kriegner et al.,J.Appl.Cryst. 50 (2017), 369-377.
[2] K. Carva et al., Phys.Rev.B 93 (2016), 214409.

HL 50.23 Thu 19:00 Poster B

Geometry and electronic structure of the antimonene/Bi2Se3 interface — •Conor Hogan[1], Kris Holtgrewe[2], Simone Sanna[2], Roberto Flammini[1], Stefano Colonna[1], Fabio Ronci[1], Sanjoy Mahatha[3,4], Paolo Moras[3], Polina Sheverdyaeva[3], Alessandro Barla[3], Marco Papagno[5], Z. S. Aliev[6], E. V. Chulkov[7], and Carlo Carbone[3] — [1]CNR-ISM, Rome, Italy — [2]University of Giessen, Germany — [3]CNR-ISM, Trieste, Italy — [4]University of Aarhus, Denmark — [5]University of Calabria, Italy — [6]Azerbaijan National Academy of Science, Baku, Azerbaijan — [7]DIPC, San Sebastian, Spain

The interface between the 2D trivial semiconductor antimonene (Sb-ene) and the 3D topological insulator Bi2Se3 has attracted much interest due to its potential for exploiting the proximity effect. We report a joint theoretical-experimental study of the growth and electronic properties of single/multilayered Sb-enes on Bi2Se3. STM measurements show the presence of ordered domains displaying a perfect lattice match with bismuth selenide. Ab initio DFT calculations of the most stable atomic configurations demonstrate that the ordered domains can be attributed to stacks of single or double bilayers of buckled antimonene sheets. ARPES of the clean Bi2Se3 surface and Sb-ene interfaces, coupled with spin polarization analyses of the computed band structures, yield clear interpretations of the measured spectra in terms of topological surface states, confirming that Sb/Bi2Se3 is an ideal model system for investigating the unique physical topological and emergent phenomena at such heterostructures.

HL 50.24 Thu 19:00 Poster B

Selective area grown ZnTe nanowires as the basis for a quasi-one-dimensional realization of the Topological Insulator HgTe — •Jan Hajer, Willi Mantei, Maximilian Kessel, Christoph Brüne, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

In this work, we present a successful approach to selective area molecular beam epitaxy of ZnTe nanowires. The wires obtained serve as a substrate for radial overgrowth with different II-VI materials, allowing for the realization of quasi-one-dimensional CdTe-HgTe nanowire shells. The full position control due to patterning of the growth seed not only guarantees a homogeneous environment for overgrowth, but also opens up the possibility for designing high quality bottom-up grown Topological Insulator networks.

HL 50.25 Thu 19:00 Poster B

Growth and Electrical Characterization of $(Bi_{1-x}Sb_x)_2Te_3$ Topological Insulator Nanoribbons — •Dingxun Fan, Matthias Rössler, Zhiwei Wang, Oliver Breunig, Fan Yang, Alexey Taskin, and Yoichi Ando — II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany

Surface states of topological insulator (TI) nanoribbons, when proximitized by s-wave superconductors, are expected to realize topological superconducting phases harbouring Majorana bound states (MBS) at the ends. MBS platform based on TI nanoribbons has the advantage of a wide parameter range in terms of the chemical potential and magnetic field, resulting from the inherent property of spin-momentum locking. However, the experimental progress is largely hindered by bulk conduction. As a first step, it is desired to grow bulk-insulating TI nanoribbons where the bulk contribution is minimized while preserving circumferential quantization from quasi-1D band structure.

Here we study the growth of ternary $(Bi_{1-x}Sb_x)_2Te_3$ nanoribbons by a Au-catalysed VLS method in a tube furnace. High quality Bi_2Te_3 and Sb_2Te_3 powders prepared by crushing lab-grown single crystals are placed at different temperatures in an Ar gas flow. By tuning the growth temperature and flow rate, very thin $(Bi_{1-x}Sb_x)_2Te_3$ nanoribbons down to ∼20 nm in width and thickness and up to ∼10 um in length can be achieved. The composition of the nanoribbons is determined by electron diffraction spectroscopy. Subsequent nanofabrication is also carried out to characterize the electrical properties of these nanoribbons.

HL 50.26 Thu 19:00 Poster B

Measuring Quantum Spin Networks with NV Centers in Diamond — •Domenico Paone[1,2], Dinesh Pinto[1,2], Lukas Schlipf[1], Bastian Kern[1], Amit Finkler[3], Jörg Wrachtrup[1,2], and Klasu Kern[1,4] — [1]Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany — [2]3rd Institute of Physics and Research Center SCoPE, University Stuttgart, 70569 Stuttgart, Germany — [3]Department of Chemical and Biological Physics, Weizmann Institute of Science, Rehovot, Israel — [4]Institut de Physique, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

The coherent control and communication between distant qubits is essential for quantum information processing. A sensor scheme based on an atomic sized quantum sensor, the nitrogen vacancy (NV) center in diamond, pushes the sensitivity to the local read out of single spins. Due to its access to various transitions in the optical and microwave frequency domain the coupling between single NV centers and electron spin networks can be observed in a reliable way [1]. Here, we present electron spin resonance studies on doubly spin labeled polypeptides and endohedral $N@C_{60}$ controlled by shallow NV centers. For this, we employ an UHV cryo-microscopy setup [2]. By locally coupling our atomic-sized sensor to interacting spins we are able to investigate transfer mechanisms through spin networks.

[1] L. Schlipf et al., Sci. Adv. 2017; 3, e1701116 (2017)

[2] E. Schaefer-Nolte et al., Rev. Sci. Inst. 85, 013701 (2014)

HL 50.27 Thu 19:00 Poster B

Tight-Binding Simulation of Multilayer Graphene Quantum Dots — •Christian Wimmenauer, Stefan Fasbender, and Thomas Heinzel — Solid State Physics Laboratory (IPkM), Heinrich-Heine-Universität-Düsseldorf

Multilayer Graphene Quantum Dots (ML-GQDs) are simulated using an tight binding approach implemented with the KWANT Software Package. The emphasis lies on the investigation of the size, shape and edge structure interplay in regards to the energetic structure of these multilayer systems. Thus armchair type and zigzag type ML-GQDs, as well as mixed edge type ML-GQDs are examined for different lateral sizes and numbers of layers. The calculations suggest, that the systems will undergo a redshift with a growing number of layers, the magnitude depends on the edge type and the lateral size of the ML-GQDs. The results are supposed to help preparing superior nanoparticles for biomedical applications and to understand the impact of clustering on their optical properties.

HL 50.28 Thu 19:00 Poster B

Precise frequency estimation using a quantum sensor — •Simon Schmitt[1], Daniel Louzon[1,2], Tuvia Gefen[2], Liam McGuinness[1], Alex Retzker[2], and Fedor Jelezko[1] — [1]Institute of Quantum Optics, University of Ulm, Germany — [2]Racah Institute of Physics, The Hebrew University of Jerusalem, Israel

Precise frequency measurements are important for a range of applications in science, medicine and technology. Using a quantum sensor to measure frequency has particular advantages of sensitivity and spatial resolution to measure at the single molecule level. For quantum sensors, the best possible parameter estimation is limited by the sensor decoherence time. While for static components of a given Hamiltonian the uncertainty scales linear with the sensor coherence time, it was recently theoretically shown that for frequency estimation an optimal quadratic scaling is possible. We use single nitrogen vacancy centres in diamond to experimentally verify this enhanced scaling and discuss possible applications in nanoscale metrology, where frequency measurements are important in spectroscopy, imaging and analysis.

HL 50.29 Thu 19:00 Poster B

Coherent control of solid state nuclear spin nano-ensembles — •Nikolas Tomek[1], Thomas Unden[1], Timo Weggler[1], Florian Frank[1], Paz London[2], Hideyuki Watanabe[3], Kohei M. Itoh[4], Martin B. Plenio[5], Boris Naydenov[1], and Fedor Jelezko[1] — [1]Institute for Quantum Optics and IQST, Albert-Einstein-Allee 11, Universität Ulm, 89069 Ulm, Germany — [2]Department of Physics, Technion, Israel Institute of Technology, Haifa 32000, Israel — [3]Correlated Electronics Group, Electronics and Photonics Research Institute, AIST, Tsukuba, Japan — [4]Department of Applied Physics and Physico-Informatics, Faculty of Science and Technology, Keio University, Yokohama, Japan — [5]Institute for Theoretical Physics and IQST, Albert-Einstein-Allee 11, Universität Ulm, 89069 Ulm, Germany

Detecting and controlling nuclear spin nano-ensembles is crucial for the further development of nuclear magnetic resonance (NMR) spectroscopy and an important step towards a nuclear spin based quantum simulator. Here we demonstrate a method for coherent control of few tens of nuclear spins by using radio frequency pulses. A single nitrogen-vacancy center in diamond (NV) is used for polarization of the nuclear spins and the readout of their magnetization. The experiments are performed on a nanometer thick layer of 13C enriched single crystal diamond doped with NV centers embedded in a nuclear spin free 12C diamond matrix. We demonstrate the basic coherent control experiments - Rabi oscillations, Ramsey spectroscopy and Hahn echo, though any NMR pulse sequence can be implemented.

HL 50.30 Thu 19:00 Poster B

CVD grown nitrogen-vacancy centers in isotopically controlled <111> diamond — •Christian Osterkamp, Martin Mangold, Priyadharshini Balasubramanian, Boris Naydenov, and Fedor Jelezko — Institut für Quantenoptik, Ulm University, Albert Einstein Allee 11, Ulm 89081, Germany

The negatively charged nitrogen-vacancy center (NV) in diamond is one of the most promising candidates for realizing a quantum sensor. The fluorescence of single NVs can be detected and its electron spin can be polarized, read-out and manipulated at ambient conditions. The creation of NVs on demand is an important step towards quantum magnetic- and electric field sensors [1]. We engineer ^{15}NVs by delta doping during a plasma enhanced chemical vapor deposition (PECVD) process [2] and we are able to produce isotopically pure diamond by changing the ratio of ^{12}C/^{13}C atoms in the growth chamber. A high nitrogen incorporation rate combinded with the controllability of the NV axis alignment makes <111> oriented diamond an interesting material for the creation of ensembles. Shallow ensembles can be used for NV magnetometry and the detection of very small electric and magnetic fields [3].

HL 50.31 Thu 19:00 Poster B

Structural and electronic properties of natural graphite — •Ana Champi and Henrique Ferreira — Centro de Ciências Naturais e Humanas, Universidade Federal do ABC, 09210-170, Santo André, SP, Brazil

In this work, we have studied natural graphite flakes extracted from Brazil mines with high content of rhombohedral phase than artificial graphites like HOPG. We have performed measurements of Raman spectroscopy in many samples and different points on the surface in order to obtain a good statistical characterization. We verified the electrical behavior of the samples through electrical resistance measurements as a function of the temperature, initially the flakes shows extrinsic semiconductor like behavior, followed by persistent metallic behavior in the studied temperature ranges (300K to 500K). We have also studied the effect of the temperature on the Raman spectra, showing a broadening of the characteristic bands of graphite. According to the obtained results, we interpret that the extrinsic semiconductor-like behavior is due to oxygen adsorption at the graphite defects.

HL 50.32 Thu 19:00 Poster B

XPS Study on the Doping of Single-walled Carbon Nanotubes by Covalent Functionalization — •Daniel Przyrembel[1,2], Mareen Gläske[1,2], Antonio Setaro[1,2], Mohsen Adeli[1,3,4], Rainer Haag[1,3], Stephanie Reich[1,2], and Martin Weinelt[1,2] — [1]Sonderforschungsbereich 658 — [2]Freie Universität Berlin, Dept. of Physics, Berlin, Germany — [3]Freie Universität Berlin, Dept. of Chemistry and Biochemistry, Berlin, Germany — [4]Lorestan University, Dept. of Chemistry, Khorramābād, Iran

We have investigated functionalized carbon nanotubes (CNTs) by means of X-ray photoelectron spectroscopy (XPS). Covalent functionalization normally trades added functionalities for the electronic and optical properties of the CNTs. These rely on the conjugated sp^2 hybridized carbon backbone that locally breaks upon the addition of functional groups. The functionalization used for this study aims to preserve the π-conjugation.**[1]** XPS measurements prove that after formation of aziridine rings by cycloaddition and subsequent ring opening the conjugated sp^2 hybridized carbon backbone of single-walled semiconducting CNTs is restored. Moreover, the electron lone pair of the additional nitrogen atom is pushed into the π-electron system of the nanotube thereby doping it and leading to XPS peak shifts. By the amount of functionalization the doping level of the CNTs is tunable. The introduced side groups can also serve as attachment points for further functionalization, e.g., with molecular switches, to ultimately make the properties of the CNTs variable by external stimuli. See **[1]**: A. Setaro, M. Adeli, M. Glaeske et al. *Nat. Commun.* **2017**, *8*, 14281.

HL 50.33 Thu 19:00 Poster B

Mid- to far-infrared localized surface plasmon resonance in chalcogen-hyperdoped Si — •Mao Wang[1,2], Slawomir Prucnal[1], Yonder Berencén[1], Lars Rebohle[1], Tommy Schönherr[1], Ye Yuan[1,2], Chi Xu[1,2], Muhammad Bilal Khan[1], Roman Böttger[1], Wolfgang Skorupa[1], Manfred Helm[1,2], and Shengqiang Zhou[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany

Mid-infrared plasmonic sensing allows the direct targeting of molecules relevance in the so-called *vibrational fingerprint region*. Presently, heavily doped semiconductors exhibiting the potential to replace and outperform metals in the mid- infrared frequency range to revolutionize plasmonic devices. In this work, we demonstrate the occurrence of localized surface plasmon resonances (LSPR) in Te heavily-doped Si layers developed by ion implantation combined with flash lamp annealing. We fabricate micrometer-sized antennas out of the Te-hyperdoped Si layers by electron-beam lithography and reactive ion etching processes. The optical response characterized by Fourier-transform infrared (FTIR) spectroscopy demonstrates the enhancement of localized

plasmon resonances in antennas, from mid- to far- infrared frequency range. Our results set a new path toward integration of plasmonic sensors with the one-chip CMOS platform.

HL 50.34 Thu 19:00 Poster B

Stimulated Microwave Emission from Vacancy Defects in 4H Silicon Carbide for Maser Applications — •Andreas Gottscholl[1], Georgy V. Astakhov[1], Andreas Sperlich[1], and Vladimir Dyakonov[1,2] — [1]Experimental Physics VI, Julius Maximilian University of Würzburg, 97074 Würzburg — [2]Bavarian Center for Applied Energy Research (ZAE Bayern), 97074 Würzburg

It is hard to imagine everyday life without lasers and their applications. Nevertheless the maser, which operates with electromagnetic waves in a lower energy regime, is only finding its use in some niche applications such as microwave amplification for radio astronomy or satellites. One main reason are the operating conditions, requiring cryogenic temperatures and vacuum techniques. Here, we investigate a concept for microwave emission which is promising masing even at room-temperature based on vacancy defects in 4H silicon carbide [1]. These spin defects form a quadruplet ground-state which can be spin-polarized by near infrared light. By applying an external magnetic field we tune the microwave transition into the range of 10GHz and by means of high optical pumping a population inversion can by far exceed the Boltzmann equilibrium at room-temperature.

[1] Kraus et al., Nat. Phys. **10**, 152 (2014)

HL 50.35 Thu 19:00 Poster B

Liquide phase crystallized silicon for tandem cell application — •Martina Trahms[1], Natalie Preissler[2], Cham Thi Trinh[1], Bernd Rech[1], and Daniel Amkreutz[1] — [1]Institute for Silicon Photovoltaics, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [2]PVcomB, Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

Silicon Photovoltaic has been approaching the theoretical Shockley-Queisser limit of energy conversion efficiency over the last decades. For that reason, the reduction of material usage and production cost becomes more important. An approach to that challenge consists in thin film technologies, among which Liquid Phase Crystallized Silicon (LPC-Si) is a promising candidate with relatively high efficiencies and the potential of low cost production. The idea to boost the efficiencies in tandem devices became especially important as Perovskites emerged for top cell application.

In this contribution we present tandem-concepts for two and four terminal devices. Optical simulations show that theoretically efficiencies up to 23 % are possible on thin-film LPC-Si/Perovskite tandem devices. First experiments involving Perovskite filters show that there is much room for improvement on both the Silicon and Perovskite side.

Investigations of the interface at the pn-junction in the LPC-Si cells show that especially Carbon and Nitrogen impurities can be responsible for defects and high recombination at that interface. Furthermore stacking faults and grain boundaries serve as recombination centers in this polycrystalline material.

HL 50.36 Thu 19:00 Poster B

Structure and chemistry of crystalline silicon-aluminum oxide interfaces — •Arne Ahrens and Michael Seibt — Georg-August University Göttingen, 4th Physical Institute, Göttingen, Germany

Aluminum oxide deposited on crystalline silicon by atomic layer deposition (ALD) is known for its high surface passivation capabilities. This surface passivation is attributed to a high negative fixed charge density of about -4×10^{12} cm^{-2}[1] in the aluminum oxide layer close to the silicon-aluminum oxide interface [2]. This makes aluminum oxide an interesting material to increase the efficiency of solar cells by passivation of surface states. The high surface passivation capability of aluminum oxide on silicon changes and can even be improved due to UV irradiation depending on the temperature treatment [3], which is used to activate the surface passivation.

In this work, we apply transmission electron microscopy (TEM) and electron energy loss spectroscopy (EELS) to study the structure and chemistry of the interface of aluminum oxide deposited by atomic layer deposition (ALD) and crystalline silicon subjected to different processing schemes. Here, we focus on the effect of post-deposition heat treatments and the effect of the UV irradiation.

[1] F. Werner and J. Schmidt, Appl. Phys.Lett Vol.104, 091604 (2014). [2] B. Hoex et al., J. Appl. Phy. Vol.104, 113703 (2008). [3] B. Veith-Wolf et al., Photovoltaic Specialists Conference (PVSC), 2016 IEEE 43rd, 16483697

HL 50.37 Thu 19:00 Poster B

Controlled Nickel Silicidation of Silicon Nanowires for Fabrication of Reconfigurable Field Effect Transistors — •Muhammad Bilal Khan[1], Dipjyoti Deb[1], Slawomir Prucnal[1], Mathias Voelskow[1], Artur Erbe[1], and Yordan M. Georgiev[1,2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]On leave of absence from the Institute of Electronics at the Bulgarian Academy of Sciences, 72, Tsarigradskochausseeblvd., Sofia 1784, Bulgaria

Physical scaling down of field effect transistors (FET) is reaching its end. To meet the consistent demand for faster, smaller and energy efficient transistors, new concepts which include new materials, new architectures, new computation principles and enhanced functionality are under research. The aim of this work is to fabricate devices with enhanced functionality, the so called reconfigurable FET (RFET) which can be configured as *p*- or *n*-channel FET. The RFETs are realised by fabricating silicon nanowires (SiNWs) on Si on insulator (SOI) substrates. These NWs are subsequently nickel silicided at both ends to form Si-$NiSi_2$-Si Schottky junctions. Control over silicide length is important to scale down the Si channel and to have symmetric contacts on both sides of the nanowires. The focus of our recent work is to achieve this control by using flash lamp annealing (FLA). Comparison between silicidation with flash lamp annealing (FLA) and rapid thermal annealing (RTA) along with the resulting electrical characteristics of these devices will be presented at the conference.

HL 50.38 Thu 19:00 Poster B

Top-down fabrication of sub-20 nm germanium nanowires for nanoelectronics and photonics applications — •Shim Jazavandi Ghamsari[1], Muhammad Bilal Khan[1], Lars Rebohle[1], Arthur Erbe[1], and Yordan M. Georgiev[1,2] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]Institute of Electronics at the Bulgarian Academy of Sciences, 72, Tsarigradsko chaussee blvd., Sofia 1784, Bulgaria

High-mobility channel materials are one of the recent performance boosters in the roadmap of semiconductor industry. Germanium(Ge) is among the materials that are nominated for future nanoelectronic devices beside silicon (Si).However, the chemical characteristics of Ge native oxide are a matter of concern in fabrication processes, especially at nanoscale. To produce Ge nanostructures of sub-20 nm size using electron beam lithography (EBL) with hydrogen silsesquioxane (HSQ) as a negative tone EBL resist, it is imperative to remove the Ge native oxide and passivate the Ge surface. In this poster we will present a fast and simple method to clean and passivate the Ge surface, which uses only non-hazardous household acids such as citric and acetic acids.The method improves the adhesion of HSQ to the substrate and allows to effectively avoid lifting off the HSQ nanostructures. With this method, sub-20 nm Ge nanowires can be fabricated, which will be used to develop a technology for doping Ge nanostructures by ion implantation and flash lamp annealing with outlook to possible nanoelectronics and photonics applications.

HL 50.39 Thu 19:00 Poster B

Magneto-conductivity experiments and simulation on two dimensional Lorentz gas systems — •Beate Horn[1], Jakob Schluck[1], Klaus Pierz[2], Hans Werner Schumacher[2], and Thomas Heinzel[1] — [1]Institut für Experimentelle Physik der kondensierten Materie, Heinrich-Heine-Universität, Universitätsstraße 1, 40225 Düsseldorf, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesalle 100, 38116 Braunschweig, Germany

The Lorentz gas system (LGS) is of fundamental scientific interest predicting omnipresent phenomena like the motion of pathogens in blood stream or the electron motion in porous media. In the present contribution two dimensional LGSs are realized by patterning Poission distributed obstacles of equal size and shape by electron beam lithography and reactive ion etching on a high electron mobility $GaAs/Ga_xAl_{1-x}As$ heterostructure [1]. Magneto-conductivity measurements are performed on samples with different obstacle densities. The as described system is implemented in numerical simulations using the Python package Kwant [2]. Experimental and simulated data are compared.

[1] N. Siboni, J. Schluck, K. Pierz, H.W. Schumacher, D. Kazazis, J. Horbach and T. Heinzel, arXiv:1708.01039 (2017) (manuscript sub-

mitted for publication)

[2] Groth, M. Wimmer, A. R. Akhmerov, X. Waintal, *Kwant: a software package for quantum transport*, *New J. Phys.* 16, 063065, (2014)

HL 50.40 Thu 19:00 Poster B

Simulation of morphology and electric behavior of a printed vertical field effect transistor — •Manuel Rommel, Pascal Friederich, and Wolfgang Wenzel — Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany

Decreasing device dimensions is a common strategy to increase field effect transistor performance. In printed electronics, device dimensions are linked to the printing resolution, thus limiting its properties. Therefore, a vertical field effect transistor has been experimentally demonstrated (doi:10.1002/adma.201603858), where channel length is defined by the thickness of the printed layers instead. However, neither the local charge distribution nor the influence of parameter changes on the transistor are easily accessible in experiment.

Therefore, we will show simulation results of domain formation using a Monte Carlo method as well as 3D drift diffusion simulations of the electric behavior of this device architecture. The drift diffusion simulations yield the local charge carrier distribution and electric potential, which show the conduction channel doesn't penetrate the whole system, resulting in ohmic stray currents. A domain formation model was used to generate morphologies exhibiting smaller and larger domain sizes, as they would occur in a slower or faster annealing step in experiment. The simulated transfer curves of these virtual devices show an increased on/off-ratio for smaller domain sizes. A doping concentration sweep yields a dependence of the off-current on doping concentration. These results promise increased performance on smaller domain sizes and the tunability via doping concentration.

HL 50.41 Thu 19:00 Poster B

Quantum mechanical simulations of the magneto-conductivity of two dimensional Lorentz-gases — •Christopher Kraus, Jakob Schluck, and Thomas Heinzel — Heinrich-Heine Universität

An electron gas with poisson-distributed obstacles is known as Lorentz-gas. Even though it has been studied for more than 20 years some properties of the magneto-conductivity of such systems are not fully understood. Since previous simulations in the classical regime deviated from the experiments, especially for high scatterer densities, it seems natural to look into quantum mechanics for further insight. By using Kwant [1], a Python package with focus on quantum transport, we simulate the magneto-cunductivity in the quantum regime and compare our results with data of experiments and classical simulations. Reproducing aspects of the experimental data in our simulation that were absent in classical simulations shows that they are of quantum mechanical origin.

[1] Groth, M. Wimmer, A. R. Akhmerov, X. Waintal, Kwant: a software package for quantum transport, New J. Phys. 16, 063065, (2014)

HL 50.42 Thu 19:00 Poster B

Optical and structural properties of PLD-grown TiN single layers and TiN/MgO superlattices on MgO(100) substrates — •Florian Jung[1], Santana Ellis[1], Chris Sturm[1], Rüdiger Schmidt-Grund[1], Michael Lorenz[1], Marius Grundmann[1], Christian Patzig[2], Susanne Selle[2], and Thomas Höche[2] — [1]Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik, Leipzig, Germany — [2]Fraunhofer IMWS, CAM, Halle, Germany

For TiN/MgO-superlattices with single layer thickness of some nanometers, a hyperbolic dispersion in the NIR and visible spectral range is predicted[1]. These structures are promosing for a variety of applications, such as hyperlenses[2]. However, the growth of high-quality superlattices is challenging due to the combined *in situ* growth of an oxide and a nitride material. We investigate the optical properties of the TiN/MgO-superlattices by ellipsometry. We found that the miscut of the substrate has a strong impact on the dielectric function of the first layer pair and is negligible for subsequent layers. As expected, the plasma frequency of TiN was found to be in the visible spectral range. Structural properties were determined using RHEED, x-ray- and TEM-techniques. The analysis shows that smooth TiN/MgO-interfaces, a homogeneous layer density, as well as a low strain gradient and low mosaicity of the films were achieved[3].

[1] Naik, G.V., *et al.*, Opt. Mater. Express 2, pp. 478-489 (2012)
[2] Liu, Z., *et al.*, Science, Vol. 315, 1686 (2007)
[3] Lorenz, M., *et al.*, J. Mater. Res. 32, pp. 3936-3946 (2017)

HL 50.43 Thu 19:00 Poster B

Investigation of Silicon Nanocrystals in Silicon-Rich Silicon Oxide using Electron Nanodiffraction in STEM — •Hendrik Voigt, Tobias Meyer, and Michael Seibt — IV. Physikalisches Institut der Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

Silicon as the most prominent element in semiconductor physics shows interesting behaviour in low-dimensional systems. Nanocrystalline Silicon (nc-Si) particles exhibit photoluminescence at room temperature which is of great interest for future applications in light-emission techniques. Different methods have been utilized to achieve the temperature driven phase transition of silicon rich silicon oxide into stable silicon dioxide and nc-Si, one of which is laser irradiation allowing for spatially confined formation of nc-Si [1].

Lamellas of such laser irradiated samples are prepared by focused ion beam and subsequently, to investigate the properties of the nc-Si after phase transition, Electron Nanodiffraction in a Scanning Transmission Electron Microscope (STEM) is used. A diffraction map is recorded and Fluctuation Electron Microscopy is utilized to further characterize the distribution and size of the nanoparticles.

[1] Nan Wang, et al., Journal of Alloys and Compounds 707 (2017) 227-232

HL 50.44 Thu 19:00 Poster B

Optical properties of carbon nanodots as active material in planar microcavities — •Lukas Trefflich[1], Frank Dissinger[2], Mizuki Kakei[1], Chris Sturm[1], Siegfried R. Waldvogel[2], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1] — [1]Felix-Bloch-Institute for Solid State Physics, Universität Leipzig, 04103 Leipzig — [2]Institute for Organic Chemistry, Johannes Gutenberg Universität Mainz, 55128 Mainz

We present electronic and optical properties as well as temporal dynamics of carbon nanodots (C-dots) in different solvents and transparent matrices. We found bright light emission in the visible spectral range and decay time constants in the order of 10 nanoseconds. Both properties depend on the dilution of the solvents or the material of the host matrix, leading to differing emission wavelengths and decay times. This enables to tune the optical properties of carbon nanodots. We explore their application as active material in planar microcavities for possible laser and white LED application. White light LEDs usually contain rare-earth elements [1], which are rare and expensive. Carbon nanodots can be synthesized from environment friendly substances like coffee, tea, grass and candle soot. [2] They are biocompatible [3] and photo stable [4] and therefore promising alternatives for conventional LED designs. [1] H. Höppe, Angew. Chem., Int. Ed. 2009, 48 [2] Roy et al., Mater. Today, 2015, 18 [3] da Silva et al., Trends Anal. Chem., 2011, 30 [4] Sun et al., J. Am. Chem. Soc., 2006, 128

HL 50.45 Thu 19:00 Poster B

New approaches for hybrid passivation layers — •Till Welzel[1], Markus Wiesinger[1], Rui N. Pereira[1,2], and Martin Stutzmann[1] — [1]Walter Schottky Institut and Physik-Department, Technische Universität München, Garching bei München, Germany — [2]Department of Physics and Institute for Nanostructures, Nanomodelling and Nanofabrication, University of Aveiro, Aveiro, Portugal

The application of new hybrid materials for devices such as neuromorphic field effect transistors or high power devices is motivated by novel properties of hybrid dielectric passivation layers such as tunable dielectric constants or the ability to screen high electric fields effectively. In this study, we explore different scalable approaches to produce hybrid (semiconducting-insulating) passivation layers composed of semiconducting nanocrystals embedded in insulating organic or inorganic matrices. We investigate the morphology and optical properties of these layers by means of AFM and ellipsometry. The dielectric and electric behavior of the most promising layer structures have been investigated using impedance spectroscopy and CV-measurements. The observed properties are discussed in terms of the corresponding layer morphology and structure.

HL 50.46 Thu 19:00 Poster B

Metallurgical grade Silicon-Air Battery in alkaline solution — •Benjamin Griesche[1], Richard Schalinski[1], Stefan L. Schweizer[1], and Ralf B. Wehrspohn[1,2] — [1]Institute of Physics, Martin-Luther-University Halle-Wittenberg, Germany — [2]Fraunhofer

Institute for Microstructure of Materials and Systems IMWS, Halle (Saale), Germany

The demand of energy storage technologies is one of the most discussed, regarding the transition from fossil fuels towards renewable energy systems. Therefore, lots of research was done. Some of them are highly promising, e.g. Lithium-ion battery, which achieved extreme progress over the last 25 years, and which is widely spread in portable devices. However, concerning the huge ever-increasing request, it is necessary to develop alternative battery systems. Metal-air batteries represent a category of these alternatives, from which the zinc-air battery (820 Ah/kg) is used in small applications. We are investigating another promising system, the silicon-air battery, since its components are abundant with a high theoretical specific capacity of 3.817 Ah/kg.

We introduce a new route of electrode preparation by using inexpensive metallurgical grade silicon as starting material and ball mill it to obtain small Si-nanoparticles. These were mixed with different binders to form slurries and were then coated on a substrate. The dried electrodes were analyzed by electrochemical methods in alkaline electrolyte solution and were investigated by optical methods. In order to optimize the battery performance a variation of chemical contents and treatments were performed.

HL 50.47 Thu 19:00 Poster B

Dispersion-engineered AlGaAsOI waveguides for on-chip SPDC — •Marlon Placke and Sven Ramelow — Humboldt-Universität zu Berlin, Germany

We present AlGaAs-on-insulator as a promising nonlinear optics platform with C-band compatibility. Combination of the semiconductor's ultra-high material nonlinearity with submicron waveguiding renders possible an efficient interface with great potential for full on-chip integration - provided phasematching can be achieved. Our simulations elucidate the capabilities of dispersion engineering on this platform and predict that modal phasematching is feasible for SHG and SPDC at telecom wavelengths.

HL 50.48 Thu 19:00 Poster B

MAD-grown $NdNiO_3$ thin films for PEEM study of electronic phase separation — •Henrike Probst, Marius Keunecke, David Schmitt, Vitaly Bruchmann-Bamberg, Sabine Steil, Daniel Steil, Stefan Mathias, and Vasily Moshnyaga — I. Physikalisches Institut Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Rare earth nickelates ($RENi0_3$, RE=La, Pr, Nd, Sm) are strongly correlated electron systems in which the structure and electronic properties are interconnected. They exhibit a metal-insulator transition at T_{MI} ∼100-400 K, coupled to a charge/orbital ordering and structural phase transition.
Epitaxial $NdNiO_3$ thin films have been prepared by metalorganic aerosol deposition technique (MAD) on perovskite substrates, i.e. $NdGaO_3$, $SrTiO_3$ und $LaAlO_3$, to achieve different strain states of the films. Previously [Mattoni, Nature Comm. 7, 13141 (2016)], a coexistence of metallic and insulating regions at the scale of 100-200 nanometers in the vicinity of the T_{MI} in $NdNiO_3$ epitaxial thin films was suggested. Electrical resistivity measurements reveal a pronounced R(T) hysteresis, ΔT∼10-20 K, close to T_{MI}, thus, indicating a first-order MI transition with metastable coexistence of such regions.
To study electronic phase separation across a first-order MI transition of $NdNiO_3$ we will use photoemission electron microscopy (PEEM) to visualize metallic and insulating domains.

HL 50.49 Thu 19:00 Poster B

Spin dependent giant junction resistance in Fe/*p*-Si Schottky heterojunction — •Anirban Sarkar[1,2], Amal Kumar Das[2], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Sciences JCNS and Peter Grünberg Institute PGI, JARA-FIT, 52425 Jülich, Germany. — [2]Department of Physics, Indian Institute of Technology Kharagpur, West Bengal 721302, India.

We report on the giant positive magnetoresistive behavior of a simple Fe/*p*-Si Schottky heterojunction diode at low temperatures. The device shows good rectifying characteristics at room temperature and a dual - Schottky as well as magnetic diode - characteristics at low temperature (<50 K). Large change in the junction magnetoresistance value of 10^4% at 10 K is observed which saturates at a relatively low magnetic field (∼0.5 kOe). Quantitative analysis of the field dependence of the diode forward characteristic, reveal a spin diffusion length of 100 nm with a spin life-time of 300 ps.

Formation of a magnetic field dependent potential barrier at the interface, due to electrical injection of spin-polarized carriers from the ferromagnetic electrode into the semiconductor template is often referred to result in such large junction resistance. However, there lacks a proper experimental evidence to such models and therefore we propose that probing the depth profile of magnetization with polarized neutron reflectrometry (PNR) can reveal more information about the magnetic properties near the interface of such ferromagnetic/semiconductor heterostructures.

HL 50.50 Thu 19:00 Poster B

Charge Carrier Dynamic and Disorder in (Ga,In)As/GaAs/Ga(As,Sb) heterostructures — •Luise Rost, Sarah Karrenberg, Sebastian Gies, Christian Fuchs, Wolfgang Stolz, and Wolfram Heimbrodt — Department of Physics and Materials Science Center, Philipps- Universität Marburg, Renthof 5, 35032 Marburg, Germany

The (Ga,In)As/GaAs/Ga(As,Sb) material system is used for lasers operating over a wide spectral range in the infrared. To further optimize the design of such heterostructures, it is important to have deep understanding of the influence of the interface morphology and the charge carrier dynamic through the interface. Here we present a thorough analysis of the optical properties of (Ga,In)As/GaAs/Ga(As,Sb) type-II heterostructures by means of temperature-dependent and time resolved photoluminescence spectroscopy. We were able to determine die influence of growth interruption on the disorder in our samples to further optimize growth condition. Additionally, we introduced monolayers of GaP on different positions in our heterostructure to vary the quantum confinement and the electronic structure. Furthermore, we analyzed the decay dynamics of charge-transfer excitons in the different samples to specify correlation between interface morphology and charge carrier dynamics.

HL 50.51 Thu 19:00 Poster B

atomic-scale observations of microstructure and local chemistry at the SrMnO3-SrTiO3 heterointerface — •Hongguang Wang, Vesna Srot, Yi Wang, Hans Boschker, Jochen Mannhart, and Peter A van Aken — Max Planck Institute for Solid State Research, 70569 Stuttgart, Germany

Oxide heterointerfaces show unprecedented physical properties such as electro-magnetic coupling, 2-dimensional electron gas and high-Tc superconductivity which cannot be found in their bulk analogies. It is the interfacial lattice reconstruction that induces these unexpected electronic states dominating the macroscopic characteristics. Therefore, atomic-scale observations of the oxide heterointerfaces are important for appropriate interpretation of these phenomena. Here, by using an aberration-corrected scanning transmission electron microscope (STEM) equipped with an electron energy-loss spectrometer (EELS), we performed atomic-scale investigations at the heterointerface between SrTiO3 (STO) and SrMnO3 (SMO). Atomic-resolved high-angle annular dark-field and annular bright-field images were used to evaluate the local lattice and oxygen distortions. The lattice structure analysis shows a remarkable variation near the heterointerface. Using STEM-EELS line scan, we observe an asymmetric cationic intermixing at the interface between STO and SMO. A simulation of STEM-EELS spectrum image was performed at the interface. This demonstrates that the beam-spreading effect is weak and confirms the intermixing data. The EELS fine structure of Mn-L2,3 edges unveils a variation of Mn oxidation states at the heterointerface.

HL 50.52 Thu 19:00 Poster B

Development of industrially compatible patterning processes for the fabrication of IBC-SHJ solar cells — •Philipp Wagner[1,2], Johann-Christoph Stang[2], Lars Korte[2], Christof Schultz[1,3], Bernd Stannowski[3], Bert Stegemann[1], and Bernd Rech[2] — [1]HTW Berlin, Wilhelminenhofstraße 75a, D-12459 Berlin — [2]HZB, Institut für Silizium-Photovoltaik, Kekuléstraße 5, D-12489 Berlin — [3]PVcomB/HZB, Schwarzschildstraße 3, D-12489 Berlin

The interdigitated back contacted silicon hetero-junction (IBC-SHJ) solar cell is the ultimate Si wafer-based high efficiency approach with record power conversion efficiencies of 26.6 % [1]. It combines the advantages of IBC cells (i. e. high jsc and FF by small optical and resistive losses, respectively) and SHJ cells (i. e. high Voc by excellent interface passivation). Contact preparation of such solar cells with lab-based photolithographic processes yields high cell efficiencies [2], but is complex and costly and therefore not applicable in industrial fabrication. Hence it is the main objective of our work to develop simplified and damage-free, industrially compatible fabrication processes, while

maintaining exceptional cell properties. Here we demonstrate the successful development of a photolithography-free patterning technique using shadow masks and compare the challenges and advantages with screen printing and laser ablation. First solar cell results are presented and discussed with respect to further improvement of the passivation and minimisation of the contact resistance.

[1] K. Yoshikawa et al. (2017). Nature Energy, 2, 17032.
[2] J.-C. Stang et al. (2017). JJAP, 56(8S2), 08MB22

HL 50.53 Thu 19:00 Poster B

Shubnikov-de Haas studies on Gallium Nitride / Aluminum Gallium Nitride Heterostructures for High-electron-mobility transistors — •Raphael Müller[1], Sebastian Bauer[1], Manfred Madel[2], Hervé Blanck[2], and Klaus Thonke[1] — [1]Institute of Quantum Matter / Semiconductor Physics Group, Ulm University — [2]United Monolithic Semiconductors GmbH/ Ulm

Key parameters for High-electron-mobility transistors (HEMTs) are the electron mobility and sheet carrier density in the 2-dimensional electron gas forming at the n-type heterointerface. On GaN/AlGaN heterostructures with and w/o an additional AlN interlayer, these properties were analyzed in detail by low-temperature Shubnikov-de Haas and Hall measurements in magnetic fields up to 15 T.
With the presented results it is shown, that the AlN interlayer has a positive influence on several key parameters of the Heterostructure, due to the additional polarization field and the enlarged effective conduction band offset. We show that the carrier concentration, mobility, classical scattering time and quantum mechanical scattering time can be increased by adding this AlN interlayer, with positive influence on the performance of HEMTs.

HL 50.54 Thu 19:00 Poster B

KPFM under local illumination - direct observation of local band bending in contacted nanostructures — •Jan Siebels, Andreas Kolditz, Dino Behn, Tobias Kipp, and Alf Mews — Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg

The understanding and control of charge transfer processes within semiconductor materials and at interfaces is crucial for the design of semiconductor devices such as, e.g., solar cells, photodetectors, and gas sensors. Here, we demonstrate the power of Kelvin probe force microscopy with simultaneous, localized illumination of a nanostructure device by focused laser light. A combination of this technique with scanning photocurrent measurements allows the exploration of the mutual interaction between local charge carrier generation and band profiles. The nanostructure devices under investigation are Pt contacted (i) CdS nanowires and (ii) SnS nanosheets. For (i), the combined measurements show that local photocurrents can be explained by a strong dependence of the surface potential on the position of illumination while, for (ii), the occurrence of zero-bias photocurrent can directly be attributed to changes of the band bending due to the optically generated charge carriers.

HL 50.55 Thu 19:00 Poster B

Growth of Na-doped SnSe single crystals — •Yannik Bartlock, Marius Peters, Kristin Kliemt, and Cornelius Krellner — Physikalisches Insitut, Goethe-Universität Frankfurt am Main, D-60438 Frankfurt

Single crystalline tin-selenid has proven to be an excellent thermoelectric material, since new studies have shown that the figure of merit of hole doped SnSe is above 1 [1]. The large figure of merit arises mainly from a huge increase of the power factor, e.g. an increase of the electrical resistivity and the thermopower. This work presents the single crystal growth of tin-selenid and various Na-doped tin-selenid compounds via vertical Bridgman method. The samples were analyzed with x-ray diffraction and probed by van de Pauw measurements to investigate the influence of the Na-doping on the density and the mobility of the charge carriers.

[1] L.-D. Zhao et al., Science 351, 141 (2016)

HL 50.56 Thu 19:00 Poster B

Organic-Inorganic Hybrid Thermoelectrics based on Mesoporous Silicon and PEDOT:PSS — •Haider Haseeb, Tommy Hofmann, Danny Kojda, and Klaus Habicht — Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Berlin, Germany

This contribution presents mesoporous silicon and derived hybrid systems that incorporate conducting PEDOT:PSS into the vacant pore space as thermoelectric materials of interest. First, the synthesis of mesoporous silicon by means of electrochemical etching is explained. Grown samples are characterized in microscopic SEM studies as well as with gas adsorption isotherms to reveal morphological features that are pore size distributions, specific surfaces and porosities. Second, the impact of porousification on the thermoelectric properties is revealed and discussed. Macroscopic transport measurements that probe electrical and thermal conductivity, Hall mobility, charge carrier concentration and Seebeck coefficients allow to compare the thermoelectric performance of mesoporous silicon with the properties of the corresponding bulk system. In the third and final part of the poster, we show the infiltration of PEDOT:PSS into porous silicon as a way to form organic-inorganic hybrids. Their preliminary thermoelectric characterization and microscopic analysis conclude our presentation and allow an outlook on future material improvements.

HL 50.57 Thu 19:00 Poster B

Submonlayers as novel gain medium in opto-electronic devices — •Fuad Alhussein[1], Bastian Herzog[1], Benjamin Lingnau[2], Mirco Kolarczik[1], Sophia Helmrich[1], David Quandt[3], Udo Pohl[3], André Strittmatter[4], Olaf Brox[5], Markus Weyers[5], Ulrike Woggon[1], Kathy Lüdge[2], and Nina Owschimikow[1] — [1]Institut für Optik und atomare Physik, Technische Universität Berlin — [2]Institut für theoretische Physik, Technische Universität Berlin — [3]Institut für Festkörperphysik, Technische Universität Berlin — [4]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg — [5]Ferdinand Braun Institut, Leibniz Institut für Hüchstfrequenztechnik Berlin

For lasers and optical amplifiers the gain provided by the active region along with the line width and energy of the emitted light are important features. For many applications a broad emission spectrum is desired, such as it is produced by self-assembled quantum dots. The submonolayer growth method produces dense In-rich islands within a GaAs matrix, with a density of localization centers exceeding the density of quantum dots by an order of magnitude. We compare the properties of optical amplifiers and lasers with quantum dots, submonolayers and single quantum wells emitting at the optical band of 1060 nm. Our devices reach a peak net modal gain of 9, 25 and 28 $cm^{(-1)}$ per layer on a 3 dB bandwidth of 60, 38 and 7 meV and a lasing threshold of 1.5, 0.75 and 0.23 kA $cm^{(-2)}$, respectively.