O 3: Graphene: Magnetic Fields (jointly with DS, HL, MA, and TT)

Time: Monday 9:30–11:15 Location: H17

O 3.1 Mon 9:30 H17

Quantum interference in an electron-hole graphene ring system — •Dmitri Smirnov, Hennrik Schmidt, and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, Appelstr. 2 30167 Hannover, Germany

We analyze the electronic properties of a topgated monolayer graphene ring. Micro-mechanical cleavage was used to place a flake on a Si/SiO2 substrate. The structuring and contacting was done via plasma etching and electron beam lithography. An additional gate was placed on top of one arm of the ring which allows us to control the charge carrier concentration locally and additionally to create a pnp- (npn-) junction inside the ring. The sample was measured in a He3 cryostat and is identified as single layer graphene via magnetotransport measurements.
We observe Aharonov Bohm (AB) effect by sweeping the magnetic field around 0 T. The period of the oscillations is approx. 16 mT which fits the size of the ring well. The AB-oscillations are measured for different temperatures and the amplitude shows a saturation for lower temperatures. We also observe the AB-oscillations when a pnp-junction is created inside the ring. The period is independent of the existence of a pnp-junction and stays constant in all situations. We analyze the amplitude in dependence of the charge carrier concentration. The absolute amplitude is constant in the bipolar and unipolar region [1].

[1] D.Smirnov. et. al, Appl. Phys. Lett. 100, 203114 (2012).

O 3.2 Mon 9:45 H17

Experiments on Superlattice Graphene Structures with Patterned Top Gates — •Franz-Xaver Schrettenbrunner, Martin Drienovsky, Bastian Birkner, Sebastian Ringer, Dominik Koch, Dieter Weiss, and Jonathan Eroms — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg

We report on fabrication, finite element modelling (FEM), and the measurements of single- and bilayer graphene with structured top gates. By using micromechanically exfoliated graphene on SiO_2 surface, a Al_2O_3 dielectric was fabricated on top of the structure by either atomic layer deposition (ALD), evaporating thin aluminum films, or by combination of both methods. A digitated, patterned top gate electrode out of an AuPd alloy was fabricated by electron beam lithography (EBL). FEM yields that form and strength of the modulation strongly depend on thickness of the top gate dielectric, periodicity of the gate fingers, and applied voltage. Using both, the planar SiO_2 back gate and the patterned Al_2O_3 top gate the electric field effect creates variable modulations of the charge carrier concentration like pnp, nn'n, n0n, etc. along the whole underlying graphene. Measurements on these structures show typical behaviour for Klein-Tunneling resulting in an asymmetric curve of the Dirac Point. At high magnetic fields up to 14T unusual plateaus were observed when filling factors are mixing up in the top gated and the non top gated areas of the graphene samples.

O 3.3 Mon 10:00 H17

Weak Localization and Raman Study of Graphene Antidot Lattices Obtained by Crystallographically Anisotropic Etching — •Florian Oberhuber, Stefan Blien, Stefanie Heydrich, Tobias Korn, Christian Schüller, Dieter Weiss, and Jonathan Eroms — Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg

We report the crystallographically anisotropic etching of exfoliated graphene on SiO_2 substrates by applying an etching mechanism that was demonstrated to eliminate carbon atoms located on armchair sites thus leading to zigzag edges [1]. Before exposing samples to this carbothermal reaction, they were patterned with circular antidots (diameter ≈40nm) by EBL and RIE. In the subsequent carbothermal etching step the predefined holes evolved into hexagonal antidots (≈100nm).

We investigated a set of samples patterned with square lattices of hexagonal antidots and compare them to graphene patterned with lattices of circular holes investigated previously [2]. First, we compare samples by analyzing the weak localization peak in electron transport from which we obtain the phase coherence length and lengths for inter- and intravalley scattering. Second, samples were characterized by Raman spectroscopy focusing on G, D and D* peaks. In addition to the above mentioned comparison we demonstrate the influence of the etching reaction on graphene's properties by showing a series of Raman maps acquired between consecutive sample preparation steps.

[1] Nemes-Incze et al., Nano Res. (2010)
[2] Eroms et al., New J. Phys. (2009), Heydrich et al., APL (2010)

O 3.4 Mon 10:15 H17

Electronic structure of graphene twist flakes — •Wolfgang Landgraf, Sam Shallcross, Karla Türschmann, Dominik Weckbecker, and Oleg Pankratov — Lehrstuhl für Theoretische Festkörperphysik, Staudtstraße 7, D-91058 Erlangen

We study the electronic structure of bilayer graphene flakes with mutually rotated layers. The twist induces a large scale superstructure, a so called moiré pattern, which is a regular array of AA and AB stacked regions. We find that at low energies the electrons are trapped in the AA regions. This feature is visible even for a flake hosting a single AA moiré spot, which is thus acting as a quantum well. The electron density fluctuations induced by the moiré lattice are significant, being an order of magnitude greater than those generated by the rippling of a suspended graphene sheet. Finally, we determine the electronic properties of the twisted graphene flakes in the presence of an external magnetic field. We find a novel "zero-mode" structure, as well as Landau states that exhibit an electron current circulating between two graphene layers of the flake. The current distribution can be visualized as an electron flow on a torus circumventing the AA spot of the moiré lattice.

O 3.5 Mon 10:30 H17

Functionalized Graphene in Quantizing Magnetic Field: The case of bunched impurities — •Peter Silvestrov — Dahlem Center for Complex Quantum Systems, Freie Universitaet Berlin, 14195 Berlin, Germany

Covalent bonding of impurity atoms to graphene, in many cases leads to creation of unusual (singular) zero energy localized electron states. Existence of such states would lead to interesting phenomena, actively discussed recently.

In this talk I consider the behavior of localized impurity levels in graphene in quantizing magnetic field. In the magnetic field the impurity level effectively hybridizes with one of the n=0 Landau level states and splits into two close opposite-energy states. In turn, mixing of localized and Landau levels changes a spin content of a quantum Hall ferromagnet and modifies, via the exchange interaction, the spectrum of electrons surrounding the impurity.

Existing theories investigate graphene uniformly covered by adatoms, though some experiments indicate the tendency towards their clusterization. To address this ”unpleasant” possibility, I consider the case of a dense bunch of the impurity atoms, and show how such bunch changes dynamics and spin polarization of a large dense electron droplet surrounding it.

O 3.6 Mon 10:45 H17

Quantum Hall measurements on epitaxial graphene with oxygen adsorption — •Emiliano Pallecchi[1], Mohamed Ridene[1], Dimitris Kazazis[1], Felicien Schopfer[2], Wilfrid Poirier[2], Mark Goergig[3], and Abdelkarim Ouerghi[1] — [1]Laboratoire de Photonique et de Nanostructures (LPN-CNRS), 91460 Marcoussis, France — [2]Laboratoire National de Métrologie et d'Essais, 78197 Trappes — [3]Laboratoire des Physique de Solides, F-91505, Orsay

In this contribution we present quantum transport, ARPES, and LEED investigations of molecular oxygen-adsorbed epitaxial graphene grown on SiC. We show that the carrier concentration can be significantly reduced by exposing the sample to molecular oxygen. From Hall measurements we obtain a carrier concentration on the order of 1.2 x 10^{12} cm^{-2}, about one order of magnitude smaller than typical values of intrinsic epitaxial graphene. The reduction of electron doping is consistent with estimates from ARPES measurements. At high magnetic field, we find a fully developed quantum Hall effect, with a plateau at filling factor around 2, and a vanishing longitudinal resistance. Such a plateau is the hallmark of single layer graphene and suggests that the buffer layer is not fully decoupled from the substrate. This is further confirmed by LEED study. We then discuss the intermediate field regime, where we analyze the transition between a localized state observed at low fields and the quantum Hall regime at high fields. Finally, we compare these findings to the results obtained on epitaxial graphene exposed to atomic oxygen. We find that atomic oxygen is a more violent process that can damage significantly the graphene flake.

O 3.7 Mon 11:00 H17

Splitting of the Zero-Energy Landau Level and Universal Dissipative Conductivity at Critical Points in Graphene — •Frank Ortmann[1] and Stephan Roche[1,2] — [1]Catalan Institute of Nanotechnology, Barcelona (Spain) — [2]ICREA, Barcelona (Spain)

In graphene, the interaction of electrons with disorder impacts on their transport signature in a variety of experiments. Magnetotransport experiments can serve as an additional tool to probe this interaction with magnetic fields ranging from the low-field limit of weak antilocalization (∼mT) [1,2] to high fields defining the quantum Hall regime (∼10T). Being under study ever since the discovery of graphene, magnetic fields may unveil some interesting physics hidden otherwise or may generate new effects [3]. We are calculating the Kubo conductivity of graphene σ_{xx} and σ_{xy} in the presence of both weak and strong disorder and magnetic fields using a linear scaling method. This allows us to model realistic graphene samples up to micrometer size. Here we present our recent work on charge transport in the quantum-Hall regime and discuss our findings of universal conductivities. Particular emphasize is put on the non-trivial interference of disorder and magnetic-field and results from our novel order-N Hall-transport code.

[1] F.V. Tikhonenko et al. Phys. Rev. Lett. 103, 226801 (2009)
[2] F. Ortmann et al. EPL 94, 47006 (2011)
[3] D.A. Abanin et al. Science 332, 328 (2011)