HL 15: Graphene: Structure and Theory I

Time: Monday 15:00–17:00 Location: EW 201

HL 15.1 Mon 15:00 EW 201

Functional Polymer Brushes on Graphene — •Max Seifert[1], Amelie Koch[1], Frank Deubel[2], Tobias Simmet[1], Lucas Hess[1], Martin Stutzmann[1], Ian Sharp[1], and Jose Antonio Garrido[1] — [1]Walter Schottky Institut, TU München, Germany — [2]Wacker-Lehrstuhl für Makromolekulare Chemie, TU München, Germany

The use of graphene in biosensing applications requires a well-defined functionalization method in order to introduce sensing specificity and improve device sensitivity. It has been shown that direct photografting and photo-polymerization of styrene yields covalently bound polystyrene brushes on graphene without significantly disrupting its basal plane conjugation. We have previously suggested that hydrogen-containing defects sites can act as initiation centers for the surface polymerization. In this contribution, we demonstrate by Raman spectroscopy that the density of such hydrogen defect sites can be finely controlled by exposing the pristine CVD grown graphene sheets to a hydrogen plasma at room temperature, resulting in a tunable polymer brush grafting density. However, pure polystyrene brushes exhibit very low chemical reactivity for further functionalization. Thus, we have developed a procedure for the copolymerization of styrene and different acrylates, paving the way towards a graphene-based platform for highly sensitive and specific biosensor devices.

HL 15.2 Mon 15:15 EW 201

Electronic structure of graphene on single crystal copper substrates — •Andrew Walter[1,2], Shu Nie[3], Aaron Bostwick[1], Keun Su Kim[1,4], Luca Moreschini[1], Young Jun Chang[1,2], Davide Innocenti[5], Karsten Horn[2], Kevin F. McCarty[3], and Eli Rotenberg[1] — [1]Advanced Light Source (ALS), E. O. Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA — [2]Department of Molecular Physics, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany, — [3]Sandia National Laboratories, Livermore, California 94550, USA. — [4]Center for Atomic Wires and Layers, Pohang University of Science and Technology, Pohang 790-784, Korea. — [5]University of Rome (Tor Vergata), Rome 00173, Italy

The electronic structure of graphene on Cu(111) and Cu(100) single crystals is investigated using low energy electron microscopy, low energy electron diffraction and angle resolved photoemission spectroscopy. On both substrates the graphene is rotationally disordered and interactions between the graphene and substrate lead to a shift in the Dirac crossing. The graphene film is found to protect the surface state from air exposure, with no change in the effective mass observed.

HL 15.3 Mon 15:30 EW 201

Atomic structure and spectroscopy of graphene edges on Ir(111) — •Soo-hyon Phark[1], Jérôme Borme[1,2], Augusto León Vanegas[1], Marco Corbetta[1], Dirk Sander[1], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany — [2]International Iberian Nanotechnology Laboratory, Avenida Mestre José Veiga, 4715-310 Braga, Portugal

We performed scanning tunneling microscopy/spectroscopy (STM/S) on monolayer graphene islands grown on Ir(111). The graphene islands show moiré patterns, which are induced by the lattice mismatch between graphene and Ir(111). The atomic structure at the edge of a graphene depends on the stacking configurations of the edge atoms. The edges of graphene islands terminate with a zigzag carbon configuration and show periodic kinks in the regions of the on-top stacking carbon rings. The periodicity is given by the moiré pattern of the graphene island. The termination of a graphene island at an Ir(111) step also leads to the formation of periodic kinks, of which the positions depend on the orientation of the step edge. We tentatively ascribe these observations to a strong electronic interaction, arising from the broken σ-bond of graphene, between carbon edge atoms and the Ir lattice. Spatially resolved tunnel spectroscopy indicates a considerably reduced density of states at the edges as compared to center regions of the islands.

HL 15.4 Mon 15:45 EW 201

Bernal graphite is a narrow gap semiconductor — Nicolas Garcia[1], •Pablo Esquinazi[2], Jose Barzola-Quiquia[2], and Srujana Dusari[2] — [1]Laboratorio de Física de Sistemas Pequeños y Nanotecnología, Consejo Superior de Investigaciones Científicas, E-28006 Madrid, Spain — [2]Division of Superconductivity and Magnetism, Institut für Experimentelle Physik II, Universität Leipzig, Linnéstraße 5, D-04103 Leipzig, Germany

We have studied the resistance of a large number of highly oriented graphite samples with areas ranging from several mm^2 to a few μm^2 and thickness from ~ 10 nm to several tens of micrometers. The measured resistance can be explained by the parallel contribution of semiconducting graphene layers with low carrier density $< 10^9$ cm^{-2} and the one from metalliclike internal interfaces. The results indicate that ideal graphite with Bernal stacking structure is a narrow-gap semiconductor with an energy gap $E_g \sim 40$ meV.

HL 15.5 Mon 16:00 EW 201

Effective screening and the plasmaron bands in Graphene — •Andrew Walter[1,2], Aaron Bostwick[1], Ki-Joon Jeon[3], Florian Speck[4], Marcus Ostler[4], Thomas Seyller[4], Luca Moreschini[1], Young Jun Chang[1,2], Marco Polini[5], Reza Asgari[6], Allan H. MacDonald[7], Karsten Horn[2], and Eli Rotenberg[1] — [1]Advanced Light Source (ALS), E. O. Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA, — [2]Department of Molecular Physics, Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany, — [3]School of Electrical Engineering, University of Ulsan, Namgu, Ulsan, 680-749, South Korea — [4]Lehrstuhl fur Technische Physik, Universitat Erlangen-Nurnberg, Erwin-Rommel-Strasse 1, 91058 Erlangen, Germany — [5]NEST, Istituto Nanoscienze-CNR and Scuola Normale Superiore, I-56126 Pisa, Italy. — [6]School of Physics, Institute for Research in Fundamental Sciences (IPM), Tehran 19395-5531, Iran. — [7]Dept. of Physics, Univ. of Texas at Austin, 1 University Station C1600, Austin TX 78712

Electron-plasmon coupling in graphene has recently been shown to give rise to a "plasmaron" quasiparticle excitation. The strength of this coupling is compared to the strength of enviromental screening for graphene on four different substrates. Comparison with G0W-RPA predictions are used to determine the effective dielectric constant of the underlying substrate layer indicating that plasmaron and electronic properties of graphene can be independently manipulated, an important aspect of a possible use in "plasmaronic" devices.

HL 15.6 Mon 16:15 EW 201

Opening of a tunable energy gap in disordered graphene nanoribbons — •George Pal, Walter Apel, and Ludwig Schweitzer — Physikalisch-Technische Bundesanstalt (PTB), Bundesalee 100, 38116 Braunschweig, Germany

The absence of an energy gap in the electronic band structure is the most severe impediment for the use of graphene in electronic device applications where large on-off currents are indispensable. Recently, we have proposed a mechanism to open a spectral gap by applying structured external electric potentials to the edge regions of graphene zig-zag nanoribbons [1]. Specifically, we show that an antisymmetric potential that acts selectively on the ribbon boundaries shifts the energies of the edge states in opposite directions and thus an energy gap opens up. To check the robustness of the proposed gap-opening mechanism against disorder, which is certainly present in real samples, we study the effect of different kinds of imperfections on the spectral and the transport properties. These include uncorrelated random on-site potentials, chiral-symmetry preserving bond disorder and edge disorder which may be due to edge passivation by randomly attached atoms that saturate the carbon dangling bonds. We find that all types of disorder merely reduce the spectral gap. Bulk disorder influences only slightly the edge states responsible for the gap, and its closing is mainly due to increasing the strength of edge disorder. Still, the energy gap remains finite as long as W$<$2V, where W is a measure of the disorder strength and V is the applied potential. [1] W. Apel, G. Pal and L. Schweitzer, PRB 83, 125431 (2011)

HL 15.7 Mon 16:30 EW 201

Perturbative analysis of the conductivity in disordered monolayer and bilayer graphene — •Andreas Sinner and Klaus Ziegler — Institut für Physik, Universität Augsburg, Germany

The DC conductivity of monolayer and bilayer graphene is studied per-

turbatively for different types of disorder. In the case of monolayer, an exact cancellation of logarithmic divergences occurs for all disorder types. The total conductivity correction for a random vector potential is zero, while for a random scalar potential and a random gap it acquires finite corrections. We identify the diagrams which are responsible for these corrections and extrapolate the finite contributions to higher orders which gives us general expressions for the conductivity of weakly disordered monolayer graphene. In the case of bilayer graphene, a cancellation of all contributions for all types of disorder takes place. Thus, the minimal conductivity of bilayer graphene turns out to be very robust against disorder.

Reference: arXiv:1110.3065, to appear with PRB.

HL 15.8 Mon 16:45 EW 201

Valley symmetry breaking and gap tuning in graphene by spin doping — •Antonio Hill, Andreas Sinner, and Klaus Ziegler — Institut für Physik, Universität Augsburg

We study graphene with an adsorbed spin texture, where the localized spins create a periodic magnetic flux. The latter produces gaps in the graphene spectrum and breaks the valley symmetry. The resulting effective electronic model, which is similar to Haldane's periodic flux model, allows us to tune the gap of one valley independently from that of the other valley. This leads to the formation of two Hall plateaux and a quantum Hall transition. We discuss the density of states, optical longitudinal and Hall conductivities for nonzero frequencies and nonzero temperatures. A robust logarithmic singularity appears in the Hall conductivity when the frequency of the external field agrees with the width of the gap.