O 15: Focused Session: Epitaxial Graphene II

Time: Monday 15:00–16:30 Location: SCH 251

Topical Talk O 15.1 Mon 15:00 SCH 251

Structure and Growth of Epitaxial Graphene on SiC: a New Platform for Carbon Electronics — •Edward Conrad — The Georgia Institute of Technology, Atlanta, Georgia 30332-0430, USA

The use of epitaxial graphene as a platform for carbon electronics hinges on a number of properties of graphene: growth, structure and transport. While graphene grown on both the Si-face and C-face of SiC are possible alternatives for device materials, I will show in this talk that C-face graphene currently offers the most immediate advantages to graphene device growth and fabrication. I will show how transport properties of C-face graphene make growth problems such as controlling thickness or uniformity much less relevant than on Si-face graphene. LEEM, PEEM, x-ray diffraction and transport measurements will be presented to elucidate the unique structure of C-face graphene films. I will also review new work on how to passivate charge transport between the SiC and the graphene.

O 15.2 Mon 15:30 SCH 251

Effects of periodic potentials in graphene — •Ervand Kandelaki, Sam Shallcross, and Oleg Pankratov — Lehrstuhl für Theoretische Festkörperphysik, Staudtstr. 7-B2, 91058 Erlangen

For epitaxial graphene grown on the Si-face of SiC one expects a covalent bonding[1] and hence a significant impact of the substrate on the properties of graphene. Density-functional *ab initio* calculations[2] as well as experimental data[3] reveal the emergence of the long-periodic $6\sqrt{3}\times 6\sqrt{3}$ superstructure in the first carbon layer which plays the role of a buffer layer and does not possess graphene's characteristic spectrum. This superstructure generates a long-periodic perturbation then transmitted to a second "genuine graphene" layer. The large scale and complexity of the system invites the use of a continuum approximation to model the low energy excitation spectrum. The appropriate effective Hamiltonian is thus the Dirac-Weyl Hamiltonian with an additional periodic potential. We investigate the electronic spectrum of this effective Hamiltonian via the Korringa-Kohn-Rostocker method which is widely used for Schrödinger particles in a periodic potential. The main benefit of this method is the separation of the geometrical part, given by periodicity of the external potential, from the single-site scattering problem. The latter can be solved for any cylindrically symmetric potential. The impact upon the spectrum of various parameters such as potential periodicity, perturbation amplitude, and single-site scatterer type are discussed. [1] A. Mattausch and O. Pankratov, Phys. Rev. Lett. 99, 076802 (2007). [2] S. Kim *et al.*, Phys. Rev. Lett. 100, 176802 (2008). [3] C. Riedl *et al.*, Phys. Rev. B 76, 245406 (2007).

O 15.3 Mon 15:45 SCH 251

An *ab initio* study of graphene buffer layers on SiC — •Stephan Hensel, Michel Bockstedte, and Oleg Pankratov — Lst. Theoretische Festkörperphysik, Universität Erlangen-Nürnberg, Staudtstr 7B2, 91058 Erlangen

Silicon Carbide enables the growth of few layer graphene by thermal sublimation of silicon. Graphene layers with disparate properties are formed on (0001) and $(000\bar{1})$ surfaces.[1−4] On (0001)-SiC a $6\sqrt{3}\times 6\sqrt{3}$ buffer layer forms, which serves as a template for subsequent alined layers.[1,2] On $(000\bar{1})$-SiC, in contrast, carbon layers are mutually rotated being practically decoupled from each other and hence possessing individual Dirac spectra.[3] The distinction manifests itself in the presence (Si-termination) or absence (C-termination) of covalent graphene-SiC bonding in XPS.[4] With ab initio methods we analyzed the bonding of graphene on SiC (0001) and $(000\bar{1})$ surfaces. We consider a tractable 5×5 model that allows for low strain and the turbostratic registry of graphene. The calculations demonstrate clearly the distinct bonding features on the two surfaces. While covalent graphene-substrate bonds are present for almost all atoms on the Si-terminated surface, such bonding is absent for as much as 50% of the carbon atoms on the C-terminated face.

[1] T. Ohta *et al*, Science **313**, 951 (2006)
[2] C. Riedl *et al*. Phys. Rev. B **76**, 245406 (2007).
[3] J. Hass *et al*, Phys. Rev. Lett. **100**,125504 (2008).
[4] K.V. Emtsev *et al*, Phys. Rev. B **77**, 155303 (2008).

O 15.4 Mon 16:00 SCH 251

Dynamical properties of cubic and hexagonal silicon carbide from Si-rich to C-rich reconstructions up to graphene formation — •Juergen A. Schaefer and Roland J. Koch — Institut für Physik and Institut für Mikro- und Nanotechnologien, Technische Universität Ilmenau, P. O. Box 100565, 98684 Ilmenau, Germany

Using high resolution electron energy loss spectroscopy (HREELS) in conjunction with low energy electron diffraction (LEED) and X-ray induced photoelectron spectroscopy (XPS), we have studied the vibrational properties of cubic SiC (001) and hexagonal SiC (0001) surface reconstructions from Si-rich to C-rich SiC surfaces, and up to graphene formation in the hexagonal case. Upon subsequential annealing from 30 K up to 1500 K, the coupling between the longitudinal optical phonons, the so called Fuchs-Kliewer phonons, and the carrier plasmons that originate from the presence of bulk dopants and / or from the layered semimetallic character of graphene and few layer graphene (FLG), drastically influence the HREELS-spectra. It seems that the latter graphitic layer is essentially unperturbed by the substrate underneath. The measured phonon dispersion strongly resembles that of graphite.

O 15.5 Mon 16:15 SCH 251

Graphene nanomembranes excited by ac voltages of an STM — •Torge Mashoff[1], Viktor Geringer[1], Tim Echtermeyer[2], Max Lemme[2], Marcus Liebmann[1], Marco Pratzer[1], and Markus Morgenstern[1] — [1]II. Institute of Physics, RWTH-Aachen University and JARA-FIT, 52074 Aachen — [2]Advanced Microelectronic Center Aachen (AMICA), AMO GmbH, 52074 Aachen

We investigate graphene monolayers deposited on a SiO_2 surface using scanning tunneling microscopy (STM) at ultra-high vacuum and temperatures of 5 K. Depending on the tunneling-voltage it is possible to lift nanometer-sized areas of the partly freely suspended flake by a few 100 pm while still achieving stable STM-measurements. From I(U) and I(z)-spectroscopy data we determine mechanical properties of the nanomembrane such as pretension and Young's modulus using a model of a parallel-plate capacitor and a clamped circular membrane. These data are in good agreement with previous measurements using atomic force microscopy. Application of an ac voltage leads to oscillations of the nanomembrane which are detected by strongly nonlinear in-phase current oscillations.