HL 29: 2D Materials: Graphene

Time: Thursday 9:30–11:00 Location: H36

HL 29.1 Thu 9:30 H36

Twist angle engineering of proximity exchange in graphene/$Cr_2Ge_2Te_6$ bilayers — •Klaus Zollner and Jaroslav Fabian — Institute for Theoretical Physics, University of Regensburg, 93053 Regensburg, Germany

Van der Waals heterostructures composed of twisted monolayers promise great tunability of electronic, optical, and magnetic properties. The most prominent example is twisted bilayer graphene, exhibiting magnetism and superconductivity due to strong correlations [1]. In addition, twistronics has already demonstrated its potential in tuning proximity spin-orbit coupling in graphene/TMDC heterostructures [2]. In this talk, we present the twist-angle and gate dependence of the proximity exchange coupling in graphene/$Cr_2Ge_2Te_6$ bilayers from first principles [3]. The proximitized Dirac band dispersions of graphene show a continuous tunability of the ferromagnetic exchange from 4 to −4 meV, when twisting from 0° to 30°. Remarkably, at 19.1° the induced exchange coupling becomes even antiferromagnetic. Further tuning is provided by a transverse electric field and the interlayer distance.

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[1] X. Lu *et al.*, Nature 574, 653 (2019). [2] T. Naimer *et al.*, Phys. Rev. B 104, 195156 (2021). [3] K. Zollner and J. Fabian, arXiv:2108.03984 (2021).

HL 29.2 Thu 9:45 H36

Direct observation of ultraclean tunable band gaps in bilayer graphene — •Eike Thomas Icking[1,2], Luca Banszerus[1,2], Philipp Schmidt[1,2], Corinne Steiner[1,2], Frederike Wörtche[1], Frank Volmer[1], Stephan Engels[1,2], Jonas Hesselmann[1], Matthias Goldsche[1,2], Kenji Watanabe[3], Takashi Taniguchi[4], Christian Volk[1,2], Bernd Beschoten[1], and Christoph Stampfer[1,2] — [1]RWTH Aachen University, Germany — [2]Forschungszentrum Jülich, Germany — [3]Research Center for Functional Material, Japan — [4]International Center for Materials Nanoarchitectonics, Japan

Control over the charge carrier density and the band gap size of a semiconductor paves the way for a wide range of applications, such as highly-tunable transistors, photodetectors, and lasers. Bernal-stacked bilayer graphene (BLG) allows tuning the band gap by an out-of-plane electric displacement field. The first evidence of this unique band gap tunability was found ten years ago, but it took until recently to fabricate sufficiently clean heterostructures to use the band gap to suppress electric current or confine charge carriers. We present a detailed study of the tunable band gap in gated BLG characterized by temperature-activated transport and finite-bias spectroscopy measurements. The latter method allows comparing different gate materials and device technologies that directly affect the effective disorder potential. We show that in graphite-gated BLG there are as good as no sub-gap states resulting in ultraclean band gaps with values in good agreement with theory, allowing to achieve band gaps up to 120 meV.

HL 29.3 Thu 10:00 H36

Domain determination of rhombohedral multilayer graphene devices for magnetotransport measurements — •Christian Eckel, Anna Seiler, Francesca Falorsi, Niklas Kohlrautz, and Thomas Weitz — 1. Physikalische Institut, Universität Göttingen, Friedrich-Hund Platz 1 37077 Göttingen

Graphene as the most prominent example of a 2D-material exhibits relatively different electronic band properties compared to its bulk counterpart. For monolayer, bi-layer or tri-layer the electronic properties have already been explored by multiple groups in the past. However, studies on higher layer number rhombohedral graphene (5 layers in this work) with respect to magnetoelectrical transport measurement are still pending. Finding and determining the rhombohedral domains in mechanically exfoliated flakes is the first bottleneck in the fabrication procedure. Raman spectroscopy is a well-established technique for layer number determination but often lacks a high lateral resolution. Kelvin-probe-force- microscopy (KPFM) allows a lateral resolution of the domains where the different stackings exhibit a distinguishable 15meV work function difference. Additionally, a cryogenic scanning near field optical microscopy (Cryo-SNOM) allows to depict the domains in a temperature dependent manner. The combination of all measurements will be discussed on the poster. A second challenge is the fabrication process of high quality devices for magnetotransport measurements in the milli Kelvin regime. Therefore, encapsulation in hexagonal Boron Nitride (hBN) together with graphite contacts and gates are necessary.

HL 29.4 Thu 10:15 H36

All-optical modulation of third harmonic generation in graphene — •Omid Ghaebi[1], Sebastian Klimmer[1], Habib Rostami[2], and Giancarlo Soavi[1] — [1]Institute of Solid-State Physics, Friedrich Schiller University, Jena, Germany — [2]Nordita, KTH Royal Institute of Technology and Stockholm University, Sweden

Graphene is a unique platform for non-linear optics thanks to its linear band dispersion that allows gate tunable resonant light-matter interactions [1]. While the gate tunability of THG have been investigated in recent years [1], less is known about the possibility to realize all-optical nonlinear modulators, which could provide higher modulation speed (THz) compared to electrical modulators (GHz) [2]. In this work, we show all-optical TH modulation in graphene at different values of the Fermi level and with a modulation depth up to 85%. First, we demonstrate that it is possible to actively control the THG recombination dynamics by tuning the graphene Fermi level. This is due to phase-space filling and quenching of the scattering between hot electrons and optical phonons [3]. In addition, we reveal the interplay between TH modulation due to increase in the electronic temperature and due to Pauli blocking at different values of the Fermi level. This work offers new insights for the understanding of TH all-optical modulation and thus for the realization of ultrafast frequency converters and nonlinear modulators. [1] Soavi, G. et al. Nature Nanotechnology 13, 583-588 (2018). [2] Cheng, Y. et al. Nano Letters 20, 8053-8058 (2020). [3] Pogna, E. A. et al. ACS Nano 15, 11285-11295 (2021).

HL 29.5 Thu 10:30 H36

Anisotropic transport in 1D graphene superlattices — •Julia Amann[1], Kenji Watanabe[2], Takashi Taniguchi[2], Dieter Weiss[1], and Jonathan Eroms[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Regensburg, Germany — [2]National Institute for Materials Science, Tsukuba, Japan

One-dimensional superlattices (1DSL) in graphene were predicted to show intriguing effects, such as anisotropy in transport, additional Dirac points and a distorted Fermi contour. In contrast to two-dimensional graphene superlattices, which have been widely studied, only very few experiments on graphene 1DSLs have been reported. We use a patterned few-layer graphene gate underneath an encapsulated monolayer graphene to create a 1DSL. With the combined action of a global silicon backgate and the patterned bottom gate we are able to control superlattice potential strength and charge carrier density independently. We show low temperature transport measurements on a gate tunable 1DSL in graphene with a period of 50 nm in directions parallel and perpendicular to the modulation as we use an L-shaped Hall bar. The typical Dirac cone shape gets distorted, and we observe anisotropic transport in x and y direction. We observe the emergence of multiple Dirac points in modulation direction due to band flattening with increasing superlattice potential. These extra Dirac points are represented as additional Landau fans in magnetotransport. Further, Weiss oscillations can be observed which confirm the 1D superlatice modulation and the anisotropy.

HL 29.6 Thu 10:45 H36

Topological Phenomena in Self Assembled Folded Graphene — •Lina Bockhorn[1], Sung Ju Hong[2], Bei Zheng[1], Johannes C. Rode[1], and Rolf J. Haug[1] — [1]Institut für Festkörperphysik, Leibniz Universität Hannover, 30167 Hannover, Germany — [2]Division of Science Education, Kangwon National University, Chuncheon, 24341, Republic of Korea

The stacking- and folding angle of 2D materials to 3D structures has emerged as an important, novel tuning parameter for the tailoring of optical, mechanical, electronic and magnetic properties. Here, we investigate the final interlayer configurations of self-assembled folded graphene structures generated via atomic force microscopy technique [1, 2] and its electronic properties [3, 4].

Self-assembled folded graphene shows not only the typical electronic properties of twisted graphene layers but also phenomena due to the folded region [3, 4]. In our magnetotransport measurements, we observe e.g. an additional peak next to the charge neutrality peak which is independent of the magnetic field. This peak at a certain charge carrier density is attributed to the compressive strain due the folded edge [3].

[1] J. C. Rode et al., 2D Mater. 6, 015021 (2018)
[2] L. Bockhorn et al., Appl. Phys. Lett. 118, 173101 (2021)
[3] S. J. Hong et al., 2D Materials, 8, 045009 (2021)
[4] S . J. Hong et al., Phys. Rev . B, 105, 205404 (2022)