Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

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Masterarbeit:

Optical Characterization of Bilayer Graphene Bandgaps

Motivation: Bilayer graphene has the property that an electric field perpendicular to the surface opens a bandgap of up to 150 meV in the material, allowing it to be continuously switched between metallic and semiconducting behavior. Local gates can therefore be used to create functional structures. This is traditionally investigated using transport measurements, which however lack spatial resolution. Here, optical methods shall be used to measure the bandgap as well as other electronic properties in bilayer graphene. The approach is based on placing a layer of a two-dimensional semiconductor (WSe_2) near the graphene. Excitons in WSe_2 are charge carrier pairs bound by Coulomb interaction. Their binding energy responds sensitively to changes in dielectric screening by neighboring materials. Gating of bilayer graphene leads to different electronic densities of states and thus to altered screening properties. The method therefore promises to investigate changes in the low-energy structure at the metal-insulator transition using optical methods with spatial resolution.

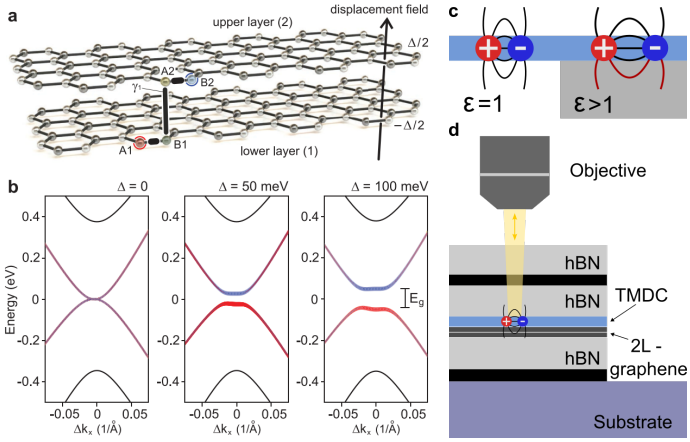

***Figure 1**: a) Crystal structure of bilayer graphene and b) the electronic structure at three different external electric fields. c) In an environment with higher dielectric function, the Coulomb interactions of excitons (electron-hole pairs) in WSe_2 are more strongly screened, leading to lower binding energies. d) This can be read out using optical methods. WSe_2 therefore serves as a sensor of the electronic structure in graphene.*

Goal of the work: The goal of this work is to measure the electronic properties of bilayer graphene using optical methods.

Your task: Your task includes the fabrication of samples through exfoliation of 2D crystals as well as optical measurements of the resulting structures. Sample fabrication will be carried out in a glovebox in our laboratories, where you will have access to a transfer system as well as an automated flake search system. A fully equipped laser laboratory is available for optical measurements. You can also expand your knowledge in the following topics:

- Optical spectroscopic and electrical transport measurement techniques
- Operation and understanding of vacuum and low-temperature setups (~5 K)
- Physics of electronic band structures, phase transitions, excitonic states, and 2D materials
- Sample fabrication through stacking, e-beam lithography, etching, and metal deposition

Furthermore, you will participate in group seminars and journal clubs to discuss current developments in this research field.

Contact: For further information and interest in the project, please contact David Tebbe (david.tebbe@rwth-aachen.de) or Bernd Beschoten (bernd.beschoten@physik.rwth-aachen.de). More information about our work can also be found at www.stampferlab.org.