Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

Bachelor Thesis:
Fabrication of nanostructured graphite gating for van der Waals heterostructures

Motivation: In recent years, various quantum devices have been realised in bilayer graphene (BLG) heterostructures, including quantum point contacts (QPCs), quantum dots (QDs), and quantum interferometers. In most cases, the necessary gates were fabricated using conventional semiconductor fabrication techniques, like resist-based lithography, metal evaporation, and atomic layer deposition. We know that such gates lead to imperfect interfaces at a scale that affects device performance.

Alternatively, one could realise such gates using only van der Waals materials such as hexagonal boron nitride as a dielectric and graphite as a gating material. Using atomic force microscopy (AFM) based electrode-free local anodic oxidation (EFLAO), the graphite gate can be structured without traditional lithographic techniques, thereby avoiding wet-chemical steps that could introduce unwanted residues. This would lead to significantly cleaner devices, allowing us to probe physics masked by the disorder in current systems.

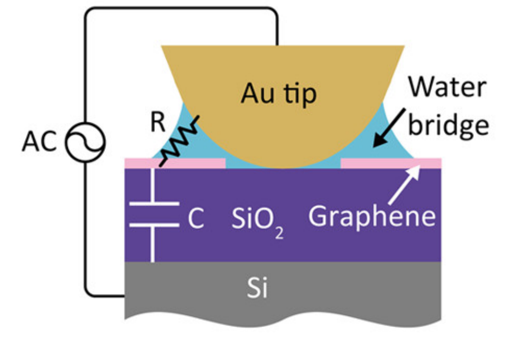
Aim of the thesis: You would focus on the fabrication of nanostructured graphite-gates integrated in van der Waals heterostructures, with the goal of fabricating a BLG-QD device with either one or both layers of gates substituted with graphitic gates.

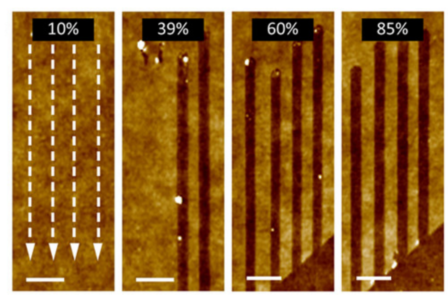
Your tasks: You will contribute to fabricating bilayer graphene quantum dot devices. The fabrication process includes working in a cleanroom environment, characterizing samples using techniques such as Raman spectroscopy and AFM, and designing gate layouts.

You will gain experience in the following topics:

- Quantum dot physics, 2D materials, and electronic transport experiments
- Fabrication of state-of-the-art quantum devices
    - Clean room experience
    - Spectroscopy and Microscopy tools, like Raman microscopy and advanced atomic force microscopy techniques
    - Working in a glovebox environment
- Data evaluation with *Python*

Furthermore, you participate in group seminars and journal clubs where you follow current developments in this field of research and discuss recent experiments.





Upper image:
sketch of the principle behind EFLAO. A thin metal tip is brought into contact with the sample, thereby forming a water meniscus between sample and tip. By applying an AC voltage between the tip and the sample, electrolysis is performed locally, leading to the oxidation of the nearby graphite.

Lower image:
Example of simple line cuts through the graphite

Li, H. et al. (2018), "Electrode-Free Anodic Oxidation Nanolithography of Low-Dimensional Materials", Nano Lett. 2018, 18, 12, 8011–8015

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