Aachen Graphene & 2D Materials Center

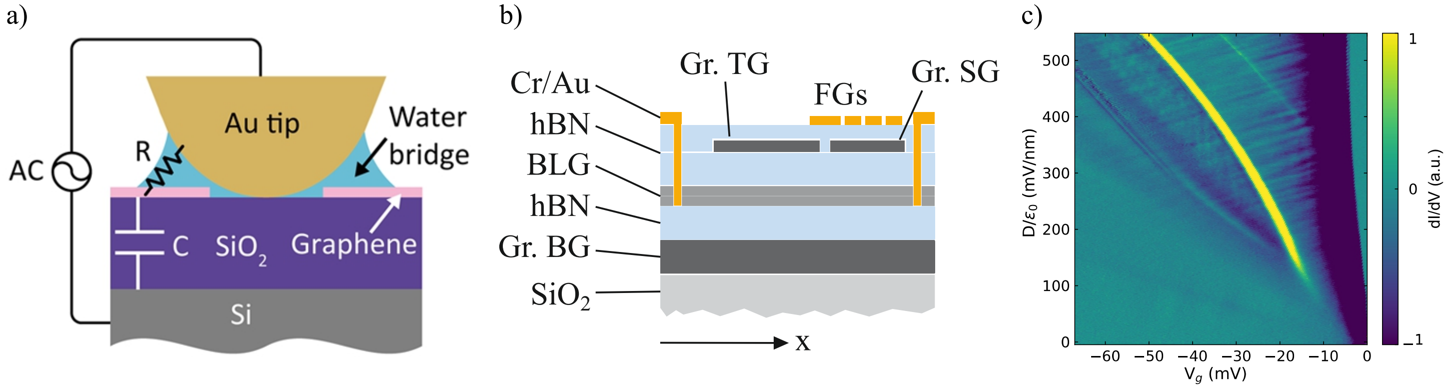
2D Materials and Quantum Device Group

RWTH AACHEN UNIVERSITY

Master Thesis:

Investigating the magnetic ground state in Bernal bilayer graphene using quantum dots

Motivation: Bernal bilayer graphene (BLG) is a fascinating and multifaceted material. Its electrostatically tunable band-gap allows for the realization of complex nanostructures, such as quantum point contact and quantum dots [1].
While measurements of clean heterostructures of BLG, foregoing confinement by lithographically defined metal gates in favor of graphitic gates, reveal a complex phase diagram of magnetic phases and even superconducting behavior [2].
We aim to combine these approaches utilizing electrode free local oxidation (EFLAO) [3] to pre-etch gates in order to preserve the necessary high devices quality while still allowing for confinement of charge carriers in the same heterostructure.



a) Schematic showing the working principle of EFLAO, using an AC-field between a sharp AFM tip and the substrate to oxidize the graphene below the tip. Taken from [3] b) Schematic sideview of the device. The Gr. TG allows to access and tune the magnetic phases and the Gr. SGs allow for the confinement of charge carriers in close proximity. c) Displacement field vs effective gate voltage phase diagram of BLG. Sharp increases and decreases in differential current indicate phase transitions.

Aim of this thesis: The aim of this thesis is the utilization of a quantum dot as a novel readout mechanism and spin-valley filter for a BLG structure exhibiting intrinsically magnetic behavior.
As well as using the magnetic phases as an in-situ spin-valley polarized reservoir for the quantum dot.
Providing new insights into the magnetic ground state of BLG.

Your tasks: You will be involved in the fabrication process, beginning with the exfoliation of 2D materials, and proceeding to assemble the heterostructure. You will then characterize the finished stacks and carry out further processing using advanced fabrication techniques, including electron-beam lithography, reactive ion etching, local anodic oxidation, and metal evaporation. Lastly, you will participate in measurements conducted at cryogenic temperatures as low as 20 mK and analyze the resulting data.

You will gain experience in the following topics:

- Quantum physics, 2D materials, transport and optical measurements
- Fabrication of state-of-the-art quantum devices
- Performing measurements in a dilution refrigerator
- Data evaluation using a preferred programming language (e.g., Python).

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

Contact: For further information, please contact David Emmerich (david.emmerich@rwth-aachen.de).
More information about our work can be found at stampferlab.org and www.graphene.ac.

[1] L. Banszerus, Dissertation, „ Gate-defined quantum dots in bilayer graphene“, (2022), 10.18154/RWTH-2022-08912
[2] Zhou et al., Science, „Isospin magnetism and spin-polarized superconductivity in Bernal bilayer graphene“, (2022), 10.1126/science.abm8386
[3] Li et al., Nano Lett., „Electrode-Free Anodic Oxidation Nanolithography of Low-Dimensional Materials“, (2018), 10.1021/acs.nanolett.8b04166