Aachen Graphene & 2D Materials Center

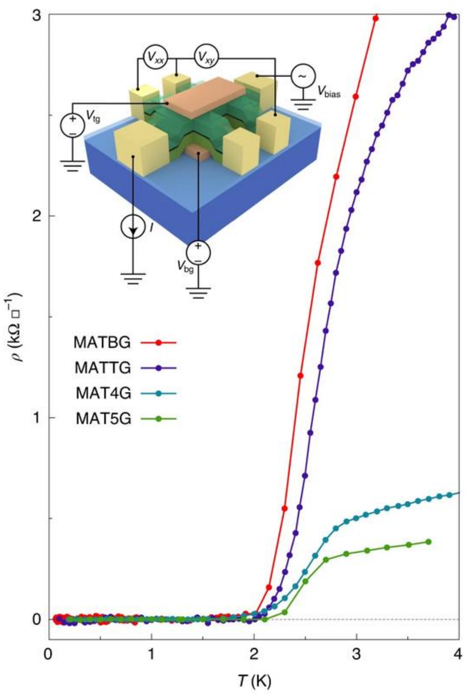
2D Materials and Quantum Device Group

RWTH AACHEN UNIVERSITY

Master Thesis:

Fabrication and characterization of magic-angle twisted decalayer graphene

Are you fascinated by cutting-edge quantum physics and eager to explore the extraordinary properties of 2D materials? Join us for your MSc thesis and delve into the world of magic-angle twisted multilayer graphene—a rapidly evolving field with exciting prospects for groundbreaking discoveries.



Resistivity versus temperature for magic-angle multilayer graphene up to 5 layers thick. From Ref. [1].

Motivation: In moiré materials, stacking 2D layers at a slight relative angle creates unique electronic properties. For graphene, near the *magic angle*, interlayer coupling and a larger unit cell produce extremely flat electronic bands. These bands give rise to exotic phenomena like correlated insulators, ferromagnetism, quantum anomalous Hall effects, and even superconductivity.
Although robust superconductivity has been observed in twisted graphene systems with up to 5 layers, exploring thicker stacks (6–10 layers) remains a challenging frontier. This project offers a chance to pioneer the fabrication and investigation of these advanced quantum systems.

Aim of this thesis: You will work on creating and studying magic-angle multilayer graphene devices (6–10 layers). Your objectives include:

- Employ state-of-the-art nanofabrication techniques to produce high-quality, large-area single-layer graphene sheets from natural graphite and assemble them into twisted multilayer devices.
- Conduct electronic transport measurements at ultralow temperatures and in strong magnetic fields, aiming to uncover whether superconductivity can persist in these thicker stacks.
- Study how parameters like the number of layers, applied electric fields, and magnetic fields influence the electronic band structure and topology.

What will you gain? This thesis offers the chance to work at the forefront of condensed matter physics and quantum materials, with access to cutting-edge experimental techniques. You will be part of a dynamic and collaborative research environment, where you will make meaningful contributions to an exciting and fast-evolving field of study.
Specifically, you will develop expertise in:

- Advanced **nanofabrication** techniques for quantum devices.
- Cutting-edge **cryogenic transport experiments**.
- Theoretical and experimental insights into **quantum effects**, **topological physics**, and **strongly correlated electron systems**.

In addition, you will participate in group seminars and journal clubs, keeping up with the latest developments in the field of two-dimensional materials.

Contact us: For further information contact Dr. Robin Dolleman (dolleman@physik.rwth-aachen.de). More information about our work you can find at www.stampferlab.org and www.graphene.ac.

References

[1] Park, J.M., *et al. Nat. Mater.* **21**, 877–883 (2022). https://doi.org/10.1038/s41563-022-01287-1