Aachen Graphene & 2D Materials Center

2D Materials and Quantum Device Group | RWTH AACHEN UNIVERSITY

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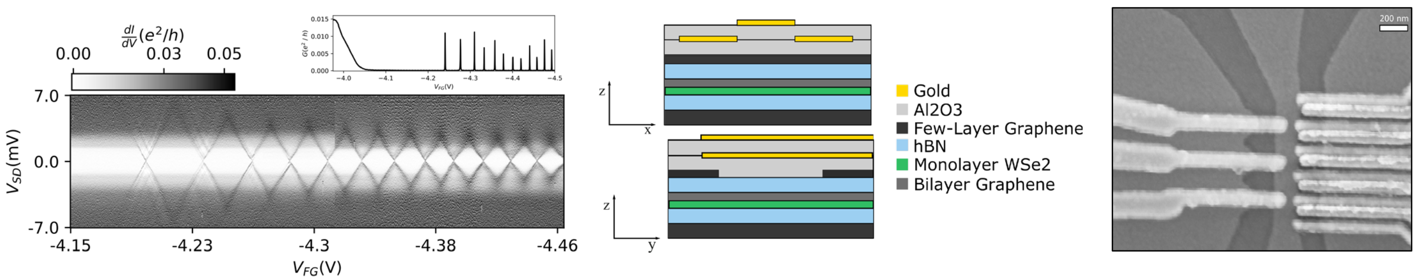
Master Thesis:

Electrostatically defined double quantum dots in bilayer graphene/WSe_2 heterostructures

Motivation: The rapidly advancing field of two-dimensional materials has opened up new opportunities for exploring unique electronic and quantum phenomena. Bilayer graphene, with its intriguing band structure and tunable band gap, combined with transition metal dichalcogenides (TMDs) like WSe_2, which possess strong spin-orbit coupling and strong light-matter interactions, forms an exciting heterostructure. This heterostructure exhibits layer selective proximity enhanced spin-orbit coupling, holding promising prospects for various quantum computing applications, for example, as a platform for spin-valley qubits.

a) b) c)



a) Transport measurement of a single quantum dot in the Coulomb blockade regime showing Coulomb resonances up to the first twelve charge carriers. b) Sketch of the schematic cross-section of the heterostructure. A split gate structure will be used to define a conducting channel on top of which two finger gate layers will be used to locally deplete and invert the polarity of the channel to define the double quantum dot and tune its occupation and energy levels. c) Scanning electron microscope image of an exemplary two-finger gate layer design.

Aim of this thesis: *The goal of your thesis will be to investigate the transport properties of bilayer graphene/WSe_2 heterostructures to gain insight into the energy spectrum and the influence of proximity-induced spin-orbit coupling on the energy spectrum of a double quantum dot, pathing the way for future qubit operation in similar systems.*

Your tasks: In a clean-room environment, you will fabricate bilayer graphene/WSe_2 heterostructures using exfoliation and dry transfer techniques. You will then process those heterostructures using state-of-the-art semiconductor manufacturing techniques like electron-beam lithography, metal evaporation, and atomic layer deposition/etching. Further, you will perform electronic transport measurements insight cryogenic environments down to 20 mK and evaluate the obtained data with a programming language of your choice.

You will gain experience in the following topics:

- Quantum physics, electronic transport, quantum dots, 2D-materials
- 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 Hubert Dulisch (hubert.dulisch@rwth-aachen.de).
More information about our work can be found at stampferlab.org and www.graphene.ac