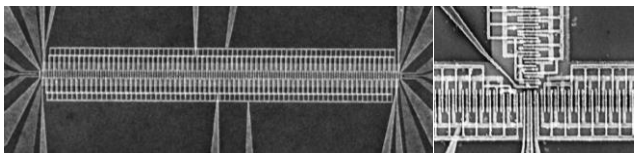


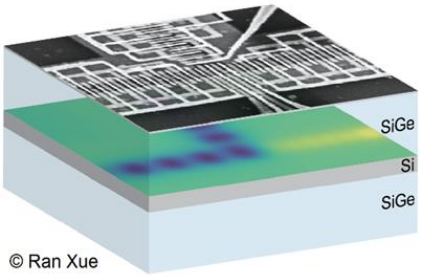
Quantum Technology Group

RWTH AACHEN UNIVERSITY

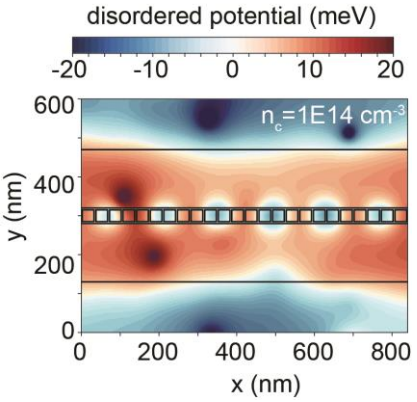
Impacts of charged defects on T-junction shuttling devices in Si/SiGe

Bachelor's project starting 2023

Scientific background In order to implement quantum error correction, a physical qubit is required to interact with four adjacent ancillary qubits. Hence, we need a 2D transport network for spin qubits made from qubit shuttles. A **T-Junction** acting as an intersection between two linear shuttle routes single electron spin qubits through a 2D matrix of qubits. Ideally, a qubit is shuttled along each direction and transferred between intersecting channels by moving potential minima adiabatically with high fidelity [1]. However, either charge defects introduced by imperfect oxides during fabrication or those intrinsically located defects in Si/SiGe heterostructure will scatter the shuttled electron and have an impact on the shuttle fidelity of spin qubit [2].



Research goal By including charge defects as potential disorder, you will electrostatically model in COMSOL physics their impact on the moving potential in a T-junction. There, the single electron representing the spin qubit gets trapped/repelled by the impurities. You optimize the geometry of the T-junction and explore a proper set of voltages to shuttle an electron around the T-junction in the presence of charge defects. It is of interest to investigate the dynamic of electron during aforementioned process by employing the adiabatic theorem to complement the physics picture and to suggest criteria of shuttling single electron across the T-junction with 99.9% fidelity.



Top: Schematic of T-junction. Metallic top-gates (yellow) defined quantum dots in the Si/SiGe two dimensional electron gas (2DEG). Bottom: Impacts of charge impurities on electric fields that sees by 2DEG in a linear conveyor.

Your task You will learn about the concept of conveyor-mode shuttling of spin. You will gain experience in

- Spin quantum computation.
- Finite-element simulations using COMSOL physics.
- Numerical solution of Schrödinger equation in python/matlab.

Furthermore, you will attend group seminars and journal clubs to learn about new developments in quantum computing.

[1] I. Seidler *et al.*, Conveyor-mode single-electron shuttling in Si/SiGe for a scalable quantum computing architecture. *npj Quantum Inf.* **8**, 100 (2022).

[2] V. Langrock *et al.*, Blueprint of a scalable spin qubit shuttle device for coherent mid-range qubit transfer in disordered Si/SiGe/SiO2, arXiv :2202.11793.

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