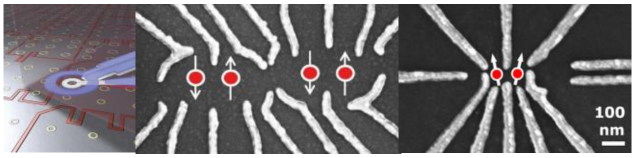
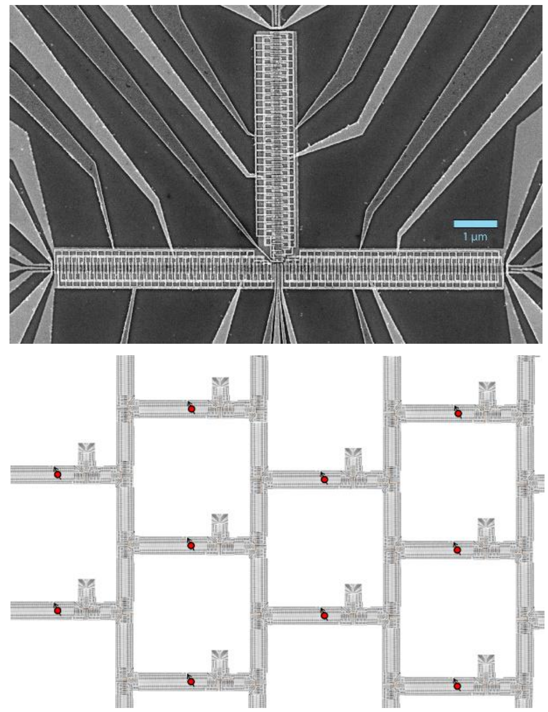


High level simulation of a QuBus-based architecture for quantum computation

Master's project starting 2023

Scientific background

Semiconductor spin qubits are one of the most promising building blocks for quantum computing devices. Nevertheless, the complexity of semiconductor spin qubits is a major obstacle towards the realization of large-scale devices. To overcome this problem, we have developed a conveyor-based architecture, where the quantum information is encoded in the spin of an electron that is shuttled around through conveyor-like structures (QuBus). We have successfully modeled and fabricated some of the most basic components for this architecture. Now we need to put all these elements together and study the dynamics of a larger-scale system. This architecture consists of the QuBus—the elements that move the electrons around—, the T-junctions—which couples three QuBus together—, and a manipulation/read-out area, where single- and two-qubit gates can be implemented and the state of the qubit can be measured



Top: Three QuBus devices joint together in a T-junction. Bottom: Full architecture with the multiple QuBus, T-junctions and manipulation/read-out areas. The system may contain several qubits (electrons, in red).

Research goal

We will study the dynamics of the electrons in this system as a concatenation of quantum processes. Each of the sub-processes (shuttling, T-junction, single-electron manipulation, two-electron interaction, measurement) have already been studied in detail, and we will use the coherence time, operation time and fidelities that we have previously obtained for each of these processes to simulate the full architecture. The goal of the project is not only to create a digital twin of the device that we are fabricating, but also to find efficient ways to perform one and two-qubit gates, given the constraints of the system and the architecture (coherence times of different processes, target fidelities, etc.)

Your task

For each process (shuttling of an electron, electron-electron interaction, etc.), you will identify a quantum mechanical discrete operator. With these operators you will derive a scheme for the concatenation of quantum processes. You will also investigate optimal operation protocols and run simulations to obtain coherence times and fidelities.

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

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