Quantum Science and Technology based on Semiconductor Nanowires

Growth of Semiconductor Nanowires

Motion of electrons can influence their spins through a fundamental effect called spin-orbit interaction. This interaction provides a way to control spins electrically and thus lies at the foundation of spintronics. Even at the level of single electrons, the spin-orbit interaction has proven promising for coherent spin rotations. Here we implement a spin-orbit quantum bit (qubit) in a nanoscale ensemble nanowire, where the spin-orbit interaction is so strong that spin and motion can no longer be separated. In this regime, we realize fast qubit rotations and universal single-qubit control using only electric fields; the qubits are hosted in single nanowires that are individually addressable. We enhance coherence by dynamically decoupling the qubits from the environment. Nanowires offer various advantages for quantum computing: they can serve as one-dimensional templates for scalable qubit registers, and it is possible to vary the material even during wire growth. Such flexibility can be used to design wires with suppressed decoherence and to push semiconductor qubit coherence times achieved here are sufficient with optical dots in p-doped InSb. Furthermore, electrical dots can be integrated with optical dots in p-n junction nanowires. The coherence times achieved here are sufficient for the conversion of an electronic qubit into a photon, which can serve as a flying qubit for long-distance quantum communication.

Research: Spin-orbit qubit in a nanowire (Nature 2010)

Spin-orbit qubit is a quantum yo-yo: spin rotates when electron is moved back and forth. Here we implement a spin-orbit qubit in an indium arsenide nanowire, where the spin-orbit interaction has proven promising for coherent spin rotations. The chips are cooled down in order to reach temperatures as low as a few millikelvins. They operate by circulating He3 gas in a closed loop. The cooling occurs in the mixing chamber where He3 is diluted in He4. Dilution refrigerators help reach temperatures as low as few millikelvins. They operate by circulating He3 gas in a closed loop. The mixing chamber where He3 is diluted in He4.

Quantum Transport Measurements

Ultra-Low Temperatures

Nanoscale devices fabricated in the cleanroom are wirebonded to gold chip bonded chip and loaded into a dilution fridge. The chips are cooled down in order to allow for low-energy quantum effects to manifest themselves and not be masked by thermal broadening. Measurements are often performed at high magnetic fields (several Tesla) created by superconducting magnets.