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Fabrication and Characterization of Ge/Si Core/Shell Nanowire Based Devices Towards a Hole Spin Qubit

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Ge/Si core/shell structured nanowires have been suggested as a promising candidate to form good spin qubits. The hole gas accumulates naturally in the Ge core due to the large valence band offset between the two constituents[1] thus avoiding the requirement to intentionally implant impurity dopants as in conventional semiconductors. Moreover, the lack of nuclear spin of group-Ⅳ material and the predicted strong spin-orbit interaction[2] (SOI) in such core/shell heterostructures may ensure long spin coherence times[3] and fast operation by the electrical field respectively. We endeavor to eventually realize the spin operation and the entanglement between distant spin qubits *via* cavity quantum electrodynamics (CQED). Prior to this ultimate goal we aim to elucidate the magnitude of the SOI in the Ge/Si nanowire and the dependence of SOI on the external electric field. The SOI can be extracted either by studying the weak-antilocaliztion (WAL) effect in an open-wire regime or by realizing electrically driven spin resonance (EDSR) in double quantum dots. Upon controlled surface etching and rapid thermal annealing, electrically transparent metal contacts are made along Ge/Si nanowires, and the expected p-type transport behavior is observed, Fig. 1(b). The magnetoconductance is investigated on open wire junctions, which shows a pronounced decrease of conductance with the increasing magnetic field, indicating the significant WAL effect due to the presence of SOI, Fig. 1(c). This result will be crosschecked with future EDSR experiments.

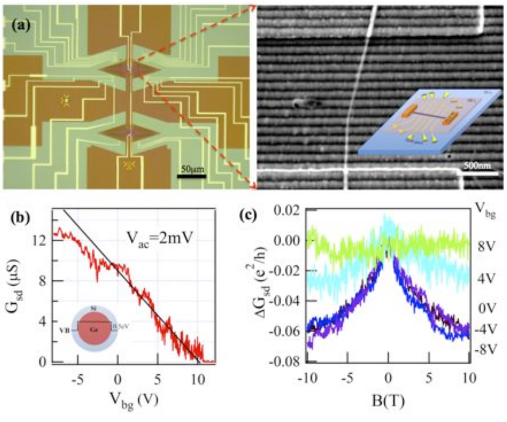

Figure 1 (a) Optical image and high resolution scanning electron micrograph of a typical Ge/Si nanowire device on predefined fine local gates. The junction behaves either as an open-wire or isolated quantum dots depending on the applied gate voltage. (b) Transport behavior of a Ge/Si transistor. (c) Magnetoconductance of a Ge/Si transistor as a function of magnetic field for various back-gate voltages.

References

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