Single-electron-shuttling in Si/SiGe

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Abstract

The electron-spin in gate-defined quantum dots in a Si/SiGe heterostructure is one of the most promising qubits for scalable quantum computing. A quantum processor with sparse qubit array has been proposed exploiting an electron shuttling concept across a distance of 10 µm [1]. Here we study the feasibility of single electron shuttling by forming a propagating sinusoidal potential in a gate-defined 1-dimensional channel, namely the conveyor mode shuttling. A 99.42 ± 0.02% high single-electron shuttle fidelity over a distance of 420 nm has been demonstrated in our recent research. [2] Additionally, conveyor mode shuttling for longer distance is under investigation by using of the device depicted in Figure 1a. Only 4 signal lines are physically connected to four terminals of the 10 µm shuttle (Fig. 1b), therefore, no additional scalability complexity regarding signal generation and wiring is expected. It provides adiabatic movement of a quantum dot filled by a single electron representing the qubit (Fig. 1c). According to our theory studies on qubit decoherence mechanisms, the conveyor mode shuttling across 10 µm with high shuttling fidelity is feasible in our shuttle device. [3] Our concept is compatible with established gating technology and can be readily transferred to industrial CMOS fabrication lines.

References

[1] Boter, J. et al., arXiv:2110.00189v1 (2021)
[2] Seidler, I. et al, arXiv:2108.00879 (2021)
[3] Langrock, V. et al., arXiv: 2202.11793 (2022)

Figures

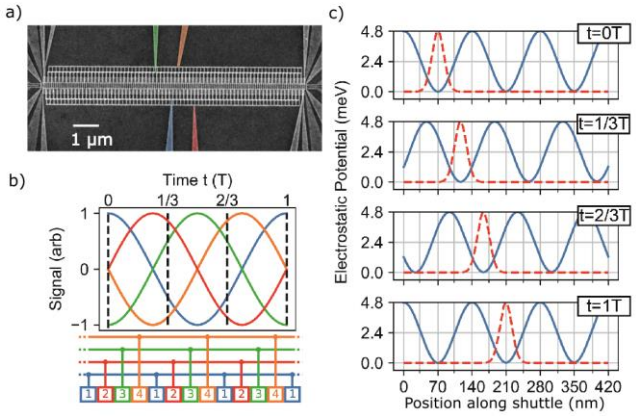

Figure 1: SiGe shuttle device for conveyor mode shuttling: a) A scanning electron micro-graph of the measured device. b) 4 sine waves with π/2 phase among each other are applied to the coloured terminals in panel a to form a propagating sinusoidal potential for conveyor mode shuttling. c) The single electron shuttling over 1 period (T), when the ground state of electron (red dashed line) is adiabatically shuttled forwards due to the confinement of electric potential (blue solid line).