Study of the effective mass dependent charge qubit performance in voltage-tunable double quantum dot channel nanowire FETs

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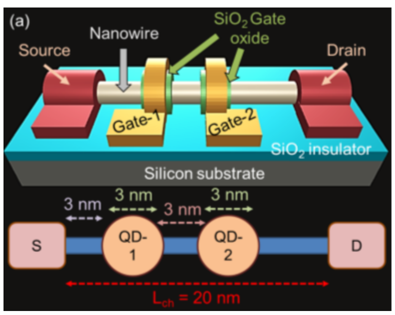
Abstract:

Charge qubits in a double quantum dot (DQD) architecture [1] are attractive for quantum computers with simple operation [2] and potential compatibility with the existing CMOS technologies. However, short dephasing times (~1-10 ns) [3] and ~mK operational temperatures challenge such qubit operation. Therefore, exploration of novel device schemes in the existing state-of-the-art CMOS architectures [4-5] is the need of the hour. Recently, a GaAs nanowire FET, with two separated gates (Fig. 1(a)), has been proposed for charge qubit operation at room temperature [6] and the scheme shown in Fig. 1(b). The current work theoretically studies the effective mass dependent performance of such qubit device in terms of Bloch sphere coverage, charge stability and dephasing times by employing the NEGF approach for transport modeling. Increasing effective mass in the transport direction (m_z^*) from 0.04 to 0.1 increases dephasing time from ~40 ns to 120 ns (Fig. 2(a)), whereas it degrades anticrossing energy from ~20 meV to ~5 meV (Fig. 2(b)), in line with experimental reports [7]. The Bloch sphere coverage and charge stability diagrams are depicted in Fig. 3(a)–(d) and (e)–(h), respectively.



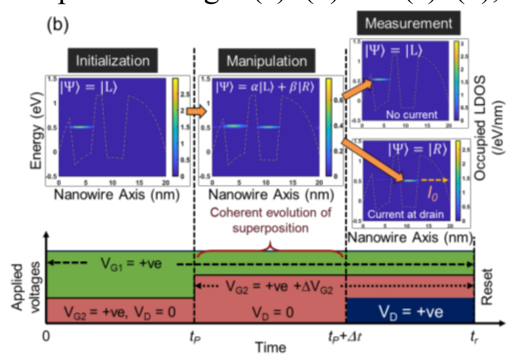


Fig. 1(a) Schematic of the charge qubit device; **(b)** Scheme of charge qubit operation.

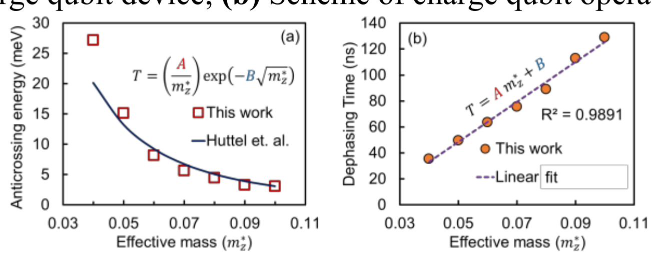


Fig. 2 Change in **(a)** anticrossing energy; **(b)** Dephasing time for the change in m_z^* from 0.04m₀ to 0.10m₀.

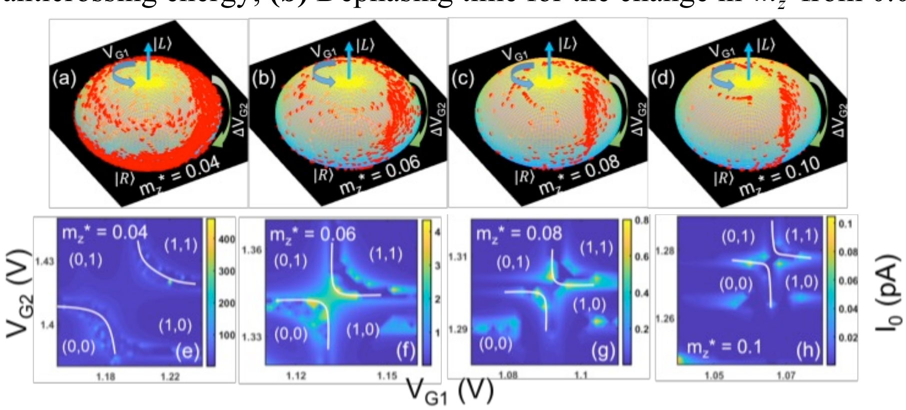


Fig. 3(a) – (d) Bloch sphere coverage; **(e) – (h)** Charge stability diagrams for m_z^* in the range of $0.04m_0$ to $0.10m_0$.

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