Large-scale extraction of quantum dots capacitances from industrial FD-SOI spin-qubits devices

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Significant progress has been achieved in automating the characterization of silicon Quantum Dot (QD) devices. Automated methods are implemented for large-scale characterization [1-3] in order to optimize devices geometry and manufacturing processes. However, the systematic large-scale study of QDs at the single-electron level remains challenging.

Here we introduce a semi-automatic method to characterize the single-electron regime of QDs within FD-SOI split-gate devices at 2K, based on a non-simplified version of the Constant Interaction (CI) model. Numerical resolution of CI model equations allows us to quantify the capacitances of a QD, in particular its mutual couplings with other QDs, and to extract its lever arms and charging energies. This systematic characterization method has enabled us to carry out a large-scale comparative analysis on 300 mm wafers using a cryogenic wafer prober.

Firstly, we compare devices with varying nanowire width and their effects on the mutual coupling between a QD in the few charges regime and its charge detector. Secondly, we demonstrate how backgate bias tuning in FD-SOI devices can be used to systematically improve the mutual coupling (Fig. 1-2), thereby optimizing charge readout.

References

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[3] S. Neyens, et al. Probing single electrons across 300 mm spin qubit wafers (Nature 629, 2024).

Figures

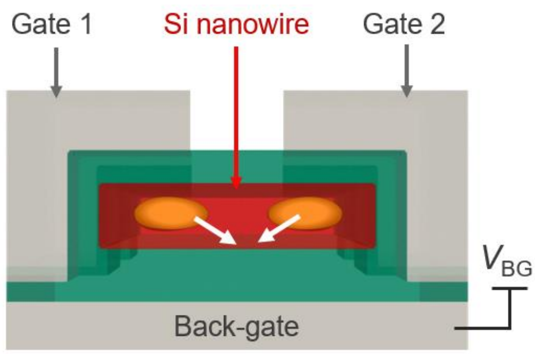

Figure 1: Schematic cross-section of measured devices. White arrows highlight the electrostatic effect of positive backgate polarization on two corner dots (in orange).

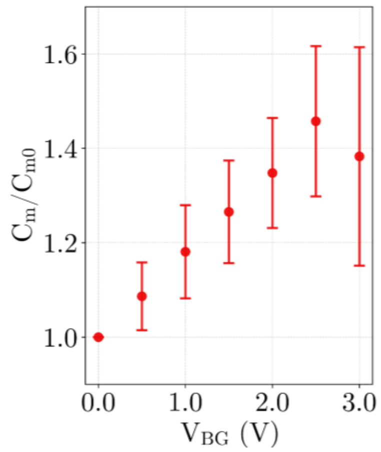

Figure 2: Increased mutual coupling with positive backgate polarization.