Electron and Hole Spin Qubits Variability in Si MOS Devices

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Semiconductor spin qubits may show significant device-to-device variability in the presence of spin-orbit coupling mechanisms. Interface roughness, charge traps, layout or process inhomogeneities indeed shape the real space wave functions, hence the spin properties. It is, therefore, important to understand how reproducible the qubits can be in order to assess strategies to cope with the scattering of their properties. Here we model the variability of Larmor and Rabi frequencies due to disorder at the Si/SiO_2 interface (roughness, charge traps) in metal-oxide-semiconductor devices [1]. We consider both electron qubits (with synthetic spin-orbit coupling fields created by micro-magnets) and hole qubits (with intrinsic spin-orbit coupling). We identify charge traps as the main source of variability, we unravel the microscopic mechanisms responsible for this variability of both electrons and holes, and we analyse the implications of these results for the design of the hosting platform and for the performance of an eventual quantum processor.

References

[1] B. Martinez, Yann-Michel Niquet, Physical Review Applied, 7 (2022) 024022.

Figures

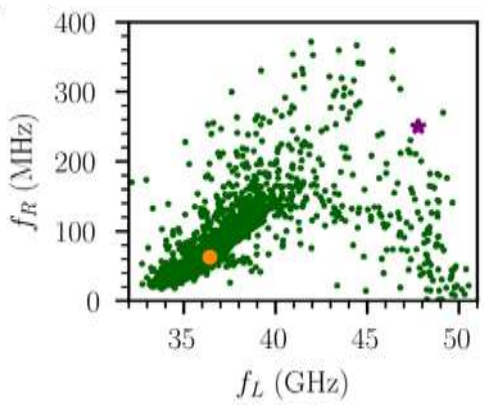

Figure 1: Hole spin qubit Rabi and Larmor frequencies for different random distribution of charge traps with density $n_i = 5 \cdot 10^{10}$ cm^{-2}. Green points show individual simulations, whereas orange point denotes ideal device properties, and purple star highlights the simulation illustrated in Figure 2.

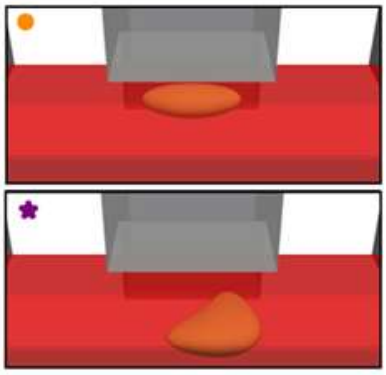

Figure 2: Squared ground state wave function for the ideal device (top panel) and for a sample charge trap distribution (bottom panel).