High density overlapping gate architecture for Si/SiGe quantum dots

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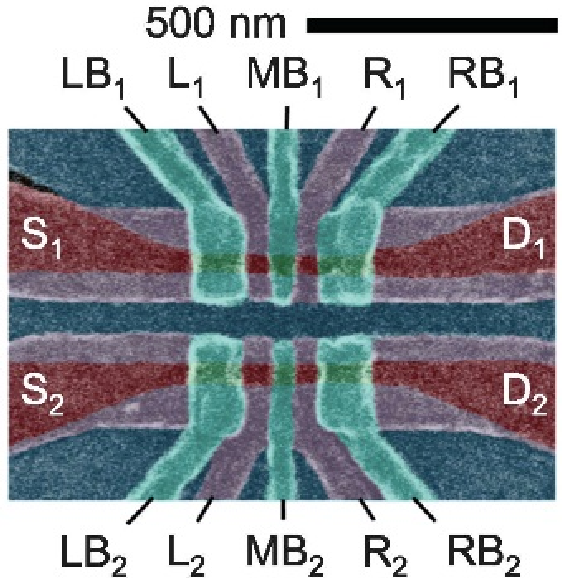
Silicon is a promising host material for long coherence time spin qubits since it lacks piezoelectric electron-phonon coupling, has weak spin-orbit coupling, and its naturally abundant isotope is spin-0. However, Si poses new difficulties for the fabrication of spin qubits due to lower quality heterostructures, higher effective electron mass and the presence valley states. Successfully implementing quantum dot qubits in Si/SiGe heterostructures requires improved gate designs that allow control of single electron wavefunctions. I will describe a device architecture that uses three overlapping Al gate layers to define two parallel transport channels. One of the channels is used to define quantum dots and the other is used for charge sensing. By characterizing four single dots, we extract single dot charging energies $E_c = 4 – 6.7$ meV, orbital excited state energies $E_{orb} = 1.4 – 2.5$ meV, and valley splittings $\Delta_v = 35 – 70$ μeV. The same device can be reconfigured to form a few-electron double quantum dot. We demonstrate (0,0) charge occupancy and tune the interdot tunnel coupling from $< k_BT$ to over 100 μeV in the one-electron regime. In another device, designed to support two triple dots and known as the "triple-triple," we reach the few-electron regime in four distinct double dot pairs and demonstrate (1,1,1) charge occupancy with the device configured as a triple quantum dot.



Scanning electron microscope image of a quantum device used to isolate single electrons in a Si/SiGe quantum well. From D. M. Zajac *et al*., “A reconfigurable gate architecture for Si/SiGe quantum dots,” Appl. Phys. Lett. **106**, 223507 (2015).