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Modeling of Accumulation-Mode Quantum Dot Structures for Quantum Information Processing[1] R.S. ROSS, A.A. KISELEV, B.H. FONG, M.F. GYURE, HRL Laboratories, Malibu, CA 90265 — We present modeling and simulation results relevant to the design of SiGe and III-V based accumulation-mode quantum-dot structures for use as electron-spin-based qubits. We have developed a self-consistent real-space multi-electron simulation tool to efficiently explore and optimize these structures. Specific practical issues we address include the design of double-quantum-well heterostructures, enhancement-gate-electrode design and quantum-dot electronic structure with attention to the effects of electrostatic gate action. We examine the addition and excited-state spectra of single quantum dots (QD), the exchange coupling of nearest-neighbor quantum dots and the vertical tunneling behavior of our accumulation-mode devices. We also present comparisons to recently obtained experimental results on addition spectra in accumulation-mode quantum dots and show that our models correctly capture the relevant behavior. In addition, we address the robustness of device designs with respect to randomly distributed discrete dopants using a semi-analytical model and full numerical simulation based on impurity-induced random potentials.

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