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Interface roughness mediated phonon relaxation rates in Si quantum dots. RIFAT FERDOUS, YULING HSUEH, GERHARD KLIMECK, RAJIB RAHMAN, Purdue University — Si QDs are promising candidates for solid-state quantum computing due to long spin coherence times. However, the valley degeneracy in Si adds an additional degree of freedom to the electronic structure. Although the valley and orbital indices can be uniquely identified in an ideal Si QD, interface roughness mixes valley and orbital states in realistic dots. Such valley-orbit coupling can strongly influence T_1 times in Si QDs. Recent experimental measurements of various relaxation rates differ from previous predictions of phonon relaxation in ideal Si QDs. To understand how roughness affects different relaxation rates, for example spin relaxation due to spin-valley coupling, which is a byproduct of spin-orbit and valley-orbit coupling, we need to understand the effect of valley-orbit coupling on valley relaxation first. Using a full-band atomistic tight-binding description for both the system's electron and electron-phonon hamiltonian, we analyze the effect of atomic-scale interface disorder on phonon induced valley relaxation and spin relaxation in a Si QD. We find that, the valley splitting dependence of valley relaxation rate governs the magnetic field dependence of spin relaxation rate. Our results help understand experimentally measured relaxation times.

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