Low-Temperature Epitaxial Silicon Growth and Confinement of Delta Doped Si:P Nanostructures

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Atomically precise placement of phosphorus dopants using scanning tunneling microscopy-based hydrogen depassivation lithography (Figure 1) on silicon (Si:P) has implications for both high-performance digital electronics and quantum devices. Devices are fabricated by dissociative chemisorption of donor precursor molecules into patterned reactive areas in a hydrogen resist. A silicon capping layer, needed to encapsulate the device, is deposited at temperatures low enough to prevent dopant movement, but high enough to minimize defect generation.

Here, we explore the origin and influence of atomic defects in both the dopant layer and Si overgrowth, techniques available for characterization of these defects, and the relationship between surface passivation and device fidelity. Using a combination of optical spectroscopy, electrical transport, and transmission electron microscopy (TEM) (Figure 2), we relate P confinement and defect density in Si epitaxy to parameters of the fabrication process, surface chemistry, and the electronic characteristics of the resulting devices.

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Figure 1 Lithographically defined device on Si(100) 2×1:H

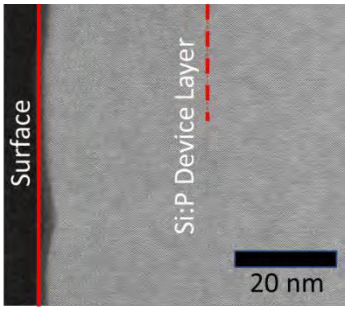

Figure 2 TEM cross-section of Si:P device after Si epitaxy

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