Lithography for Robust, Editable Atomic-scale Silicon Devices

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The first demonstrations of controlled atomic manipulation fostered a vision of practical, atomically perfect devices. However, realization of functional devices outside of the laboratory has been largely limited by the instability of the structures at room-temperature and poor electronic isolation from substrates. Hydrogen lithography (HL) on hydrogen-passivated silicon surfaces has the potential to surmount these limitations without introducing materials incompatible with current semiconductor fabrication processes and is becoming an increasingly important technique for the development of novel atomic scale logic devices. Historically though, HL has been hindered by the inability to fabricate large error-free structures with atomic precision.

In this report, advanced scanning probe microscope techniques are developed to substantially improve and automate HL. We will also demonstrate the ability to reversibly passivate unwanted surface atomic sites with hydrogen atoms, creating an error correction methodology. These techniques allow for state-of-the-art HL and enable the fabrication of perfect, room-temperature stable, silicon atom structures of unprecedented size. With HL no longer encumbered by fabrication errors, silicon-based atomic devices formed of silicon atom surface states, are now possible.