Halogen surface chemistries for atomically precise manufacturing on Si(100)

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Atomic-scale fabrication of electronic devices in silicon has been widely demonstrated using a scanning tunneling microscope (STM) and hydrogen-based surface chemistries to precisely place phosphorous donor atoms on the surface. Incorporation of PH_3 precursors into lithographic patterns formed from a hydrogen resist in a Si surface can produce metallic wires, quantum dots defined by electrostatic gates, and single donor atom qubits for quantum information (QI) research[1]. However, interest in acceptor dopants and hole-based devices necessitates the development of alternate precursor and/or resist chemistries for device fabrication. Halogen chemistry is potentially more favorable for acceptor incorporation than hydrogen[2], and to that end we explore halogen-based resists including Cl, Br, and I, along with metal-halide precursors to deposit acceptor dopants.

Here, we present results on the complete surface passivation of Si(100) using Cl, Br, and I, and demonstrate STM lithography at cryogenic and elevated temperatures [3]. We further study the stability of halogen-terminated Si(100) in ambient environments using x-ray photoelectron spectroscopy (XPS) to facilitate transport of samples outside of ultra-high vacuum environments. Finally, we present results of metal-halide adsorption on Si(100) as a viable path towards acceptor doping.

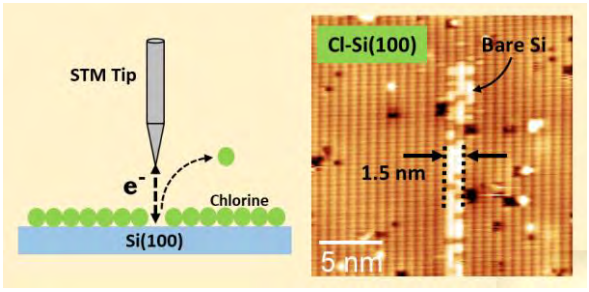

Figure 1. Schematic of STM lithography on Cl-Si(100). A 2-dimer wide lithographic line demonstrates atomic precision patterning.

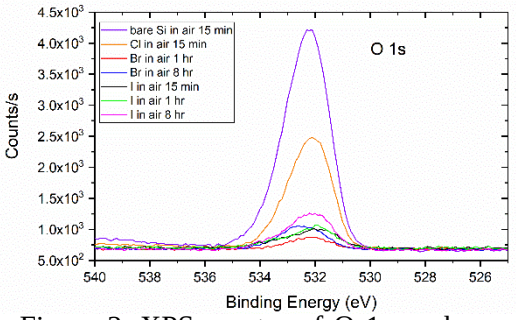

Figure 2. XPS spectra of O 1s peak as a function of halogen surface termination and exposure time in air.

[1] *Science*, **335**, 64 (2012)

[2] *Langmuir*, **27**, 6, 2613-2624 (2011)

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