

Surface Characterization of Implanted Arsenic on Si(100) using Scanning Tunneling Microscopy and Spectroscopy

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Many quantum and classical device technologies require understanding tunneling in semiconductors, which are sensitive to defects in the tunnel barrier. Characterizing these defects is challenging because the devices involve heterogeneous interfaces and tight sub-10 nm dimensions. Meanwhile, it has been difficult to interpret data about the role of specific defects in semiconductors from scanned probe because of both the non-perturbative role of the tip and features of the electronic structure that are specific to surfaces [1][2][3][4]. Here, we present a method of identifying surface and subsurface features by creating local density of states (LDOS) maps using a scanning tunneling microscope at the surface of hydrogen-terminated silicon. We find that most defects that show up in the topography either do not show up in the LDOS maps or come from imperfections in the hydrogen passivation. By contrast, donors and acceptors are generally

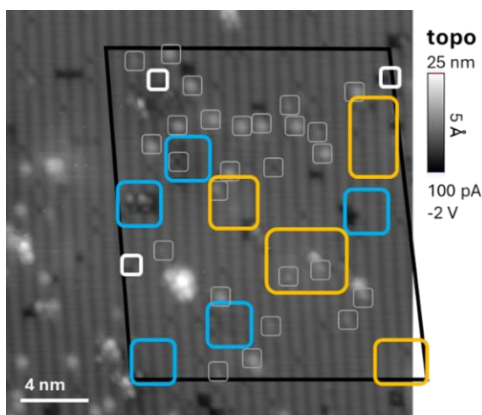


Figure 1. STM image of H:Si(100) with defects identified in the black box with colors outlining different defects.

not visible in the topography, but can be detected as bright regions from the shift they impart in one of the band edges. The figure on the left provides an example of how we have identified different defects based on their LDOS. The grey boxes show dangling bonds which produce a high LDOS centered around zero bias, independent of the parent electronic structure. The blue and yellow boxes outline where there are donor and acceptor defects that produce bright features at the conduction and valence band edges in the LDOS. We also find some unexpected mid-gap defects in white. With this methodology in place, we plan on investigating mechanisms of dopant diffusion and defect formation more generally in devices ranging from tunnel field effect transistors to single-donor qubits.

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