Electronic Structure of Ultra-Dense, Two-Dimensional Dopant δ-Layers in Silicon

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Abstract. Probing the electronic properties of two-dimensional (2D) dopant layers (δ-layers) in silicon is crucial to establish the quasi-2D characteristics of functional quantum-electronic devices. Here, we present the first soft x-ray angle-resolved photoemission spectroscopy (SX-ARPES) measurements of silicon δ-layers. The SX regime allows us to directly probe through the native surface oxide, where we demonstrate that nearly ideal 2D electron states exist in these technological silicon samples. We quantify the morphology of the δ-layer conduction valleys and deconvolve the spatial confinement of the δ-layer directly from the SX-ARPES k_z-response. We use this to demonstrate that arsenic δ-layers yield the thinnest (< 1 nm) 2D electron liquids ever fabricated in silicon.