The Arsenic Advantage: Surpassing Phosphorus for Atomic-Scale Quantum Devices in Silicon and Germanium

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Abstract:Atomic-scale quantum electronic devices can be fabricated via the deterministic placement of individual donor atoms in semiconductors. This breakthrough technology paves the way for innovative quantum electronic components and potentially scalable architectures. At the core of this potential lies the atomically precise incorporation of dopant atoms into semiconductor surfaces, achieved by adsorbing chemical precursor molecules onto surfaces lithographically patterned using a scanning tunnelling microscope. To date, the focus in this area has been the creation of devices using phosphorus in silicon; however, recent work suggests this may not be the ideal material system for atomic-scale quantum devices. In this talk, I will present a brief overview of this rapidly developing field, including our recent results for the incorporation of arsenic atoms into silicon and germanium and reasons why arsenic may soon replace phosphorus as the dopant of choice for atomic-scale semiconductor quantum electronics.

[1] Hofmann,et al., `Room Temperature Incorporation of Arsenic Atoms into the Germanium (001) Surface', Angew. Chemie - Int. Ed. 62, e202213982 (2023).
[2] Constantinou, et al., `Photoemission tomography of ultra-thin electron liquids in δ-doped silicon', submitted.
[3] T. J. Z. Stock, et al., `Atomic-Scale Patterning of Arsenic in Silicon by Scanning Tunneling Microscopy', ACS Nano 14, 3316 (2020).

Bio: Steven Schofield is an Associate Professor of Condensed Matter Physics at University College London with a joint appointment between the London Centre for Nanotechnology and the Department of Physics and Astronomy. He is interested in understanding and controlling the fundamental quantum properties of matter at the atomic scale for potential applications in classical and quantum information processing. His research group uses atomic-scale fabrication and cryogenic temperature, ultrahigh vacuum scanning tunnelling microscopy and spectroscopy to create and investigate nanostructures in semiconductor and two-dimensional materials. Often these measurements are made in conjunction with complementary techniques including momentum-resolved photoelectron spectroscopy and first-principles simulation.