Spatial metrology of dopants in silicon with exact lattice site precision

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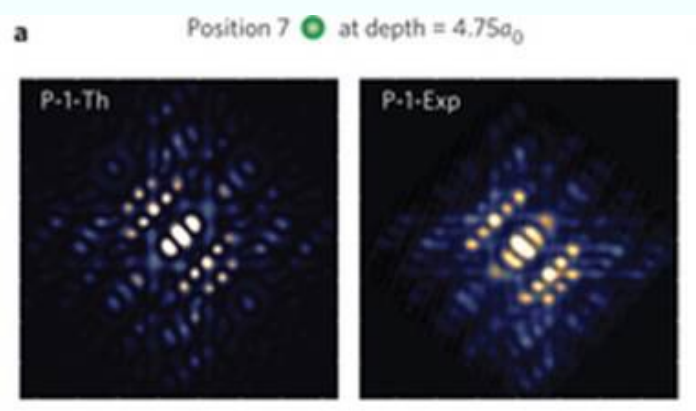

Theoretically computed and experimentally measured images (normalized equivalently) for dopants P-1 (a) and P-2 (b) at final determined lattice site positions.

Scaling of Si-based nanoelectronics has reached the regime where device function is affected not only by the presence of individual dopants, but also by their positions in the crystal. Determination of the precise dopant location is an unsolved problem in applications from channel doping in ultrascaled transistors to quantum information processing. Here, we establish a metrology combining low temperature scanning tunnelling microscopy (STM) imaging and a comprehensive quantum treatment of the dopant–STM system to pinpoint the exact coordinates of the dopant in the Si crystal. The technique is underpinned by the observation that STM images contain atomic-sized features in ordered patterns that are highly sensitive to the STM tip orbital and the absolute dopant lattice site. The demonstrated ability to determine the locations of P and As dopants to 5 nm depths will provide critical information for the design and optimization of nanoscale devices for classical and quantum computing applications.

LINK TO FULL PAPER (SUBSCRIBERS ONLY):
PAPER: http://www.nature.com/nnano/journal/vaop/ncurrent/full/nnano.2016.83.html