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Building quantum states at the silicon surface using dangling bonds

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Scanning tunnelling microscopes can be used to deterministically introduce atomic-scale defects in semiconductors [1-3], and this is considered a promising route toward the fabrication of a solid-state quantum computer. Here, we investigate the properties of deep centre defects created in the hydrogen terminated silicon (001) surface by removing individual hydrogen atoms to form dangling bonds (DBs). We demonstrate that pairs, linear chains, and two dimensional structures of individual DBs form quantum dot type states with probability density maxima between the missing H atom sites. By using the STM tip as an electrostatic gate to control which states contribute to the STM image, we suggest the origin of these surprising and previously unobserved states are first excited states of the individual DBs [1]. Our results show that quantum states can be fabricated on silicon with atomic-scale precision, and suggest a general model of quantum state fabrication using other passivated semiconductor surfaces.

[1] Schofield et al., Nature Commun. 4, 1649 (2013)
[2] Schofield et al., PRL 91, 136104 (2003).
[3] Koenraad et al., Nature Mater. 10, 91, (2011)