Atomic-Scale, All Epitaxial In-Plane Gated Donor Quantum Dot in Silicon

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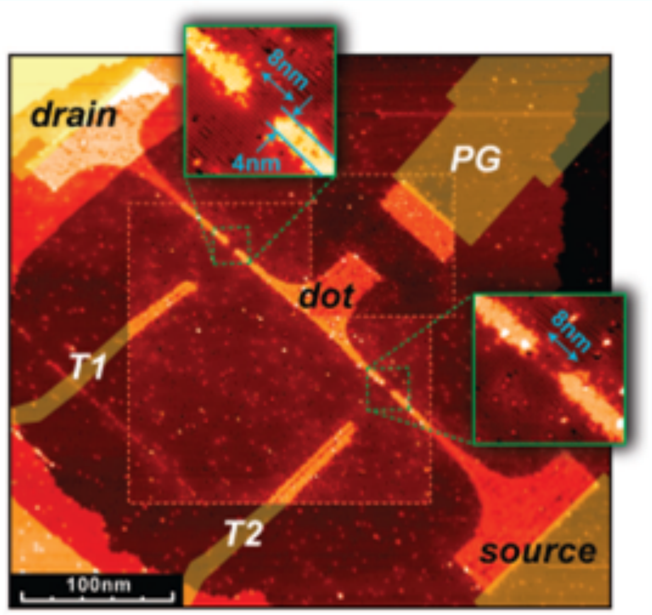

Composite STM image of an in-plane, all epitaxial quantum dot (bright regions) directly after performing STM lithography on a single atomic terrace on the Si(001)/H surface.

Nanoscale control of doping profiles in semiconductor devices is becoming of critical importance as channel length and pitch in metal oxide semiconductor field effect transistors (MOSFETs) continue to shrink toward a few nanometers.Scanning tunneling microscope (STM) directed self-assembly of dopants is currently the only proven method for fabricating atomically precise electronic devices in silicon. To date this technology has realized individual components of a complete device with a major obstacle being the ability to electrically gate devices. Here we demonstrate a fully functional multiterminal quantum dot device with integrated donor based in-plane gates epitaxially assembled on a single atomic plane of a silicon (001) surface. We show that such in-plane regions of highly doped silicon can be used to gate nanostructures resulting in highly stable Coulomb blockade (CB) oscillations in a donor-based quantum dot. In particular, we compare the use of these all epitaxial in-plane gates with conventional surface gates and find superior stability of the former. These results show that in the absence of the randomizing influences of interface and surface defects the electronic stability of dots in silicon can be comparable or better than that of quantum dots defined in other material systems. We anticipate our experiments will open the door for controlled scaling of silicon devices toward the single donor limit.

LINK TO FULL PAPER (SUBSCRIBERS ONLY):
http://pubs.acs.org/doi/pdf/10.1021/nl803196f Si(001)/H surface.