Research pair find a way to measure electrical conductance at sites on individual atoms

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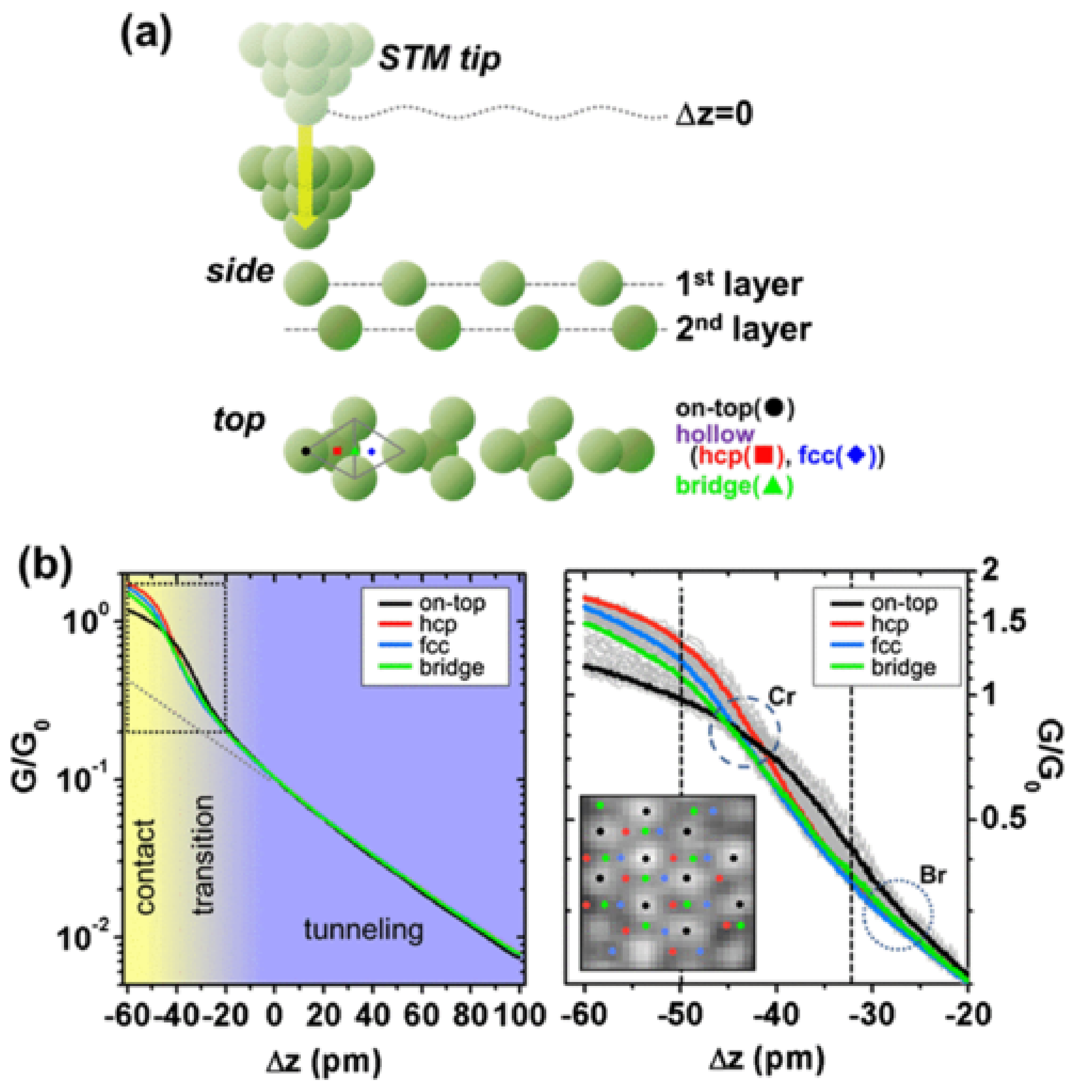

(a) Schematic of the conductance measurements as a function of the tip displacement Δz. (b) Conductance traces measured at on-top (black), bridge (green), hcp (red), and fcc (blue) sites on a flat Pb(111) surface, which were obtained from each 10 points marked in the inset STM image (1.2×1.2nm2 , VS=3.8mV, It=30nA) and averaged. The right panel is a zoom of the dotted area in the left panel. All 100 traces (gray) taken in the inset image are also plotted. The circles labeled “Cr” and “Br” indicate the regions in which the crossover and branching of the conductance traces occur, respectively. Credit: arXiv:1504.05494 [cond-mat.mes-hall]

(Phys.org)—A pair of researchers with the University of Tokyo has found a way to improve on scanning tunneling microscope (STM) technology where it is now possible to measure electrical conductance at individual sites on and between individual atoms. In their paper published in *Physical Review Letters*, Howon Kim and Yukio Hasegawa describe the changes they made and what they found using the newly improved device.

A STM is able to render imagery of atomic scale materials by using a needle with a tip so sharp that it is actually just one atom in size. To make images it measures electrons jumping from the tip to a material under study. Less well known is the ability to use a STM tip to touch materials under study, to move atoms or measure conductance of a material at atomic scale—due to the bonding that occurs between the tip and atoms on the surface of another material. But the touching technique has run into some problems, it can cause inadvertent movement of atoms or leave behind nanosized material bits, both of which can contaminate a sample. In this new effort, the research duo found a way to stabilize the tip so that neither problem occurs.

Their approach was to use lead, both as a tip for the STM and as the material under study. They also found a way to reduce electronic noise and mechanical vibration—that combination allowed them to measure the conductance of different areas on a single atom—a first. It also allowed for measuring conductance extraordinarily close to atoms and in the spaces, or holes that are created when two atoms are touching one another.

In using their new and improved STM, the researchers found a higher capacitance atop an atom than between them, when studying from a very close distance. When they allowed the tip to touch the surface, things changed however, conductance was found to be greater in the holes, but it varied by configuration. For example, it was greater when measuring a hole where three atoms met, than when there were just two. They believe the differences are related to the chemical bonding that occurs.

The two researchers next plan to use their modified STM to investigate Cooper pairs in lead that has been cooled enough to cause it to become a superconductor.

More information: Site-Dependent Evolution of Electrical Conductance from Tunneling to Atomic Point Contact, *Phys. Rev. Lett.* 114, 206801 – Published 22 May 2015.
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ABSTRACT
Using scanning tunneling microscopy (STM), we investigated the evolution of electrical conductance between a Pb tip and Pb(111) surface from tunneling to atomic point contact at a site that was defined with atomic precision. We found that the conductance evolution depended on the contact site, for instance, on-top, bridge, or hollow (hcp and fcc) sites in the Pb lattice. In the transition from tunneling to contact regimes, the conductance measured at the on-top site was enhanced. In the point contact regime, the hollow sites had conductances larger than those of the other sites, and between the hollow sites, the hcp site had a conductance larger than that of the fcc site. We also observed the

enhancement and reversal of the apparent height in atomically resolved high-current STM images, consistent with the results of the conductance traces. Our results indicate the importance of atomic configuration in the conductance of atomic junctions and suggest that attractive chemical interactions have a significant role in electron transport between contacting atoms.

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