Physics

Single-atom current heeds orbital count

Electronic wires and devices, getting smaller every year, may eventually shrink to single-atom dimensions. A new study of one-atom electric contacts finds that their conductivity depends on different properties than does the bulk-metal conduction in today's circuitry.

In bulk metal, conductivity is limited by the presence of crystal defects and impurities that impede electron flow. The conductivity of single atoms, however, depends on their individual chemical properties, report Elke Scheer of the University of Karlsruhe in Germany and her colleagues in the July 9 NATURE.

In particular, experiments on lone atoms of aluminum, gold, lead, and niobium reveal that metals with more valence-electron orbitals can pass more current because they have more conduction channels available. Valence electrons, which are located in outer orbits, participate in chemical bonds.

As a single atom, one of the best bulk conductors now in use—gold—became the least conductive of the four metals tested. With only one valence electron, gold boasts only one conduction channel, whereas lead atoms—in bulk only a tenth as conductive as gold—allow three channels.

The researchers also found that single atoms of metal could transmit up to 100 microamperes of current. That robust flow bodes well for the future of single-atom electronics, says Lydia L. Sohn of Princeton University, "because it shows that atomic-sized devices could handle currents on the same order of magnitude as today's devices." —P.W.

Foiling friction by jiggling a junction

Friction can cause a hard-disk drive to crash or a microscopic motor to seize. One problem is that the lubricants in the minuscule gaps between surfaces of such devices settle into semi-solid layers that resist slipping motions.

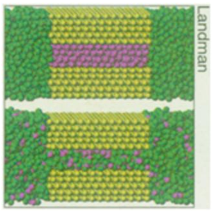
A rhythmic resizing of those gaps will break up the layers and keep things gliding easily, according to computational and experimental results presented in the June 25 JOURNAL OF PHYSICAL CHEMISTRY B.

"Typically we think of replacing the lubricant," says Uzi Landman of the Georgia Institute of Technology in Atlanta, who coauthored the computational report. "This is the first [study] that says: Keep the same lubricant and do something external."

Prior studies by Landman and his colleagues found that a waxy lubricant such as hexadecane would separate into four or five stable, motion-resistant layers, but only if the size of the gap filled by the lubricant remained fixed.

In new supercomputer simulations, Landman's team confirmed that if the gap becomes a little smaller or larger, molecules rearrange, disturbing the order and reducing friction. Rapidly varying the spacing by as little as 5 percent of a 2-nanometer, lubricant-filled gap caused "ultralow" friction, the team says.

In an accompanying experimental report, researchers at the Laboratory for Surface Science and Technology in Zürich and at the University of California, Santa Barbara describe sliding lubricated surfaces against each other while oscillating the top surface by less than 0.1 nm. Friction dropped markedly, they report—in one circumstance, falling to less than a tenth of what it was with no oscillations. —P.W.



Landman

When the size of the gap between solids (yellow) in a computer model oscillates, the lubricant (purple and green) becomes disordered (lower) and friction decreases.