Manipulation of single atoms provides fundamental insights

September 28 2005

It seemed like science-fiction just a few years ago, but is now common practice for scientists at the Paul Drude Institute for Solid State Electronics (PDI) in Berlin. The scientists manipulate single atoms resting on surfaces and assemble them into wires or tiny clusters. In the world of nanometric dimensions, fundamental material properties such as magnetism, electrical conductivity or chemical reactivity differ from the conventional behaviour observed in everyday life.

If metal clusters or semiconductor crystals are made just tiny enough, effects often arise which can be only explained by the laws of quantum physics. Recently, a team of scientists at the PDI documented the transition of the quantum world characteristics of atomic structures to the world of macroscopic material properties. They assembled individual copper atoms on a crystalline copper surface and examined the electronic properties of these artificial structures. Jérôme Lagoute, Xi Liu and Stefan Fölsch published their study in the journal Physical Review Letters *.

The scientists assembled atomic clusters one atom high by manipulating one atom after another and found that, depending on the number of atoms, characteristic quantum states are formed which eventually merge into a widely known surface property, the Shockley surface state. This state can be described as an electron gas located at the surface. "The two-dimensional surface state is text book physics", says Stefan Fölsch, "but we found something new." For the first time, Lagoute and colleagues revealed the physical linkage between quantum states in atomic-scale structures and the traditional properties of extended surfaces. The researchers conclude that their findings apply not only to copper but to other materials as well.

To manipulate the atoms and to analyze the assembled structures, the scientists used a home-built low temperature scanning tunneling microscope. “At present, few research groups world-wide are able to conduct atom manipulation experiments on this level”, says Fölsch. However, the method will not directly lead to new products or applications in the near future.“Our experiments are performed under very well-defined conditions at low temperature and on ultra-clean surfaces." Nevertheless, studies of suchlike perfect model systems yield fundamental insight which is essential for future developments in nanoscience and technology. “For instance, if you assemble a quantum wire atom by atom”, says Fölsch, “you’d like to know about the detailed electronic characteristics and the electron dynamics associated with this one-dimensional object." The present experiment by the PDI scientists provides an instructive approach to exploring how electronic properties evolve when building artificial structures atom by atom. A detailed understanding of such a scenario is an essential step towards the ultimate goal of “tailoring” magnetic and electronic material properties by controlling size, geometry, and composition at the atomic level.

Citation: Manipulation of single atoms provides fundamental insights (2005, September 28) retrieved 9 April 2024 from https://phys.org/news/2005-09-atoms-fundamental-insights.html