Scientists Make 'Perfect' Nanowires

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Scientists have created silicon nanowires that are perfect—at least atomically. Down at the single-atom level, the identical wires have no bumps, bends, or other imperfections. They are perfectly crystalline, even more so than bulk silicon. The full array of nanowires is also highly parallel, and each wire is an excellent metallic conductor.

This research may be an important step forward for nanotechnology. Nanowires play a key role in developing nanoelectronics applications, and silicon nanowires are particularly important because of the central function that silicon plays in the semiconductor industry and current technologies. Some scientists believe that silicon nanowires will overtake carbon nanotubes in popularity, and they are being eyed for a variety of electronics applications and even quantum computing.

Therefore, the ability to create straight, identical, parallel, and atomically smooth nanowires could lead to new developments in nanoelectronics.

The nanowires were created by scientists from the Institute for the Structure of Matter (CNR-ISM) in Rome, Italy; the Institute of Atmospheric Sciences and Climate, also in Italy (both institutes are part of Italy's National Research Council); and the Center for Research on Condensed Matter and Nanoscience in Marseilles, France, a branch of France's National Center for Scientific Research.

Using two separate tools, a scanning tunneling microscope and a beam of low-energy x-rays, the researchers observed that the the nanowires are essentially made of individual 1.5-nanometer-diamter silicon nanodots.

The nanodots “self-assembled” into nanowires: the more nanodots, the longer the nanowire, up to a maximum achieved length of 31 nanometers. The most common length was about 10 nanometers.

The research group noticed a “surprising” characteristic of the nanowires. Despite the wires' otherwise atomic perfection, they display an usual lack of symmetry across their widths: One side of each nanowire is effectively shorter than the other side. This dip, as the researchers refer to it, sometimes occurs on the left side and sometimes the right.

Why the asymmetry arises seems to be due to the particular surface, or “substrate,” on which the nanowires were grown: silver. More specifically, the substrate consists of two very, very thin layers of silver, each only a single atom thick. The two layers give the substrate a grooved appearance, with the top layer of silver atoms forming regularly spaced lines over the bottom layer.

To “grow” the nanowires, two atom-thick layers of silicon were deposited on top of the silver substrate at room temperature. The top layer of silicon consisted of silicon “dimers,” or bonded atom pairs. The bottom layer was composed of single silicon atoms, which made contact with both silver layers.

Due to the complex electronic interactions that can occur between silicon and silver atoms, the silicon atoms on silver can self-assemble into ordered structures—in this case, nanowires. But those interactions, coupled with the grooves on the silver substrate, also produced the nanowire asymmetry.

The scientists say that more work needs to be done before the scientists know more about the wires' exact atomic structure and the number of silicon atoms that comprise them, as well as better understanding the asymmetry. They are currently involved in follow-up research.

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