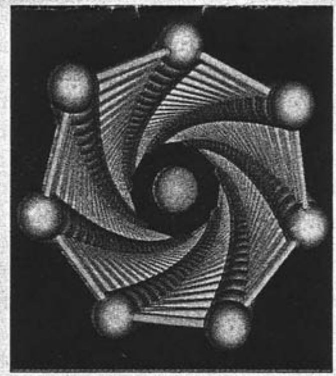
Strange Behavior At One Dimension

TOKYO—For Kunio Takayanagi, a physicist at the Tokyo Institute of Technology, thinner is better. Takayanagi has calculated that electrons should pass through the 1-nanometer gold wires he has crafted at speeds several orders of magnitude faster than those at which they pass through larger wires. If such wires could be fashioned into circuits, they could set the stage for even faster supercomputers. "In electronic device technology," he says, "the speed of the electron is the most important thing."

Such high speeds are made possible by the internal structure of the nanowires through which the electrons pass. "At larger scales, materials form crystals," explains Erio Tosatti, a theorist at the Institute for Theoretical Physics in Trieste, Italy. "In the nanowires, the material is not a crystal. It is very different, electrically and mechanically."

Takayanagi was the first to determine this structure by putting a miniaturized scanning tunneling microscope (STM) within an ultrahigh-vacuum, high-resolution transmission electron microscope (TEM). By irradiating a thin gold film with an electron beam, he reduced it to a wire. Imaging with the TEM and the STM revealed that when the wire was thinned to a diameter of roughly 1 nanometer, atoms organized themselves into nested tubes, with the atoms in each tube arranged in a helix coiled around the wire axis. The structure is akin to that of carbon nanotubes.



Twister. Spirals of gold, 1 nm across, may rev electrical currents up to record speeds.

Takayanagi's prediction of the speed of electron transport is based on some preliminary conductance measurements and theory. Theory suggests that the electrons would move so efficiently that no heat would be generated. Groups at Nagoya and Osaka universities in Japan and at Leiden University in the Netherlands have produced similar wires and plan to measure some of their mechanical and electrical properties.

In addition to the obvious advantages for the electronics industry, the work has important implications for basic science. Pointing to the helical structure of carbon nanotubes and the double helix of DNA, Takayanagi says it's possible that "all material will take on a stable helical structure if it is one-dimensional like a nanowire." Tosatti is equally excited. "I think this work could lead to an understanding of how matter spontaneously organizes itself at the nanoscale," he says.

–**DENNIS NORMILE**