Toward a Quantum Computer, One Dot at a Time

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Researchers at the University of Pittsburgh have developed a way to create semiconductor islands smaller than 10 nanometers in scale, known as quantum dots. The islands, made from germanium and placed on the surface of silicon with two-nanometer precision, are capable of confining single electrons.

“We believe this development moves us closer to our goal of constructing a quantum computer,” said Jeremy Levy, Pitt professor of physics and astronomy and director of the Pittsburgh-based Center for Oxide-Semiconductor Materials for Quantum Computation. Levy and colleagues reported on the advance in a paper published in October 2005 in the journal Applied Physics Letters.

Quantum computers do not yet exist, but it is known that they can bypass all known encryption schemes used today on the Internet. Quantum computers also are capable of efficiently solving the most important equation in quantum physics: the Schrödinger equation, which describes the time-dependence of quantum mechanical systems. Hence, if quantum computers can be built, they likely will have as large an impact on technology as the transistor.

Electrons have a property known as “spin,” which can take one of two directions-clockwise and counter-clockwise. Because of their quantum-mechanical nature, electrons can spin in both directions at once. That bizarre property allows the spin to be used as a “quantum bit” in a quantum computer. The ability to confine individual electrons, as opposed to “puddles” of electrons used in conventional computer technology, is essential for the working of a quantum computer.

The next step, said Levy, is to perform electronic and optical measurements on these materials to prove that there is indeed one electron on each quantum dot and to probe the coupling between the spins of neighbor electrons. “We can do that now because we have this control over the spacing and the size,” he said.

The results achieved by Levy and colleagues are an example of “essentially nano” research, which involves manipulating properties at the smallest scales-from one to 20 nanometers.

Pitt has invested heavily in nanoscale research, beginning with the establishment of its Institute for NanoScience and Engineering (INSE), and continuing with the NanoScale Fabrication and Characterization Facility, which contains core technology such as electron-beam lithography, transmission electron microscopes, and a state-of-the-art cleanroom environment. The INSE is an integrated, multidisciplinary organization that brings coherence to the University's research efforts and resources in the fields of nanoscale science and engineering. For more information, visit www.nano.pitt.edu.

Other researchers on the study were John T. Yates Jr., R.K. Mellon Professor of Chemistry and Physics at Pitt; former Pitt chemistry graduate student Olivier Guise; Joachim Ahner of Pittsburgh-based Seagate Technology; and Venugopalan Vaithyanathan and Darrell G. Schlom of Pennsylvania State University.

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Source: University of Pittsburgh