- ACS
- Journals
- C&EN
- CAS

Chemical & Engineering News

Latest News

November 19, 2007
Volume 85, Number 47
p. 10

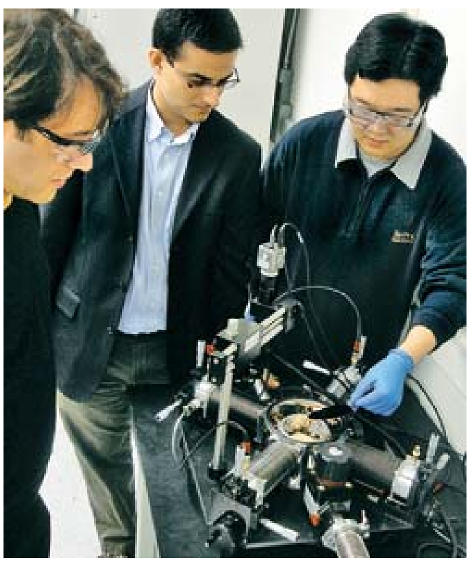
Semiconductors

Nanoscale Doping Via Chemistry

Surface reactions tailor silicon's properties with high spatial precision

Mitch Jacoby

A NEW CHEMICAL PROCEDURE
implants dopant atoms in semiconductor materials with nanometer-scale spatial precision (*Nat. Mater.*, DOI: 10.1038/nmat2058). The technique may help overcome a technological hurdle that could hinder further miniaturization of microelectronic circuitry.


Courtesy Of Ali Javey/UC Berkeley
Yerushalmi (from left), Javey, and Ho measure electrical properties of a silicon sample that was prepared by a new chemical doping method.

Semiconductors are the bedrock of today's powerful microelectronics devices, primarily because of the materials' highly useful electronic properties. But those properties are not intrinsic to silicon or other semiconductors, which in their pristine states are poor conductors. Rather, by embedding charge-carrying dopants, such as boron and phosphorus, into semiconductors, manufacturers customize a material's electronic characteristics as needed for a given application.

The semiconductor industry has perfected standard doping methods, such as high-energy ion implantation, for modifying the properties of relatively large circuit components. But for electronics based on nanowires and other nanosized components, which could further shrink electronic circuitry, that method lacks the dexterity required to embed dopants exactly where they are needed. In addition, ion implantation induces significant crystal damage and suffers from other shortcomings.

To address these problems, a team of electrical engineers at the University of California, Berkeley, has developed an alternative doping method based on surface chemistry. Assistant professor Ali Javey, graduate student Johnny C. Ho, postdoc Roie Yerushalmi, and coworkers treat silicon with dopant-containing reagent molecules that form well-ordered, covalently bonded thin films. Then, by rapidly annealing the samples at high temperature, the group breaks the molecules and drives the dopant atoms into the silicon. Demonstrating the procedure, the team doped silicon crystals and nanowires with boron and separately with phosphorus, using an allylboronic acid ester and organic phosphonate precursors, respectively.

By exploiting self-assembling-monolayer chemistry, the team pins the location and concentration of the dopant atoms on the surface with molecular precision. And by controlling the heat treatment conditions, they carefully select the depth to which the dopants penetrate into the silicon, as indicated by several analytical methods.

"The work shows the exquisite power of well-defined chemistry in controlling electronic properties of nanoscale structures," says Harvard University chemistry professor Charles M. Lieber. "I really wish we had done this experiment."

- Email this article to a friend
- Print this article
- E-mail the editor

Chemical & Engineering News
ISSN 0009-2347