Doping technique brings nanomechanical devices into the semiconductor world

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With the help of a device capable of depositing metals an atom at a time in the materials used in computer chips, a team of University of Wisconsin-Madison engineers has successfully blended modern semiconductor technology and nanomachines.

The work, reported this week (Sept. 26) in the journal *Physica Status Solidi*, marks the advent of a new class of nanomechanical devices with implications ranging from improved solar energy cells and light-emitting diodes to highly sensitive probes capable of measuring single biological molecules.

"This is a marriage of two different fields," explains Robert Blick, a UW-Madison professor of electrical and computer engineering. The ability to confer the properties of a semiconductor onto the submicroscopic machines scientists are now learning how to build opens the door to a host of new tiny mechanical devices that can be manipulated with a single electron or, in the case of a biological application, a single molecule such as a protein.

The new work was conducted using a unique device known as a focused ion beam writer, an instrument that, in essence, operates like a sandblaster and can shower a sample of silicon with atoms to impregnate the material with metal in precise patterns at the nanoscale.

In the new study, Blick's group, including lead author of the paper Dominik V. Scheible, was able to deposit a small plume of gallium atoms into a silicon nanomachine and confer electromechanical properties — the ability to drive moving parts with electrons.

"This constitutes a direct combination of mechanical and electric tunability with unprecedented precision," the authors write in the new report. "This will considerably enhance the mechanical properties of (nanomachines)."

At present, nanomechanical devices are sculpted from sandwiches of silicon and metal. The new technique means the metal layer can be removed completely, making the nano devices lighter, more sensitive and easier to manipulate.

"All of a sudden, you're not relying on metal layers anymore," says Blick. "You can dope the device itself, not the material from which the device is made. This technology allows for more customized devices."

The new electromechanical qualities in nanodevices, according to Blick, can be employed in a wide range of applications.

In the biomedical area, for example, where scientists are seeking ways to efficiently measure hundreds of thousands of biological molecules, it may be possible now to build sensors capable of rapidly establishing the masses of single proteins. The mass of a protein, Blick explains, can be enough to activate the nanodevice and provide a measure that scientists can use to quickly and precisely determine the protein's mass.

"The intrinsic mass of the devices themselves is very small," says Blick. "You can hit them with proteins and you can get information out, in this case mass, which is a very important quality."

Other potential applications, Blick notes, include new battery technology, mechanically tunable transistors, improved solar cells and highly sensitive light-emitting diodes that can serve as readouts for microscopic sensors.

Co-authors of the new Wisconsin study, in addition to Blick and Scheible, include Hua Qin and Hyun-Seok Kim.

Source: University of Wisconsin-Madison