Silicon superlattices: New waves in thermoelectricity

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(PhysOrg.com) -- A University of Wisconsin-Madison research team has developed a new method for using nanoscale silicon that could improve devices that convert thermal energy into electrical energy.

The team, led by Max Lagally, Erwin W. Mueller Professor and Bascom Professor of Surface Science, published its findings in the March 24 issue of the journal *ACS Nano*.

Thermoelectric devices can use electricity to cool or, conversely, convert heat to electricity. To improve efficiency in tiny thermoelectric devices, researchers build superlattices of alternating thin layers of two different semiconductor materials, called heterojunctions. Charges in multilayer heterojunction wires travel through a periodic electric field that influences their motion; however, it is difficult to create modulation large enough to be effective with traditional heterojunctions, Lagally says.

The UW-Madison team addressed the problem by creating a superlattice from a single material: a sheet of silicon nanometers thick, called a nanomembranes, and cutting it into ribbons nanometers wide. The researchers can induce localized strain in the silicon, creating an effective strain wave that causes charges the electric field in the ribbon to vary periodically.

"Essentially we're making the equivalent of a heterojunction superlattice with one material," says Lagally, whose home department is materials science and engineering. "We're actually doing better with these strained regions than you can do easily with multiple-chemical-component systems."

The strained-silicon superlattices display greater electric field modulation than their heterojunction counterparts, so they may improve silicon thermoelectric near or above room temperature. In addition, they are relatively easy to manufacture. Lagally and his group theorize that their method could apply to any type of semiconductor nanomembrane.

"It's cool in several ways: It's a single material, the modulation in the electric field is bigger than what others can make easily, and it's very straightforward," says Lagally.

Co-authors of the paper include Lagally; UW-Madison postdoctoral associate Hing-Huang Huang; graduate students Clark Ritz and Bozidar Novakovic; assistant scientists Frank Flack; associate scientist Don Savage; materials science and engineering associate professor Paul Evans; and electrical and computer engineering assistant professor Irena Knezevic; along with Decai Yu, Yu Zhang and Professor Feng Liu of the University of Utah.

Provided by University of Wisconsin-Madison (news : web)