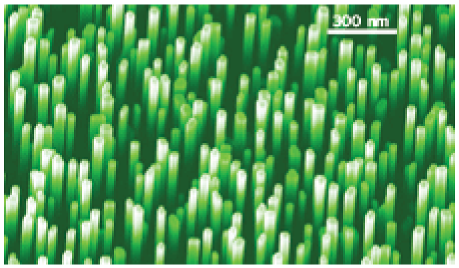
Introducing nanopiezotronics

THE NIGHT BEFORE giving a talk at an MRS meeting, most speakers review their notes, check their presentations for typos, and try to ge some beauty sleep. But Zhong Lin Wang had slightly more ambitious plans on the eve of his presentation. He decided to invent a new wor nano-piezotronics.

Wang, director of Georgia Institute of Technology's Center for Nanostructure Characterization, said his new addition to the nano lexicon arose out of an attempt to describe the use of piezoelectric semiconductors to make novel nanoscale electronic devices.



Courtesy of Z. L. Wang
Nano Energy Field An array of ZnO nanowires like the one in this scanning electron micrograph could someday power nanoÂpiezotronic devices.

Nanopiezotronics is going to be important for nanoscale electronics, Wang explained, because in today's electronic devices, the size of the power source dictates the size of the system. "There are a lot of neat nanodevices out there, but there are no nanobatteries," he said. "Wh we're doing is going from a nanodevice to a self-powered nanosystem, which includes nanodevice components as well as a nanoscale power source."

The key to Wang's tiny power generators is zinc oxide's combination of piezoelectric and semiconducting properties. Piezoelectric materia possess the ability to generate a voltage in response to mechanical stress. Bending a ZnO nanowire, for example, transforms the mechanical energy of bending into electrical energy. Bending an array of ZnO nanowires might generate enough electricity to power a nanodevice (*Science* **2006**, *312,* 242).

A ZnO nanowire can also be used as a semiconductor, one of the core components in a field-effect transistor (FET), the key switching structure in nanoscale sensors and devices. In this capacity, the nanowire bridges the source electrode on one end and the drain electrode on the other. Applying an electrical potential to a third electrode, known as the gate, controls whether current can pass through the semiconductor.

Taking advantage of the piezoelectric properties in a ZnO nanowire, Wang's group was able to create an FET without a gate electrode. That's because ZnO does the gate's job too, Wang explained, bending or straightening in response to pressure. This movement creates a potential across the nanowire, controlling the current flow between the source and the drain.

Wang and colleagues, including postdoc Xudong Wang and graduate student Jinhui Song, have already used this architecture to create pressure sensors with the ability to measure forces in the nanonewton range (*Nano Lett.* **2006,** *6,* 2768). That's sensitive enough to weigh dust mite.

"The potential applications are tremendous," Wang enthused. Nanopiezotronic devices could some day cover airplanes and space shuttle in a skin of wireless pressure sensors, he said. Nanopiezotronic generators could be put into knee patches on military fatigues and the sol of combat boots, creating power for soldiers on the march.

Don't plan on plugging your laptop into your running shoes just yet. Wang noted that the technology is still in its early stages. But he thinks nanopiezotronics is going to be more than just a new word. "This should be a whole new field," he remarked.

Tiny tuning-fork sensors

BY MINING THE INNER WORKINGS of an everyday wristwatch, Nongjian Tao, a chemistry professor at Arizona State University, has bui a novel and inexpensive sensor that can detect improvised explosives and environmental pollutants and also distinguish between different brands of beer.