Nanogenerator Converts Body's Energy into DC Output

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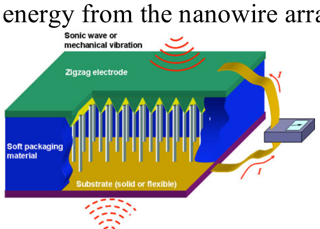
Researchers at the Georgia Institute of Technology have developed a prototype nanometer-scale generator that produces continuous direct-current electricity by harvesting mechanical energy from such environmental sources as ultrasonic waves, mechanical vibration, muscle movements, or blood flow. It is based on arrays of vertically-aligned zinc oxide nanowires that move inside a novel "zig-zag" plate electrode. The nanogenerators could provide a new way to power nanoscale devices without batteries or other external power sources. The nanogenerators take advantage of the unique coupled piezoelectric and semiconducting properties of zinc oxide nanostructures, which produce small electrical charges when they are flexed.

Fabrication begins with growing an array of vertically-aligned nanowires approximately a half-micron apart on gallium arsenide, sapphire or a flexible polymer substrate. A layer of zinc oxide is grown on top of substrate to collect the current. The researchers also fabricate silicon "zig-zag" electrodes, which contain thousands of nanometer-scale tips made conductive by a platinum coating. The electrode is then lowered on top of the nanowire array, leaving just enough space so that a significant number of the nanowires are free to flex within the gaps created by the tips. Moved by mechanical energy such as waves or vibration, the nanowires periodically contact the tips, transferring their electrical charges. By capturing the tiny amounts of current produced by hundreds of nanowires kept in motion, the generators produce a direct current output in the nano-Ampere range. With its multiple conducting tips the zig-zag electrode serves as a Schottky barrier to hundreds or thousands of wires simultaneously, harvesting energy from the nanowire arrays.



The researchers expect that with optimization, their nanogenerator could produce as much as 4 watts per cubic centimeter, based on a calculation for a single nanowire. That would be enough to power a broad range of nanometer-scale defense, environmental and biomedical applications, including biosensors implanted in the body, environmental monitors, and even nanoscale robots. Providing power for nanometer-scale devices has long been a challenge. Batteries and other traditional sources are too large, and tend to negate the size advantages of nanodevices. Also, since batteries contain toxic materials such as lithium and cadmium, they cannot be implanted into the body as part of biomedical applications. However, since zinc oxide is non-toxic and compatible with the body, the new nanogenerators could be integrated into implantable biomedical devices to wirelessly measure blood flow and blood pressure within the body. And they could also find more ordinary applications.

In their lab, the researchers aimed an ultrasound source at their nanogenerator to measure current output over slightly more than an hour. Though there is some fluctuation in output, the current flow was continuous as long as the ultrasonic generator was operating. To rule out other sources of the current measured, the researchers substituted carbon nanotubes – which are not piezoelectric – for the zinc oxide nanowires, and used a top electrode that was flat. In both cases, the resulting devices did not produce current. Additional development is needed to optimize current production. For instance, though nanowires in the arrays can be grown to approximately the same length – about one micron – there is some variation. Wires that are too short cannot touch the electrode to produce current, while wires that are too long cannot flex to produce electrical charge. Better control of the growth, density, and uniformity of the wires are needed. The researchers believe that as many as millions or even billions of nanowires can be made to produce current simultaneously, allowing them to optimize operation of the nanogenerator.

References

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