

Nanogenerators Convert Mechanical Energy to Electricity

Researchers have developed a new technique for powering nanometer-scale devices without the need for bulky energy sources such as batteries.

By converting mechanical energy from body movement, muscle stretching or water flow into electricity, these "nanogenerators" could make possible a new class of self-powered implantable medical devices, sensors and portable electronics.

Described in the April 14th issue of the journal Science, the nanogenerators produce current by bending and then releasing zinc oxide nanowires

—which are both piezoelectric and semiconducting. The research was sponsored by the National Science Foundation (NSF), the NASA Vehicle Systems Program and the Defense Advanced Research Projects Agency (DARPA).

"There is a lot of mechanical energy available in our environment," said Zhong Lin Wang, a Regents Professor in the School of Materials Science and Engineering at the Georgia Institute of Technology. "Our nanogenerators can convert this mechanical energy to electrical energy. This could potentially open up a lot of possibilities for the future of nanotechnology."

Nanotechnology researchers have proposed and developed a broad range of nanoscale devices, but their use has been limited by the sources of energy available to power them.

Conventional batteries make the nanoscale systems too large, and the toxic contents of batteries limit their use in the body. Other potential power sources also suffer from significant drawbacks, sciencedaily.com said.

"We can build nanodevices that are very small, but if the complete integrated system must include a large power source, that defeats the purpose," added Wang, who also holds affiliated faculty positions at

Peking University and the National Center for Nanoscience and Technology of China.

The nanogenerators developed by Wang and graduate student Jinhui Song use the very small piezoelectric discharges created when zinc oxide nanowires are bent and then released. By building interconnected arrays containing millions of such wires, Wang believes he can produce enough current to power nanoscale devices.

To study the effect, the researchers grew arrays of zinc oxide nanowires, then used an atomic-force microscope tip to deflect individual wires. As a wire was contacted and deflected by the tip,

stretching on one side of the structure and compression on the other side created a charge separation—positive on the stretched side and negative on the compressed side—due to the piezoelectric effect.

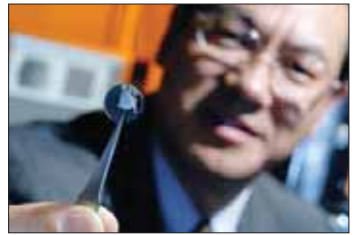
The charges were preserved in the nanowire because a Schottky barrier was formed between the AFM tip and the nanowire. The coupling between semiconducting and piezoelectric properties resulted in the charging and discharging process when the tip scanned across the nanowire, Wang explained.

When the tip lost contact with the wire, the strain was released—and the

researchers measured an electrical current. After the strain release, the nanowire vibrated through many cycles, but the electrical discharge was measured only at the instant when the strain was released.

To rule out other potential sources of the current, the researchers conducted similar tests using structures that were not piezoelectric or semiconducting. "After a variety of tests, we are confident that what we are seeing is a piezoelectric-induced discharge process," Wang said.

The researchers grew the nanowire arrays using a standard vapor-liquid-solid process in a small tube furnace. First, gold



Georgia Tech Professor Zhong Lin Wang holds a sample nanowire array that can be used to power nanometer scale devices

nanoparticles were deposited onto a sapphire substrate placed in one end of the furnace. An argon carrier gas was then flowed into the furnace as zinc oxide powder was heated. The nanowires grew beneath the gold nanoparticles, which serve as catalysts.

The resulting arrays contained vertically-aligned nanowires that ranged from 200 to 500 nanometers in length and 20 to 40 nanometers in diameter. The wires grew approximately 100 nanometers apart, as determined by the placement of the gold nanoparticles. A film of zinc oxide also grew between the wires on the substrate surface, creating an electrical connection between the wires. To that conductive substrate, the researchers attached an electrode for measuring current flow.

GE Refines, Expands Wind Turbine Production

While specific proposed wind power developments face their fair share of challenges including local and political opposition, one of the greatest challenges to wind power as a whole is a tight and increasingly expensive supply chain for key components like turbines.

In the same way a raw material shortage has cramped the solar photovoltaic industry, the wind power industry has been squeezed by a turbine shortage—a situation the manufacturers will tell you is the result of vacillating policy support in the US.

Whatever the causes, the largest manufacturer of turbines in the world, GE Energy, announced advances this week in its production chain that could help squeeze out a few more turbines to help meet robust worldwide demand.

In Germany, GE Energy's wind business has opened a new 80-ton, wind turbine "moving line" in its Salzgitter manufacturing facility that will help to meet increased global demand for wind turbines, solar-acc.com said.

This moving line is a 42-meter rail system on which the turbines are continuously moved during production. It has been designed for the manufacture of both GE 1.5 and multi-megawatt wind turbines and, according to the company, offers a 30% increase in capacity along with quality and safety improvements.

GE says the efficiency of the line will enable GE to increase its capacity by 30 percent while reducing its inventory by 40% at the Salzgitter plant. A key feature of the new moving line is its capability to detect abnormalities should they occur in wind turbine assembly and halt the manufacturing process until the issues are resolved. It can move at various speeds to accommodate different output levels.

"With the growing demand for wind power worldwide, it is critical for GE to get the highest possible levels of production out of our existing wind turbine manufacturing facilities," said Rainer Broering, Managing Director of GE Energy's wind business in Germany. "The Salzgitter team began addressing this requirement three years ago, applying 'lean-manufacturing' principles to the hub production area of the plant, transforming it into a model line. Motivated by the results of the model line, the team tackled the next challenge, the machine head line, a more diverse and complex product. The result is our new moving line."

With wind turbine design, manufacturing and assembly facilities in Germany, Spain and the United States, GE Energy is among the world's major providers of wind energy products and support services ranging from commercial wind turbines and grid integration products to project development assistance and operation and maintenance.

Alternative Fuel More Efficient With Dual-Catalyst System

As the United States' oil reserves dwindle, some say the nation will have to rely on synthetic petroleum fuel made from its large stores of coal.

A two-step chemical process augments a method of making cleaner-burning alternative fuel from coal and other carbon sources by transforming some of its waste products into diesel fuel, researchers from the University of North Carolina at Chapel Hill and Rutgers, the State University of New Jersey, report.

"Two percent of the United States' energy reserves is in oil, 3 percent is in gas, and 95 percent is in coal," said Dr. Maurice Brookhart, W.R. Kenan Jr. professor of chemistry in UNC's College of Arts and Sciences, lincolntribune.com said.

"Many people in the energy sector think that when oil starts to run out, coal will be a source of transportation fuel for some time before we perfect the science behind solar and hydrogen-based energy. Producing diesel fuels from coal is especially attractive since diesel engines are more efficient than gasoline

engines."

The Fischer-Tropsch method of making synthetic liquid fuels from coal and other carbon sources has been used since the 1920s. Today, Fischer-Tropsch fuels power most large vehicles in South Africa, and American companies have expressed interest in these fuels, which emit fewer particulates and less carbon monoxide than conventional diesel fuels. Such fuels have been termed "green diesel."

The cost of making Fischer-Tropsch fuels has been considered prohibitive. "But right now, with oil this expensive, I think it will soon become a competitive process to make liquid fuels," said Brookhart, an author of the study, which is published Friday (April 14) in the journal Science.

Dr. Alan S. Goldman, professor of chemistry and chemical biology at Rutgers, is the lead author of the study.

The Fischer-Tropsch reaction creates hydrocarbon compounds called alkanes. Methane and ethane are examples of alkanes. Some of the alkanes created by Fischer-Tropsch are desirable for use as fuel, but others have low molecular

weights that make them unsuitable.

"The process we have developed allows one to convert more of these Fischer-Tropsch materials to usable diesel fuels," said Brookhart.

"It's accomplished by a dual-catalyst system that allows us to take low molecular weight alkanes with between four and nine carbons in the chain and boost their weights up to a range appropriate for diesel fuel (10 to 19 carbons)," he added.

Brookhart said that in the dual-catalyst system, "one catalyst removes hydrogen, converting the alkane to a new material that contains carbon-carbon double bonds." Those double bonds make the new material more reactive, he added.

"Then a second catalyst 'scrambles' the carbon bonds, creating compounds with higher molecular weights. The first catalyst then returns the hydrogen atoms to the rearranged compounds, yielding alkanes that are usable as fuel.

Currently, a process termed hydrocracking is used to break down hydrocarbons with molecular weights too high for fuel use into lower molecular weight materials, but

the process is not very selective. "The catalyst system we used can combine very low molecular weight and very high molecular weight alkanes to produce alkanes in the diesel fuel range and, thus, may also prove useful for recovering value from high molecular weight materials," Brookhart said.

The investigations are in the early stages, and Brookhart added that "considerable improvements in the catalyst systems are required before they become practical. We are working hard on that."

The other authors of the study, in addition to Brookhart and Goldman, are Rutgers postdoctoral research associate Dr. Ritu Ahuja; postdoctoral research associate Dr. Amy H. Roy and research assistant Dr. Zheng Huang, both of UNC's department of chemistry; and Dr. William Schinski, a chemist with Chevron Research and Technology Company.

The research was sponsored by a grant from the National Science Foundation Center for the Activation and Transformation of Strong Bonds (CATSB), of which Brookhart and Goldman are members.

Ride Hydrogen Highway

The 2010 Olympic and Paralympic Games, to be held in Vancouver, will provide a glimpse into tomorrow's transportation world and the fuel set to power the future. The Hydrogen Highway, as it is called, is an integral part of British Columbia's Fuel Cell Strategy—a strategy aimed at making the province one of the leading lights in the hydrogen economy by 2020.

Launched as a demonstration program in 2002, the Hydrogen Highway will form a corridor that runs between Vancouver International Airport, the City of Vancouver and Whistler, with branches connecting Victoria, North Vancouver, the University of British Columbia and B.C. Hydro's Powertech Labs in nearby Surrey. Beyond 2010, the plan is to link this network to similar projects in Alberta and California.

The North Vancouver location is particularly interesting, as it provides the answer to a thorny question: Where will the hydrogen come from? The hydrogen emitted as the byproduct of a sodium-chlorate manufacturing plant in North Vancouver delivers 600 kilograms of hydrogen an hour. This is enough to refuel 20,000 vehicles once a week for an entire year, fuel-

cellworks.com said.

The other side of the technology needed to make the Hydrogen Highway work as envisioned is the fuel cell. While many view this complex device as a modern invention, the first one was actually produced in 1839. Sir William Grove noted that running an electric current through water split it into its two constituent parts, hydrogen and oxygen. He figured that if it worked the other way, it should work

other. To test his theory, Grove built the world's first fuel cell. In a delightful twist of irony, interest in his invention quickly waned because of the dawning of a new age and fuel source gasoline. Since then, the fuel cell has come a long way. Consider the unit that powers Honda's FCX. It addresses two of the problems that plagued many early fuel cell-powered vehicles. In the past, efficiency and getting the fuel cell to operate in cold weather were major headaches. The FCX's fuel cell, designed and built in-house by Honda, not only delivers an increased driving range and better efficiency (the 304 kilometers it squeezes out of each fill-up is 20 percent greater than the fuel cell it replaces), it also has the ability to function at temperatures as low as -20°C. Outwardly, decals aside,



Launched as a demonstration program in 2002, the Hydrogen Highway will form a corridor that runs between Vancouver International Airport, the City of Vancouver and Whistler.

there is little to tell the onlooker that the FCX is anything other than just another new Honda. It is marginally larger than the Honda Fit and slightly smaller than the Element, it seats four adults comfortably and handles exactly as expected. Likewise, aside from the taller step up into the cabin (needed so the fuel tanks and fuel cell can be packaged under the car) and the extra dial on the dash (it shows what the system is doing), there is very little to give the game away. It not only comes with all the modern conveniences (air conditioning, cruise control and so on), it also features traction control and anti-lock brakes. In other words, it has everything you expect from a modern car.

It is also a remarkable vehicle made all the more remarkable by the manner in which all of this complex

technology remains invisible to the driver. Step on the gas and it moves smoothly off the line without the usual mechanical noise. Indeed, aside from the slight whirring from the fuel cell's numerous fans and the electric motor that drives the vehicle, it is all but silent. It also outperforms expectations. On the drive from Vancouver to Whistler and back, it passed slower-moving vehicles with a reassuring turn of speed. The secret lies in the electric motor's ability to deliver its 200 pound-feet of torque from rev-one (a gasoline engine needs to get up to speed before delivering its goods). This is enough to deliver a top speed of 150 kilometers an hour and a zero-to-100-km/h time of around 10.5 seconds.

Most importantly, however, is what the fuel cell does for the environment.