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NANOGENERATORS

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ABSTRACT

Our body produces energy in various forms. Just a small fraction of this energy is sufficient to power implanted medical devices like pacemakers. When we take a closer look at the tiny power plants, harnessing the energy of our body we could find nanotechnology has huge potential to achieve this. Nano size machines will need a power source that is better than batteries and measures just billionths of a meter. Arrays of piezoelectric Nano wires could capture and transmit that waste to Nano devices. These power plants are called "Nanogenerators". It is found that when an atomic force microscope (AFM) bends straight, vertical nanowires; a strain field is established, with the stretched surface showing positive strain and the compressed surface showing negative strain. As the tip of the AFM scans over the Nano wires for each contact position there is voltage varying from 0-6.5mv. The piezoelectric effect creates an electric field inside the nanowires's volume. A rectangular electrode with ridged underside sits atop the nanowires and moves side to side in response to external forces such as vibration, human pulse and acoustic waves. The human body is a source of power, a small fraction of this energy when converted into electricity is sufficient to power many types of nanodevices. Other than body movement, various routes are being tried by researchers for power generations on mini scale. Medical devices are likely to be a major application for nanogenerators. Using these tiny power plants, autonomous strain sensors for structures like bridges and environmental sensors for toxin detection could also be run without the need for replacement batteries. They can also supply energy to nanorobotics and microelectromechanical systems(MEMS).These are being used in accelerometers of automobile air-bag systems, inkjet printer nozzles and a host of other systems. "This stuff will be pushed out to the commercial realm soon".

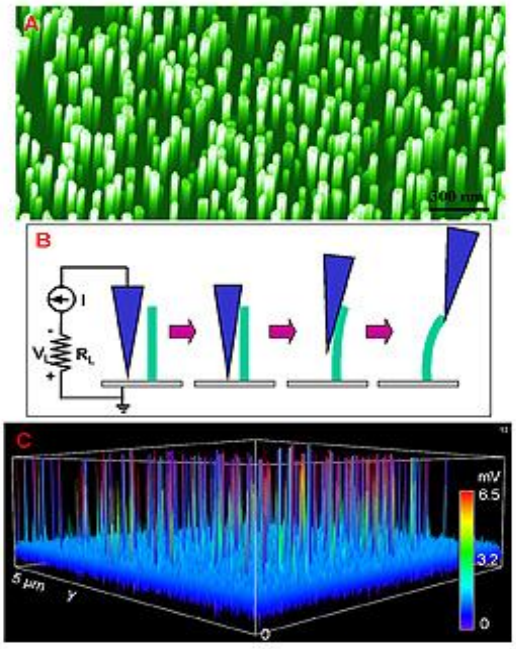
1. INTRODUCTION

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. There is a lot of mechanical energy available in our environment; our nanogenerators can convert this mechanical energy to electrical energy. This could potentially open up a lot of possibilities for the future of nanotechnology. A broad range of nanoscale devices are developed, 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.

2. ZINC OXIDE NANOWIRE

A very small piezoelectric discharge created when zinc oxide nanowires are bent and then released. By building interconnected arrays containing millions of such wires, we can produce enough current to power nanoscale

devices. To study the effect we can grow arrays of zinc oxide nanowires, and then use 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.



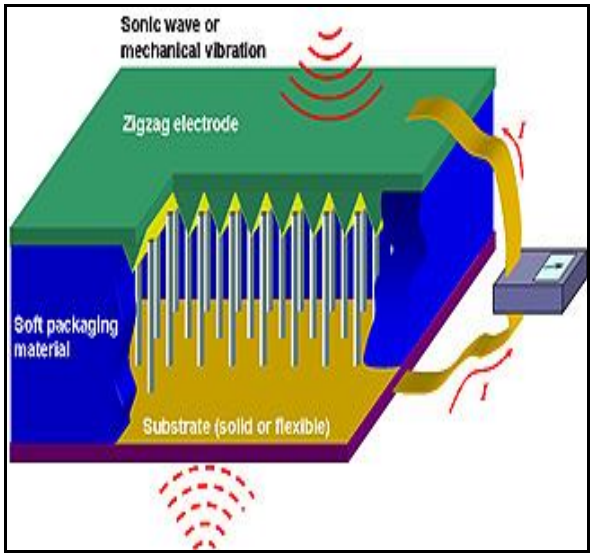
The nanowires arrays are grown using a standard vapor-liquid-solid process in a small tube furnace. First, gold nanoparticles were deposited onto a sapphire substrate placed in one end of the furnace. An argon carrier gas was then flowed into the furnace as zinc oxide powder was heated. The nanowires 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.

OPERATION

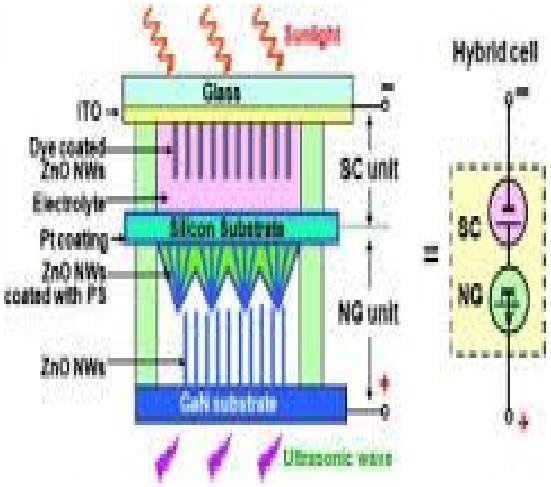
Schematic shows the direct current nanogenerator built using aligned ZnO nanowires arrays with a zigzag top electrode. The nanogenerator is driven by an external

ultrasonic wave or mechanical vibration and the output current is continuous.



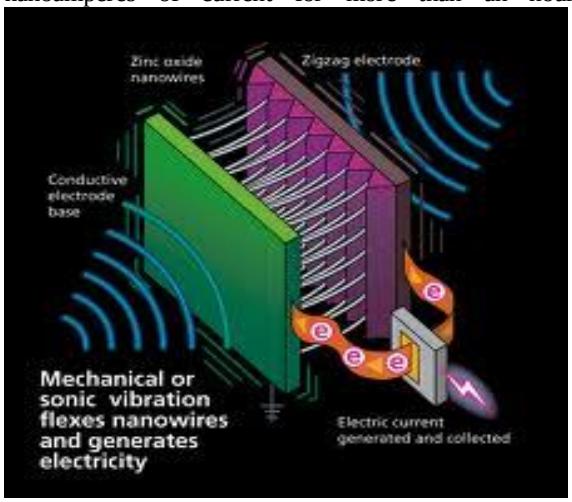
Nanogenerator allows us to harvest or recycle energy from many sources to power these devices. The electrode is then lowered on top of the nanowires array, leaving just enough space so that a significant number of the nanowires are free to flex within the gaps created by the tips. Moved by mechanical 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 similar to those of an AFM, the new zigzag electrode serves as a Schottky barrier to hundreds or thousands of wires simultaneously, harvesting energy from the nanowires arrays. Producing the top electrode as a single assembly sets the stage for scaling up this technology. Schottky barrier, helping accumulate and preserve the electrical charge as the nanowires flexed – and ensuring that the current flowed in one direction. If you had a device like this in your shoes when you walked, you would be able to generate your own small current to power small electronics.



SOURSES OF NANOGENERATORS
Nanogenerator Fueled by vibrations

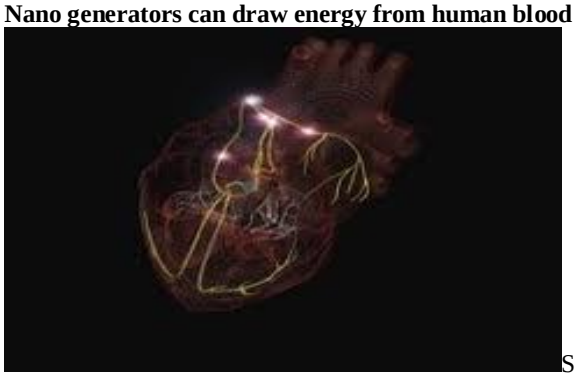
An array of zinc-oxide nanowires that generates current when vibrated with ultrasonic waves could provide a new way to power biological sensors and nanodevices. Ultrasonic waves vibrate an array of zinc-oxide nanowires, a tiny generator that can produce direct current. We can make each and every wire simultaneously and continuously produce electricity. About two millimeters square, that generates around 0.5 nanoamperes of current for more than an hour.



The technique essentially provides a new method of power generation; generator could be coupled with devices that are difficult or inefficient to power using conventional means. One important application is powering implantable biological sensors.

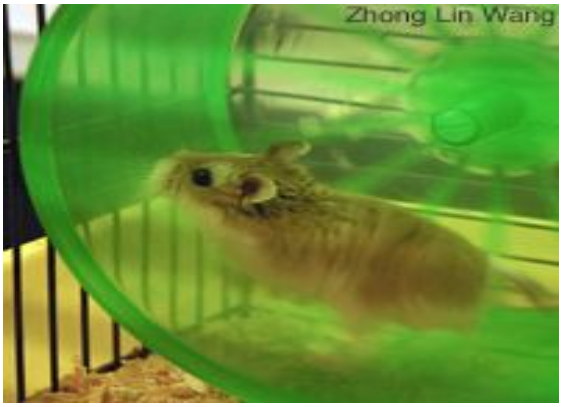
Nanoscale biological sensors limit the use of microelectromechanical sensors that measure cancer biomarkers, blood pH, and glucose. These sensors are getting smaller and smaller, but conventional chemical batteries can't keep up. The generator could also drive nanodevices. The nanowires pressure sensors can detect extremely small piconewton forces as well as nanowires gas sensors. Instead of an external battery, these devices could run on wind or water flow using the new generator.

Nano generators can draw energy from human blood



Scientists are working on a new type of nanogenerator that could draw the necessary energy from flowing blood in the human body, by using the beating heart and pulsating blood vessels. Once completed, this new cellular engine could find various applications, even beyond medicine. A personal electronics that will require no fuel source, internal or external. It will produce its own electricity while immersed in biological fluids or other liquids, using ultrasonic waves as the energy source. So far, they achieved the nanogenerator effect in an array of nanowires that could produce as much as 4 watts/cubic centimeter. Our bodies are good at converting chemical energy from glucose into the mechanical energy of our muscles; nanogenerators can take that mechanical energy and convert it to electrical energy for powering devices inside the body. Thus far, the nanogenerator has only produced nanoamperes of power-too little for powering macroscopic devices. A prototype will produce microamperes, capable of powering wireless sensor network nodes.

Nanogeneration using muscle power:



Sunlight, wind, and waves aren't the only sources of renewable energy. We have to hope power nanoscale devices with muscle power. Using nanotechnology, we can convert even irregular biomechanical energy into electricity; this technology can convert any mechanical disturbance into electrical energy. The hamster is wearing a jacket affixed to a nanogenerator that harvests every heartbeat and every fidgety movement that a person makes while sitting at a computer carries with it a small amount of energy that could potentially be scavenged. However, harvesting this biomotion is challenging because so much of it is irregular. A nanogenerator can be driven by irregular, low-energy biomotion, including the tapping of a human finger. The energy generated by the device is currently small (about a nanowatt), but this is still an important step along the road to developing useful power sources for nanoscale devices.

APPLICATIONS

Nanogenerator charge iPods and cell phones:

Imagine if all you had to do to charge your iPod or your BlackBerry was to wave your hand, or stretch your arm, or take a walk? You could say goodbye to batteries and never have to plug those devices into a power source again. The researchers will have a major impact on defense technology, environmental monitoring, biomedical sciences and even personal electronics. Quite simply, this technology can be used to generate energy under any Circumstances as long as there is movement.

Curing of cancer:

Molecular 'nanogenerator' developed that can target cancer cells and destroy them Nanogenerator releases a cascade of atomic fragments known as alpha particles on the inside of cancer cells. These nanogenerators consist of a single radioactive atom contained inside a molecular cage and attached to an antibody that homes in on cancer cells -- carrying the generator to the interior of those cells and destroying them. We have found an effective way of containing and then delivering this highly potent element directly into cancer cells. The investigators tested the nanogenerators in cell culture in a variety of human cancer cell types: leukemia, lymphoma, breast, ovarian, neuroblastoma, and prostate. They found the nanogenerators could kill all these types of cancer cells at extremely low concentrations.

Power Shirt: Nanotechnology in Clothing, Could Harvest Energy from Body Movement:

Close-up image shows a pair of entangled fibers that make up a microfiber nanogenerator. Both fibers are coated with zinc oxide nanowires; one fiber is additionally coated with gold. When rubbed together, they generate electrical current.

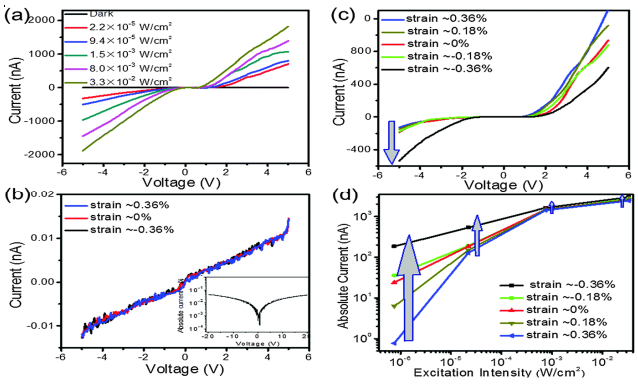
Nanotechnology researchers are developing the perfect complement to the power tie: a "power shirt" able to generate electricity to power small electronic

devices for soldiers in the field, hikers and others whose physical motion could be harnessed and converted to electrical energy.

Combining current flow from many fiber pairs woven into a shirt or jacket could allow the wearer's body movement to power a range of portable electronic devices. The fiber-based nanogenerator would be a simple and economical way to harvest energy from physical movement. If we can combine many of these fibers in double or triple layers in clothing, we could provide a flexible, foldable and wearable power source that, for example, would allow people to generate their own electrical current while walking.

Medical devices:

Medical devices are likely to be major application for nanogenerators. People fitted with battery-powered pacemakers need surgery every few years just to get the battery replaced. That can cost as much as Rs 80,000 a time. Also, the patients have to go through the pain of having their chest cavity opened to get the work done. By adding a few sensors, the body's inner power can be harnessed to convert it into electricity – in the range of micro watts to few milliwatts and recharge the pacemaker's battery so it does not need replacement.



Characteristics of voltage and current

CONCLUSION

Generators could be used to power sensors for detecting cancer or measuring blood sugar level for diabetics. Within five to 10 years, the technology will mature to the point that these generators could be placed in the soles of shoes or the fabric of clothes so that people will be able to power their iPods and cell phones using the mechanical energy created by the rustling of their clothes .A major advantage of this new technology is that many nanogenerators can produce electricity continuously and simultaneously. "Soon this stuff will be pushed out to commercial realm."

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