Self-powered devices possible, researcher says

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Imagine a self-powering cell phone that never needs to be charged because it converts sound waves produced by the user into the energy it needs to keep running. It's not as far-fetched as it may seem thanks to the recent work of Tahir Cagin, a professor in the Artie McFerrin Department of Chemical Engineering at Texas A&M University.

Utilizing materials known in scientific circles as "piezoelectrics," Cagin, whose research focuses on nanotechnology, has made a significant discovery in the area of power harvesting – a field that aims to develop self-powered devices that do not require replaceable power supplies, such as batteries.

Specifically, Cagin and his partners from the University of Houston have found that a certain type of piezoelectric material can covert energy at a 100 percent increase when manufactured at a very small size – in this case, around 21 nanometers in thickness.

What's more, when materials are constructed bigger or smaller than this specific size they show a significant decrease in their energy-converting capacity, he said.

His findings, which are detailed in an article published this fall in *Physical Review B,* the scientific journal of the American Physical Society, could have potentially profound effects for low-powered electronic devices such as cell phones, laptops, personal communicators and a host of other computer-related devices used by everyone from the average consumer to law enforcement officers and even soldiers in the battlefield.

Many of these high-tech devices contain components that are measured in nanometers – a microscopic unit of measurement representing one-billionth of a meter. Atoms and molecules are measured in nanometers, and a human hair is about 100,000 nanometers wide.

Though Cagin's subject matter is small, its impact could be huge. His discovery stands to advance an area of study that has grown increasingly popular due to consumer demand for compact portable and wireless devices with extended lifespans.

Battery life remains a major concern for popular mp3 players and cell phones that are required to perform an ever-expanding array of functions. But beyond mere consumer convenience, self-powering devices are of major interest to several federal agencies.

The Defense Advanced Research Projects Agency has investigated methods for soldiers in the field to generate power for their portable equipment through the energy harvested from simply walking. And sensors – such as those used to detect explosives – could greatly benefit from a self-powering technology that would reduce the need for the testing and replacing of batteries.

"Even the disturbances in the form of sound waves such as pressure waves in gases, liquids and solids may be harvested for powering nano- and micro devices of the future if these materials are processed and manufactured appropriately for this purpose," Cagin said.

Key to this technology, Cagin explained, are piezoelectrics. Derived from the Greek word "piezein," which means "to press," piezoelectrics are materials (usually crystals or ceramics) that generate voltage when a form of mechanical stress is applied. Conversely, they demonstrate a change in their physical properties when an electric field is applied.

Discovered by French scientists in the 1880s, piezoelectrics aren't a new concept. They were first used in sonar devices during World War I. Today they can be found in microphones and quartz watches. Cigarette lighters in automobiles also contain piezoelectrics. Pressing down the lighter button causes impact on a piezoelectric crystal that in turn produces enough voltage to create a spark and ignite the gas.

On a grander scale, some night clubs in Europe feature dance floors built with piezoelectrics that absorb and convert the energy from footsteps in order to help power lights in the club. And it's been reported that a Hong Kong gym is using the technology to convert energy from exercisers to help power its lights and music.

While advances in those applications continue to progress, piezoelectric work at the nanoscale is a relatively new endeavor with different and complex aspects to consider, said Cagin.

For example, imagine going from working with a material the size and shape of a telephone post to dealing with that same material the size of a hair, he said. When such a significant change in scale occurs, materials react differently. In this case, something the size of a hair is much more pliable and susceptible to change from its surrounding environment, Cagin noted. These types of changes have to be taken into consideration when conducting research at this scale, he said.

"When materials are brought down to the nanoscale dimension, their properties for some performance characteristics dramatically change," said Cagin who is a past recipient of the prestigious Feynman Prize in Nanotechnology. "One such example is with piezoelectric materials. We have demonstrated that when you go to a particular length scale –

between 20 and 23 nanometers – you actually improve the energy-harvesting capacity by 100 percent.

"We're studying basic laws of nature such as physics and we're trying to apply that in terms of developing better engineering materials, better performing engineering materials. We're looking at chemical constitutions and physical compositions. And then we're looking at how to manipulate these structures so that we can improve the performance of these materials."

Source: Texas A&M University

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