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Award-winning energy harvester brings practical applications closer

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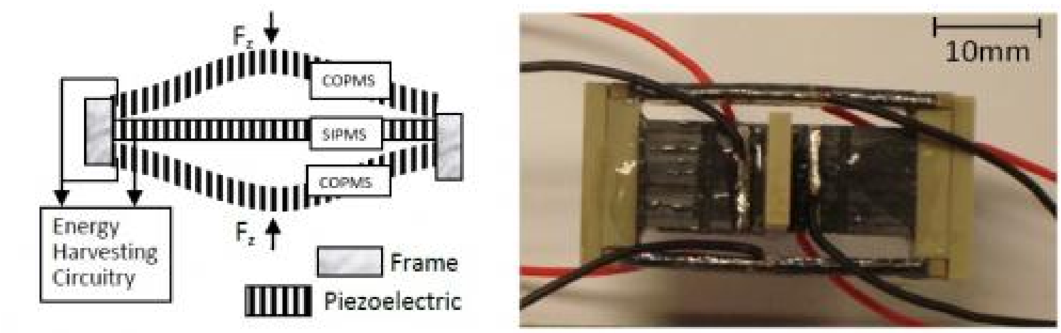

(Left) A diagram of the piezoelectric harvester with one straight inner piezoelectric multilayer stack (SIPMS) and two curved outer piezoelectric multilayer stacks (COPMSs). (Right) A photo of the first piezoelectric harvester prototype. Image credit: Tian Bing Xu, et al.

(PhysOrg.com) -- Although the idea of harvesting ambient energy from the environment and using it to generate electricity is alluring, most of the technology so far is capable of generating only very small amounts of power - on the order of microwatts to a few milliwatts with very low conversion efficiency. But a new piezoelectric energy-harvesting transducer shows that the technology is significantly improving. Researchers have predicted that 1-3 watts can be generated from a person walking when wearing a pair of shoes integrated with the new energy harvester, which is enough to power a soldier’s portable communication devices on the battlefield, among other applications.

The piezoelectric energy-harvesting transducer was developed by a team of researchers led by Dr. Tian Bing Xu from the National Institute of Aerospace in Hampton, Virginia, in collaboration with NASA Langley Research Center, North Carolina State University, Stony Brook University, and TRS Technologies. The hybrid device combines two types of piezoelectric multilayer elements (one straight inner element sandwiched between two curved outer elements) with synergistically integrated force magnification, leading to advantages in several areas. Most notably, the transducer produces 19 times more electrical energy than current top piezoelectric transducers, and up to 1,000 times more electrical energy than a regular piezoelectric beam. Also, while the best piezoelectric transducers have mechanical-to-electrical conversion efficiencies of less than 7%, the new transducer achieves an efficiency of 26%.

These improvements recently resulted in the new piezoelectric harvester winning the award for Best Technical Development of an Energy Harvesting Device at the conference of Energy Harvesting and Storage USA 2011, in Boston, MA, on November 15-16, 2011. This category was judged on which organization had made the most significant technical achievement in energy harvesting over the past 18 months. The awards are part of the IDTechEx annual conference of Energy Harvesting and Storage USA, which was attended by over 360 people from 16 countries and featured 40 exhibitors.

The researchers have described the new piezoelectric harvester in more detail in a paper that is currently under NASA internal review. In a short description available on the website of Lei Zuo, coauthor and a professor at the State University of New York at Stony Brook, the researchers highlight a few important features that contribute to the device's superior performance. For one, the curved outer piezoelectric elements are relatively soft and bendable, resulting in more deformation (and absorbing greater mechanical energy) under a given applied force. The device also does a better job of coupling this mechanical energy into the piezoelectric materials since minimal non-piezoelectric materials are used. Another advantageous characteristic is that, when a force is applied vertically onto the device, the forces of both the straight and curved elements are amplified to the sides. This design feature enables the device to generate 2-3 orders of magnitude more electric charges under a given amount of vibration.

"As we mentioned in the pending paper, the critical challenge for piezoelectric energy harvesting is how to harvest electrical power on the order of tens of milliwatts to several watts, which is good enough for powering most portable devices, from any kinds of vibration and motion at any ranges of vibration frequencies (off-resonance mode harvesting technology is needed)," Xu told *PhysOrg.com*. "The new piezoelectric transducer addresses several critical issues from energy absorption, coupling, and conversion efficiency to overcome those challenges."

In the future, the researchers hope that the new piezoelectric harvesters will be able to harvest enough energy to power different types of portable devices from the environment. In addition to being used in shoes, the harvesters could have applications in infrastructure health monitoring systems and sensor networks. Although the transducer works best when harvesting vibrations at a certain resonance, its high efficiency enables it to still use off-resonant vibrations for low-power devices, such as some sensors.

"Piezoelectric energy harvesting is a multidisciplinary issue to be addressed from the considerations of mechanical engineering, electrical engineering, material science, and system engineering," Xu said. "For each individual mechanical vibration or motion resource, a specific device is designed to get an optimized electrical energy output. Our team is confident that we can move the energy harvesting technology into a new era."