MEMS device generates power from body heat

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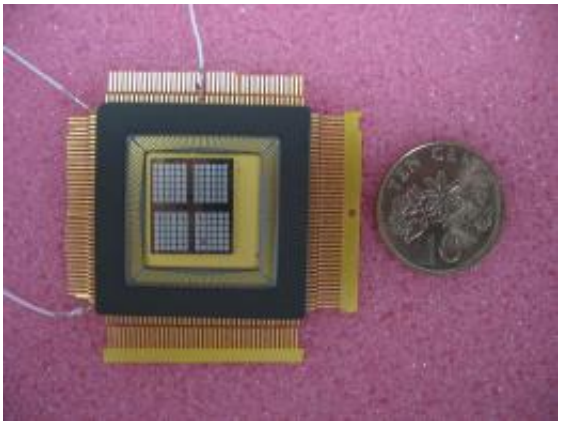

A prototype of the thermoelectric power generator assembled in a ceramic package and placed next to a Singapore ten-cent coin. Image credit: Jin Xie, et al.

(PhysOrg.com) -- In an attempt to develop a power source that is compact, environmentally friendly, and has an unlimited lifetime, a team of researchers from Singapore has fabricated an energy harvesting device that generates electricity from body heat or any environment where there is a temperature gradient. Their device, called a thermoelectric power generator, attaches to the body and generates a power output of a few microwatts, which could be useful for powering implanted medical devices and wireless sensors.

The researchers, Jin Xie and Hanhua Feng from Institute of

Microelectronics, A*STAR, Singapore's government Agency for Science, Technology and Research, along with Chengkuo Lee from the National University of Singapore, have published their study in a recent issue of the *Journal of Microelectromechanical Systems.*

The entire generator consists of a chip with a size of 1 x 1 cm^2, which holds more than 30,000 thermocouples. The thermocouples, when arranged in groups called thermopiles, detect a temperature difference between the hot and cold junctions and produce a voltage. With a temperature difference of 5K, the device can generate a voltage of 16.7 volts and a power output of 1.3 microwatts. The researchers hope that future improvements to the device could increase the power output to several microwatts. By accumulating this energy over time, it could be used to prolong the battery life of electronic devices such as pressure sensors, and also recycle heat generated from the devices during operation. By powering the wearer's medical implants, this technology could enable patients to avoid difficult, high-cost battery replacement methods.

Although similar devices have previously been developed that generate electricity from body heat, the new power generator makes several improvements that increase its overall energy efficiency. For example, the researchers incorporated vacuum cavities, a heat-sink layer, and a peripheral cavity, which are aimed at increasing the temperature difference between the side of the generator touching the body and the side exposed to ambient (cooler) air. The greater the temperature difference between the two sides of the generator, the greater the output voltage.

"The advantages include (1) top and bottom vacuum cavities are created to maximize the temperature difference between the two junctions of the thermocouples; (2) a heat sink layer is on the cold side of the device to effectively disperse heat from the cold side of the device to ambient

air; and (3) a peripheral cavity is designed to cut off heat from the surrounding silicon substrate, so that cold junctions of thermocouples at the rim edge of the device area are not affected by the heat coming from the surrounding silicon," Xie explained to *PhysOrg.com*.

As Xie added, another advantage of the new thermoelectric power generator is that it is CMOS-compatible, meaning it can be fabricated in normal CMOS manufacturing lines. This feature allows the generator to serve as a novel on-chip power source for self-powered CMOS and MEMS devices that have low power consumption requirements.

More information: Jin Xie, Chengkuo, and Hanhua Feng. "Design, Fabrication, and Characterization of CMOS MEMS-Based Thermoelectric Power Generators." Journal of Microelectromechanical Systems, Vol. 19, No. 2, April 2010.