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Body motion energy harvester may power medical and consumer wearable devices

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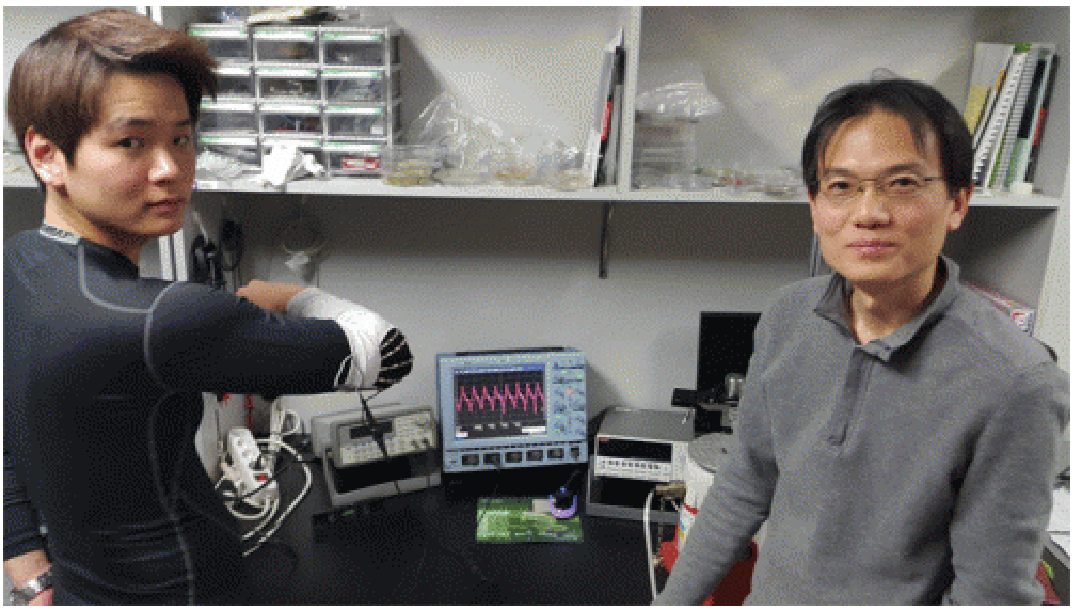


Measurement of the device implemented in wearable form: here, five of the structures connected in parallel cope with the full range of motion of the elbow joint. (left: Mr. Jinwoo Lee, right: Prof. Kwang-Seok Yun)

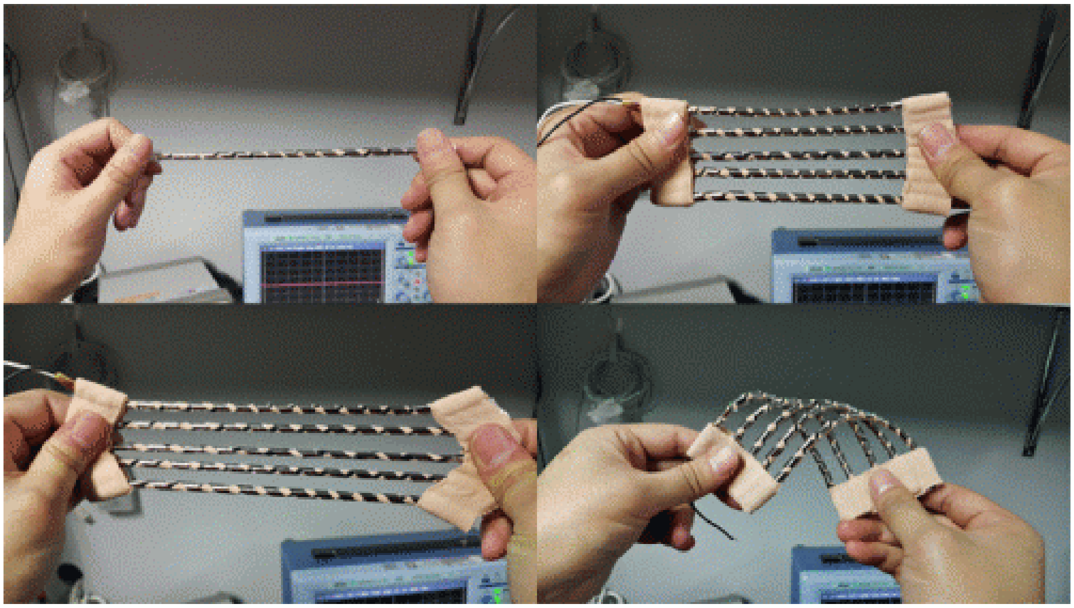
A body motion energy harvester, with the flexibility and elasticity to be applied to high-flexion joints and suitable for integration with fabrics, is being developed by researchers at Sogang University in Korea. The design is aimed at providing power for medical and consumer wearable devices.

At full stretch

With growing interest in wearable electronic devices, there is a need to find different power sources, especially to alleviate the need for regular charging or battery changes. Fortunately, the human body provides several potential energy sources, including heat and motion, and is routinely exposed to other sources like friction and light. These can be exploited using energy harvesting technologies to provide power for wearable devices, from medical and sports body sensors and networks, to mobile phone battery chargers.

Motion or kinetic energy harvesters have the advantage of being less reliant on the external environment (e.g. light and humidity), and shoe-based devices have already been shown to be capable of producing significant power levels. The goal of the team at Sogang University's Micro & Nano Engineering Laboratory (MNELAB) is to create energy harvesting technologies that get useful energy from only "wearing and moving" and can be applied to many other parts of the body.

Kinetic energy harvesters mounted on flexible substrates for application in clothing have been presented before, but have been limited in their range of flexibility and elasticity. This is a key problem as it prohibits their use where kinetic energy is potentially most abundant, i.e. around body joints with a large range of motion – the knee, elbow, hip, shoulder – and around muscles with large dimension changes in expansion and contraction.



Clockwise from top left: A single structure consists of a double-helix of piezoelectric polymer strip and fabric strap around an elastic support material core; multiple structures can be connected in parallel; each can be elastically stretched to 1.6 times their rest length; it is also extremely flexible

Elastic in structure

In their current Letter, the MNELAB team have presented a very flexible harvester design that can elastically stretch to 1.6 times its normal length, allowing it to be used on a large range of motion body areas.

"Existing flexible energy harvesters have little elasticity because they use plastic substrates that are flexible but not elastic," said MNELAB researcher Prof.Kwang-Seok Yun. "Therefore, it's difficult to harvest energy effectively in those areas. This may lead to degradation of the device performance or damage due to excessive tensile force. Our suggested device, on the other hand, has high flexibility and elasticity, from a helical spring structure and an elastic support material, which helps to harvest energy effectively."

The polymer piezoelectric film used in the device is not elastic itself, the final structure's elasticity comes from shaping the piezoelectric film and a fabric strap into a double-helical spring structure and introducing air gaps between the piezoelectric film and the elastic support material to allow the two materials to move relative to each other.

This design could be applied to the body as part of a bandage or patch or incorporated in clothing. It is also designed to harvest energy from the body's low-frequency natural motions, such as bending expansion or stretching, not from vibration energy or from repeated prescribed motions that some devices require.

Power dressing

From the results they have obtained in the laboratory, the team expect that in actual body-worn application, a 10 x 10 cm square patch incorporating these structures should be capable of producing several dozen milliwatts, which is the power level of some hearing aids, pacemakers, neurological stimulators and cochlea implants. It would also be sufficient for use as an auxiliary power source for a smart phone or smart watch.

For the longer term, the team are working to increase the power output through connecting multiple structures in parallel and series, and analysing the energy conversion processes involved, with the target of achieving hundreds of milliwatts output. This would allow applications as a main power source. They also believe that the output could be increased through miniaturising the individual structures, which are currently around 4 mm in diameter, moving toward creating similar structures using fine helical threads that would also aid incorporation with clothing.

"In future, smart phones and any other wearables may be charged automatically from body motion simply by carrying them on your person, without needing external electrical outlets to charge them. Smart phones themselves may be replaced with wearable devices or smart clothes," said Yun.

More information: Highly stretchable energy harvester using piezoelectric helical structure for wearable applications, DOI: 10.1049/el.2014.3400

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