Stretchable, wearable device lights up an LED using only the warmth of skin

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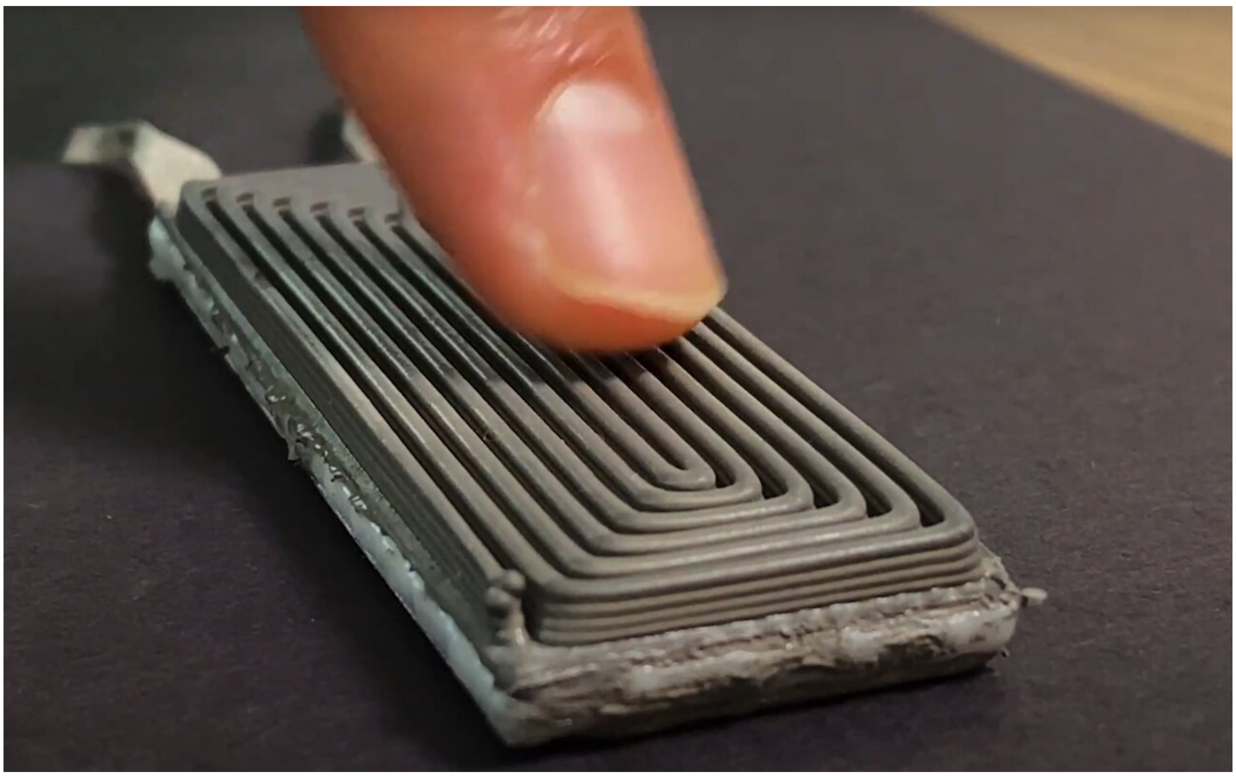

Credit: University of Washington

One of the drawbacks of fitness trackers and other wearable devices is that their batteries eventually run out of juice. But what if in the future, wearable technology could use body heat to power itself?

UW researchers have developed a flexible, durable electronic prototype that can harvest energy from body heat and turn it into electricity that can be used to power small electronics, such as batteries, sensors or LEDs. This device is also resilient—it still functions even after being pierced several times and then stretched 2,000 times.

The team detailed these prototypes in a paper published Aug. 30 in *Advanced Materials*.

"I had this vision a long time ago," said senior author Mohammad Malakooti, UW assistant professor of mechanical engineering. "When you put this device on your skin, it uses your body heat to directly power an LED. As soon as you put the device on, the LED lights up. This wasn't possible before."

Traditionally, devices that use heat to generate electricity are rigid and brittle, but Malakooti and team previously created one that is highly flexible and soft so that it can conform to the shape of someone's arm.

This device was designed from scratch. The researchers started with simulations to determine the best combination of materials and device structures and then created almost all the components in the lab.

It has three main layers. At the center are rigid thermoelectric semiconductors that do the work of converting heat to electricity. These semiconductors are surrounded by 3D-printed composites with low thermal conductivity, which enhances energy conversion and reduces the device's weight.

To provide stretchability, conductivity and electrical self-healing, the semiconductors are connected with printed liquid metal traces. Additionally, liquid metal droplets are embedded in the outer layers to improve heat transfer to the semiconductors and maintain flexibility because the metal remains liquid at room temperature. Everything except the semiconductors was designed and developed in Malakooti's lab.

In addition to wearables, these devices could be useful in other applications, Malakooti said. One idea involves using these devices with electronics that get hot.

"You can imagine sticking these onto warm electronics and using that excess heat to power small sensors," Malakooti said. "This could be especially helpful in data centers, where servers and computing equipment consume substantial electricity and generate heat, requiring even more electricity to keep them cool.

"Our devices can capture that heat and repurpose it to power temperature and humidity sensors. This approach is more sustainable because it creates a standalone system that monitors conditions while reducing overall energy consumption. Plus, there's no need to worry about maintenance, changing batteries or adding new wiring."

These devices also work in reverse, in that adding electricity allows them to heat or cool surfaces, which opens up another avenue for applications.

"We're hoping someday to add this technology to virtual reality systems and other wearable accessories to create hot and cold sensations on the skin or enhance overall comfort," Malakooti said. "But we're not there yet. For now, we're starting with wearables that are efficient, durable and provide temperature feedback."

More information: Youngshang Han et al, 3D Soft Architectures for Stretchable Thermoelectric Wearables with Electrical Self-Healing and Damage Tolerance, *Advanced Materials* (2024). DOI: 10.1002/adma.202407073

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