PRESS RELEASE

Gwangju Institute of Science and Technology Researchers Develop a Novel Thermoelectric Generator Inspired from Zebra Skin

The novel design is flexible, lightweight, and completely biodegradable, suggesting its potential for developing scalable, renewable energy systems

Conventional thermoelectric generators (TEGs), devices that convert heat to electricity, are bulky and rigid as they require out-of-plane heating and cooling areas to create a temperature difference. To tackle this, researchers from Korea have now designed a new flexible, soft, and biodegradable TEG that uses a zebra stripe pattern to create in-plane large temperature difference. The design is also easier to integrate with other electronic components, making it a sustainable choice for energy harvesting.

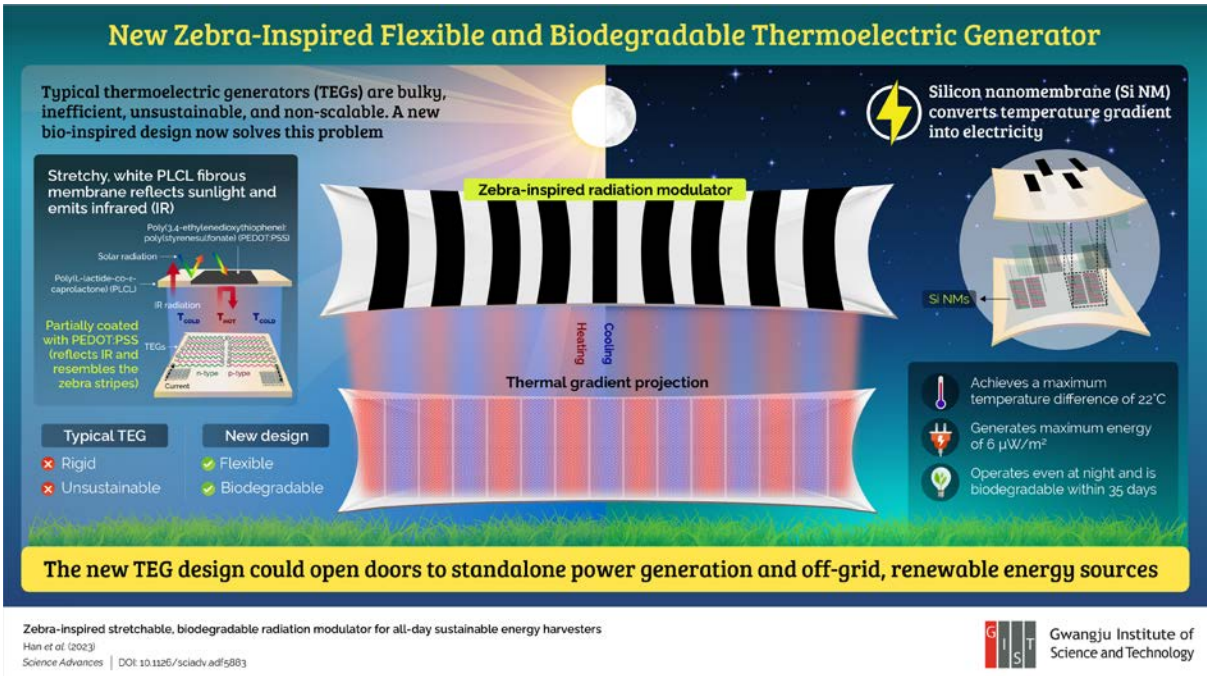

Image title: A flexible and biodegradable thermoelectric generator inspired from zebra skin.

Image caption: GIST researchers propose, in a news study, a novel thermoelectric generator design that incorporates a zebra-striped pattern to generate a large in-plane temperature gradient, which can then be converted into electricity using silicon nanomembranes. Further, the device is flexible, scalable, lightweight, eco-friendly, and integrable into other components.

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Thermoelectric generators (TEG) are devices that can convert temperature gradients to electricity. Such devices are extremely useful for generating electricity for remote sensors that cannot be connected to the main electricity grid. A conventional TEG is composed of one side(top or bottom) that radiates heat to cool down and the other side that absorbs heat from the sun or the environment. This, in turn, generates out-of-plane temperature gradient, which is converted into electricity. However, such requirements often make for designs that are bulky, complex, and inefficient. This, in turn, makes TEGs hard to integrate with other components or systems, limiting their applications in renewable energy systems.

Fortunately, researchers from Korea may now have found a way to surmount these challenges. In a new study, the researchers, led by Professor Young Min Song from Gwangju Institute of Science and Technology (GIST), reported a new flexible, lightweight, and biodegradable TEG that gets its inspiration from an unlikely place – zebra skin. Essentially, the design uses a pattern resembling black-and-white zebra stripes to create a high in-plane temperature gradient for generating electricity. The breakthrough was published in Volume 9 Issue 5 of the journal *Science Advances* on 01 February 2023.

"*Traditional TEG designs are large and bulky as they rely on natural convection, which leads to an out-of-plane temperature gradient. This requires hard insulators, which limit the application of TEGs in flexible and wearable devices. We have now transcended this paradigm in our design by creating an in-plane device that is flexible and biodegradable. This increases its applicability while reducing its environmental impact by making it scalable, integrable, and sustainable,*" explains Prof. Song.

The researchers used poly(L-lactide-co-ε-caprolactone) (PLCL), a white, flexible, and biodegradable material, for manufacturing the TEG. PLCL reflects sunlight and emits infrared (IR) radiation, which allowed the area below it to be cool. On top of this material, the researchers applied black poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) or (PEDOT:PSS), which appears black to the eye, bringing out the stripes resembling that on the zebra skin against PLCL. The reason PEDOT:PSS appears black is because it absorbs the sunlight coming on it while reflecting the IR radiation coming from below it (emitted by the PLCL). This, in turn, increases the temperature of the area below the black stripes, creating alternating warm and cold regions, i.e., a temperature gradient, which can then converted into electricity.

The researchers achieved this conversion using an array of silicon nanomembranes in their design. The novel design was able to generate a maximum temperature difference of 22°C along with a maximum energy density of 6 $\mu W/m^2$. Moreover, the device was completely biodegraded without any remaining by-products with a mere span of 35 days.

With these remarkable properties, the new TEG design is sure to open doors to scalable, eco-friendly energy systems.
"*The pandemic caused the widespread use of disposable masks and protective equipment, which pose a huge environmental impact. This underscores the need for sustainable and eco-friendly solutions like TEGs that can incorporated in such wearable devices for performing specialized functions like self-power generation and sensing,*" highlights Prof. Song. *"Our design can fill in this gap thanks to its lightweight and biodegradable nature. It can also be integrated seamlessly into various energy and smart grid technologies to further enhance their functionality and impact,*" he concludes.

Reference

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Title of original paper: Zebra-inspired stretchable, biodegradable radiation modulator for all-day sustainable energy harvesters

Journal: *Science Advances*

DOI: 10.1126/sciadv.adf5883

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About the Gwangju Institute of Science and Technology (GIST)

The Gwangju Institute of Science and Technology (GIST) is a research-oriented university situated in Gwangju, South Korea. Founded in 1993, GIST has become one of the most prestigious schools in South Korea. The university aims to create a strong research environment to spur advancements in science and technology and to promote collaboration between international and domestic research programs. With its motto of "A Proud Creator of Future Science and Technology," GIST has consistently received one of the highest university rankings in Korea.

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About the author

Young Min Song is currently serving as a full professor of the school of electrical engineering and computer science(EECS) and an assistant/associate professor of the artificial intelligence (AI) Graduate School at Gwangju Institute of Science and Technology (GIST), Korea. He received his PhD in Information and Communications from GIST in 2011. From 2011–2013 , he was a postdoctoral research associate in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign (UIUC), USA. His group at GIST is developing advanced optoelectronic sensors/systems, multifunctional nanophotonics, flexible devices, optical healthcare systems, and radiative cooling devices/materials. He is a also the co-founder of FOEL Inc.