

## Printed Energy Harvesting Wearables

**This technology utilizes composite materials as the fabric additive to enable the development of stretchable high-performance thermoelectric power generators. The durability of the wearable device is improved by undergoing 15,000 stretching cycles without mechanical or electrical failure.**

### What is the Problem?

A thermoelectric generator can be implemented for stationary conditions to continuously harvest thermal energy. This type of generator can prevent thermal energy from being wasted due to heat flux and can respond effectively to both continuous and sporadic thermal stimuli. Using the temperature difference between the human body and the surrounding environment as an energy source, previous studies have attempted to integrate thermoelectric (TE) semiconductors into a wide range of material systems such as fibers, thin film, and soft polymers (i.e., elastomers). While each of these device architectures offer unique advantages for wearable applications, elastomers are a popular choice due to their high flexibility and stretchability. Primary elastomer-based TEGs with high performance can be designed by encapsulating rigid inorganic TE semiconductors and flexible conductors (i.e., copper films) encapsulated in silicone elastomers. The limiting factors in this design are non-flexible conductors which hinders stretchability and conformability of the device, the low thermal conductivity of elastomers that lowers the efficiency, and the complex fabrication process with large number of components. Continuous powering of wearable electronics and personalized biomonitoring systems remains a great challenge.

### What is the Solution?

The solution is an additive fabrication method for stretchable high-performance thermoelectric power generators. Through this unique fabrication process and synthesis of novel composite materials, the energy harvesting performance has increased by more than 7x. At the same time, the durability and structural integrity of the wearable is significantly improved; it can go through 15,000 stretching cycles without mechanical or electrical failure. This highly stretchable and efficient printed wearable thermoelectric generator system is achieved by 3D printing elastomer composites with engineered functional and structural properties at each layer.

### What is the Competitive Advantage?

This solution introduces flexibility paired with high stretchability and efficiency, allowing for a variety of applications in wearables and industry. Most thermoelectric generators are rigid, and so there have been few applications relying on body heat for power generation. This solution

### Technology ID

BDP 8493

### Category

Cleantech/Other  
Hardware/Sensors  
Materials/Power Electronics  
Selection of Available  
Technologies  
Cleantech/Energy  
Storage/Batteries

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#### Patent Information:

[WO2023211985A1](#)

#### References

1. Youngshang Han, Leif-Erik Simonsen, Mohammad H. Malakooti(44766) ,  
<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202201413>, Advanced Energy Materials
2. Youngshang Han, Leif-Erik Simonsen, Mohammad H. Malakooti(44766) ,  
<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202201413>, Advanced Energy Materials
3. Youngshang Han, Leif-Erik Simonsen, Mohammad H. Malakooti(44766) ,  
<https://onlinelibrary.wiley.com/doi/full/10.1002/aenm.202201413>, Advanced Energy Materials