Thermoelectric generator with time dependent oscillation (2023-017)

Cellulose-based thermoelectric generator harnesses low-grade waste heat for powering wearables, environmental sensors, and improving vehicle efficiency.

Market Overview

Modern electronic devices and vehicles lose a significant amount of energy as waste heat. Traditionally, research has focused on harvesting high-grade waste heat, while low-grade heat (below 100˚C) has been largely overlooked. This gap presents an opportunity to develop technologies that can convert low-grade waste heat into usable energy, thus improving energy efficiency and reducing operation costs.

Technical Summary

Clemson inventors have developed a thermoelectric generator that utilizes the Soret effect to harvest ultralow-grade waste heat. This innovative device utilizes cellulose from delignified wood, which creates a hierarchical porous structure for ion movement in an aqueous electrolyte. The device achieves a Seebeck coefficient of up to 110 mV/K, significantly higher than previous technologies, allowing it to generate substantial voltage from low-grade waste heat.

This invention has an additional observed feature of a novel thermally rechargeable electrochemical oscillation (TRECO) while discharging the device. This time-dependent oscillation property has the potential to open new applications beyond what current thermoelectric generators can achieve.

Applications include the following:

- Wearable Sensors: Powering health monitoring devices that require constant energy.
- Environmental Sensors: Providing energy for remote and autonomous environmental monitoring.
- Automotive Heat Scavenging: Harnessing waste heat from automotive engines and batteries to improve energy efficiency.
- Wireless Power Transmission: Facilitating long-distance energy transmission from waste heat.
- Green Energy Solutions: Providing sustainable energy

Development Stage

TRL 2/3

Benefits

- **High Efficiency**: Generates high voltage from ultralow-grade waste heat.
- **Eco-friendly Materials**: Utilizes green materials, reducing environmental impact.
- **Versatile Applications**: Ideal for powering health monitoring sensors, environmental sensors, and scavenging heat from automotive engines and batteries.
- **Innovative Capabilities**: Exhibits thermally rechargeable electrochemical oscillation, even without a temperature gradient.

App Type	Country	Patent No.	CURF Ref. No.	Inventors
Provisional Patent Application	United States	NA	2023-017	Dr. Apparao Rao

About the Inventors

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Dr. Apparao M. Rao currently serves as the Robert A. Bowen Endowed Professor of Physics in the Department of Physics and Astronomy at Clemson University and the founding director of the Clemson Nanomaterials Institute (CNI). He is known for developing Raman spectroscopy as a versatile tool for characterizing carbon nanomaterials, and for developing liquid-injection based synthesis methods for carbon nanotubes. Due to his sustained research in nanomaterials and for building competitiveness in the State of South Carolina, the Governor of South Carolina conferred on him in 2014 the State's highest honor - the Governor's award for excellence in scientific research. Four prestigious scientific societies - the American Physical Society, the American Association for the Advancement of Science, the Materials Research Society, and the National Academy of Inventors - elected him as a Fellow for lifetime recognition of his research, leadership, and service to the materials field.

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