



Silicon Nanomembrane Thermoelectric Materials and Devices

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing methods for fabricating nanowires and nanoribbons that form the core of improved thermoelectric materials and thermoelectric devices.

Overview

Thermoelectric materials can turn heat into electrical power or remove heat by applying a voltage. They are used in many applications, ranging from a simple, electrically cooled ice chest, to high-tech microprocessor cooling, to the industrial generation of electricity from exhaust heat.

Thermoelectric devices offer several advantages over currently available devices; however, the performance of these materials must be improved before such devices can replace conventional vapor compression or energy conversion devices.

The Invention

UW-Madison researchers have developed methods for fabricating nanowires and nanoribbons that form the core of improved thermoelectric materials and thermoelectric devices. A lithography-based approach is used to construct nanowires and nanoribbons from semiconductor nanomembranes, such as silicon nanomembranes (SiNMs), which are single-crystal membranes from five to 200 nanometers thick. Epitaxial growth of nanostructures on free-standing wires leads to a periodic strain in the ribbon that is the equivalent of superlattice nanowires, but more easily produced in large quantities. Alternatively, the nanowires may be formed from alternating bands of different semiconductor materials.

Because the nanowires periodically vary in composition and/or strain along their length, minibands are formed that restrict the energies of charge carriers to a narrow range, optimizing the thermopower. In addition, the small size of the nanowires and these periodic variations lower the thermal conduction and increase the value of ZT, a dimensionless metric used to rate the efficiency of thermoelectrics.

Applications

- Night vision systems
- Cooling systems
- Refrigeration applications
- Medical applications

Key Benefits

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- May make thermoelectric devices cost-competitive with vapor compression and photovoltaic devices
 - Enables batch fabrication of millions of identical nanowires or nanoribbons using standard silicon technology
 - Composition, orientation, doping and strain characteristics of these nanoribbons can be controlled.



- Allows electronic properties, such as mobility, to be more precisely tuned
- Ordered quantum dots along the nanowires offer an additional level of control for electronic and thermal properties.
- Improves the efficiency of thermoelectrics
- SiNM thermoelectric structures can be used in many environments, including aqueous, fabric and biological environments.

Additional Information

For More Information About the Inventors

- [Max Lagally](#)
- [Paul Evans](#)

Related Intellectual Property

- [View Continuation Patent in PDF format.](#)
- [View Divisional Patent in PDF format.](#)

Tech Fields

- [Engineering : Micro & nanotechnologies](#)
- [Semiconductors & Integrated Circuits : Lithography.](#)

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