Silicon Based Thermoelectric Devices Using Block Copolymer Nanolithography

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OVERVIEW

A novel thermoelectric device that converts heat waste into energy

- Based upon Silicon, which is abundant and has favorable thermoelectric properties
- Applications over a wide range of conventional and critical industries

BACKGROUND

The energy conversion efficiency of internal combustion engines is limited by the fundamental laws of thermodynamics to around 30%, with the bulk of the energy released from fuel combustion wasted thermally as heat. Therefore, any substantial improvement in the efficiency of fossil-fuel-powered engines requires new technologies that can harvest the wasted heat efficiently and at low costs. Most existing heat recovery systems implemented in vehicles suffer from cost-limitations that prevent large-scale deployment in consumer markets.

Thermoelectric (TE) devices have been devised that rely on the thermoelectric effect to directly convert a temperature difference into electrical energy. Successful TE devices must have a high thermopower coefficient, high electrical conductivity, and low thermal conductivity. Metals have high electrical conductivity but low thermopower while semiconductors have large thermopower but low conductivity. TE materials currently of interest are often exotic composites comprised of lead, bismuth, and tellurium. The alloys are therefore difficult and expensive to manufacture in bulk. A need exists to discover a new type of thermoelectric device which is effective and affordable.

INNOVATION

Researchers at the University of Michigan have developed a novel method for making thermoelectric devices based on earth-abundant silicon (Si) which can be created using standard micro-electronics fabrication techniques. The invention provides a means of patterning nanostructured Si devices to optimize the thermoelectric figure of merit. By carefully embedding nanostructures on the surface of a device in the form of nanowires or nanoinclusions, the electrical and thermal properties can be tuned separately to maximize the efficiency of the device.Silicon, the material of choice in this invention report, is uniquely suited for use as a bulk thermoelectric material for waste heat recovery since it can easily be doped with p- and n-type carriers that are connected electrically in series and thermally in parallel. Applied to fossil-fuel-powered engines, this technology could substantially increase the efficiency of cars, planes, boats, and other vehicles. Other applications of this process may include computer processing chips, cooling systems, refrigerators, electric power plants, electric generators, solar cells and inverters, across multiple industries.