Thermoelectric Oxide Composite Materials with a Broad Thermal Window

BACKGROUND

Markets for thermoelectric (TE) power generation from waste heat are growing rapidly, largely driven by environmental issues, particularly reduction of CO_2 emissions. Roughly two-thirds of all energy is lost as waste heat and TE generation offers an attractive route for energy recovery by converting heat directly into electrical energy - irrespective of source size, with no moving parts, and no waste.

The challenge in developing effective TE materials lies in the conflicting properties of high electrical conductivity and low thermal conductivity. Established alloy materials such as bismuth, antimony and lead tellurides are reaching their development limit, with toxicity, high density, increasing scarcity and cost restricting their uptake. In the automotive sector, module weight and high temperature decomposition have been limiting factors.

Efforts to develop alternatives have focused on lower toxicity metal oxides that are naturally abundant, lighter, cheaper and more stable at elevated temperatures. Despite these advantages, they have lower thermoelectric efficiency than the alloys.

TE performance is measured by the thermoelectric Figure of Merit, ZT and an ideal material would achieve a ZT = 1 or above. It would also offer the benefits of the oxides but with greater TE efficiency.

THE TECHNOLOGY

A team from the School of Materials at The University of Manchester (UoM) has developed a novel improvement for TE materials based on nanostructured oxide-graphene composites. These materials not only exhibit higher TE efficiency than oxides alone, but crucially do so over a broader temperature range than existing materials. They are also stable from room temperature to over 500°C.

The UoM composite materials improve the TE performance by incorporating graphene into the structure which results in a higher ZT arising from a combination of:

- higher electrical conductivity due to the presence of graphene
- reducing the thermal conductivity through nanostructuring the oxide grains.

The University of Manchester's new composite materials have the potential to improve waste heat recovery in a wide range of industries, providing a more reliable source of electrical power irrespective of fluctuations in the thermal environment.

KEY BENEFITS

- Increased ZT which is optimal over a very broad operating window (ca. 20°C to >500°C) leading to improved TE performance.
- Low density, which equates to lighter thermoelectric modules
- Low cost and abundant materials with lower toxicity than existing materials

APPLICATIONS

Application areas for thermoelectric technologies are diverse, and include:

- transport and off-road vehicles
- electronics and IT
- aerospace (for power generation in aircraft and satellites)
- solar power generation (to improve the efficiency of solar panels)
- oil & gas production and refineries (for remote power generation)
- heavy manufacturing involving high temperature processes (such as steel, glassmaking, brick manufacture, refining and power generation).

INTELLECTUAL PROPERTY

The IP is protected by a family of patents, published as WO 2014/125292 A1, with applications pending in China, Europe, Japan, South Korea and the USA.

OPPORTUNITY

UMIP is seeking partners capable of developing this technology into commercially available state-of-the-art thermoelectric generators. Interest to date has been received from the automotive industry and large-scale industrial applications.

CONTACT

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