Generating power from waste heat

Hot stuff

A sprinkling of graphene may conjure a long-sought material into existence

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ANY sufficiently advanced technology, as Arthur C. Clarke once observed, is indistinguishable from magic. And one that seems routinely to be ascribed magical properties is graphene. It has been proposed for the manufacture of transistors and light bulbs, as a replacement for bone and a way of delivering drugs, for storing power and for transmitting it, and for lubricating things and waterproofing them. Its latest suggested role, though, is to help turn heat directly into electricity.

The Seebeck effect, first seen in 1821 by a German physicist of that name, is a property of some materials whereby heating part of an object made of that material drives electrons from the hot part to the cold part, creating a current. Generating electricity from heat in this way will never substitute for creating it in a power station specially designed for the purpose but it might, some believe, permit the exploitation of heat that would otherwise go to waste—that produced by car engines, for example; or, indeed, by the power station itself.

The problem is that materials which exhibit a strong enough Seebeck effect to be potentially useful do so only in narrow temperature ranges. One promising candidate is strontium titanium oxide—but it exhibits the effect only when it is heated to between 700° and 750°C. However, two materials scientists, Robert Freer and Ian Kinloch, who work at Manchester University, in Britain, suspected they might be able to extend that range by adding graphene—which, not coincidentally, was discovered at Manchester in 2003. As they report in *Applied Materials and Interfaces*, they think they have succeeded.

To exhibit a strong Seebeck effect, a material must conduct electricity well while conducting heat badly. Unfortunately, these properties rarely coincide. Good electrical conductors usually conduct heat, too, whereas electrical insulators are generally thermal insulators.

Oxides tend to the insulator end of the spectrum, but Dr Freer and Dr Kinloch wonder whether by adding graphene, which is an exceptionally good conductor of electricity, they might be able to decouple the two in the case of strontium titanium oxide. Previous experiments with this substance suggested that adding lanthanum could help improve its electrical conductivity. Conversely, removing a few oxygen atoms from its crystal structure could disrupt heat flow. Even with these adjustments, however, the result performed properly only between 500° and 750°C.

Adding graphene to the mix as well made all the difference. By tinkering, Dr Freer and Dr Kinloch found that the optimal proportion is 0.6%. This creates a material which has a working range that stretches from room temperature (about 20°C) to 750°C, and converts up to 5% of the supplied heat into electricity. That is not a fabulous conversion rate. But it compares favourably with the 1% of pure strontium titanium oxide—and, in any case, this first mixture is just a ranging shot.

The search is therefore on for things that can do better. Considering that the average vehicle wastes roughly 70% of the energy supplied by its fuel, something may not have to perform hugely better to provide a useful supplement to a car's electricity supply. In future, maybe, waste heat from the engine will run the air conditioning—all thanks to the pixie dust of graphene.

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