Great Power in the Smallest of Things

BY JOHN LOVÉN

Imagine going on a camping trip, and being able to charge your phone using the bonfire you just lit. Or why not charge it using the way too hot coffee you got at McDonalds? With the power of nanotechnology, these possibilities may soon be at your hand.

The technology to turn heat into electricity, without using any sort of turbine or electrical generator, has been known for hundreds of years. These devices go by the name of *thermoelectric elements*. They have never been widely used though, since they are not powerful nor efficient enough.

Researchers have struggled to improve the technology to the point of it being actually worth using, and with the help of nanotechnology may soon be close to actually doing so. The secret lies in connecting many millions of very small devices called *nanowires*. Nanowires are cylinders made from a semiconducting material, and they are about one thousand times thinner than a human hair. Nanowires are actually so thin that they can be seen as having only one dimension.

Many millions of nanowires are placed parallel to each other in an array. One end of each nanowire is connected to a cold conductor, and the other end to a hot one. Because of this temperature difference, a current will start to flow between the two ends of the nanowires, and we have electrical power!

Inside these nanowires it is possible to embed even smaller structures, called *quantum dots*. This is done simply by having different semiconducting materials along the nanowires.

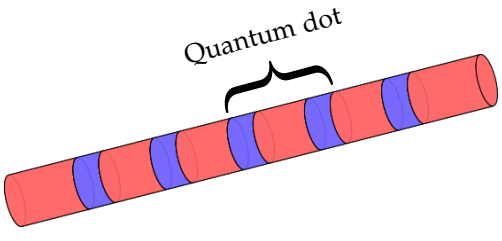

Figure 1: *A nanowire made from two different semiconducting materials with four embedded quantum dots.*

These quantum dots are so incredibly small, that they actually can be seen as having zero dimensions! This feature is what makes these structures so interesting. By having one single quantum dot inside the nanowire, it is possible to get a very efficient thermoelectric element, but the output power will be very low. However, if several quantum dots are connected is series inside the nanowire, it is possible to get a much higher output power with the same efficiency!

By having a number of quantum dots inside the nanowires, it is possible to control the electrical current that flows through the nanowires in great detail. And by making a clever choice for materials and fabrication method, this will increase the output power and efficiency of the nanowires, when they are used as thermoelectric elements.

Depending on the purpose of the device, it can be fabricated in two different ways. If the output power should be high and the efficiency isn't that important, the blue sections in Figure 1 (called the barriers), should be thicker than the red parts, that consist of a different material, and all barriers should be equally thick. If a high efficiency is desired however, the two barriers closest to the two ends of the nanowire should half as thick as the rest of the barriers. This will also mean that the output power will be much smaller, but it will be really efficient at converting heat to electricity.

Thermoelectric elements can create electrical power from any temperature difference. This means that it is possible to extract power from waste heat that would otherwise just dissipate away. Waste heat is created from many different sources such as a car's engine or light bulbs.

Maybe sometime soon, these devices will be powerful and efficient enough that we can use them in our everyday life.