The pioneering material that could change the face of engineering

June 9 2016, by Mary Cruse, Oxford Science Blog

Credit: AI-generated image (disclaimer)

All over the world, engineers are beset by a niggling problem: when materials get hot, they expand.

Why is this such an issue? Well, because materials get hot all the time. Think about aeroplanes, buildings, bridges or virtually any kind of technology.

When you expose any of these materials to energy – whether that energy comes from the sun, fuel burning in an engine or from an electric current – they're going to get bigger, and in some cases that can cause them to fail.

Whether it's a case of seasonal cracks in the road surface or a short-circuited smart phone, thermal expansion can be the bane of an engineer's existence.

But thanks to Oxford University scientists, heat-related failure could ultimately become a thing of the past.

Not all materials expand when they get hot. These so-called 'negative thermal expansion' - or NTE – materials actually contract when heated.

But scientists have never been able to control this process. The material might shrink too far or not far enough. Without being able to modulate this contraction, we just can't harness the potential of NTE materials.

However, research announced this week could change all that. A group led by Dr Mark Senn of Oxford's Department of Chemistry has successfully developed a way of manipulating a class of materials into expanding or contracting at will.

The international collaboration, made up of scientists from Oxford, Imperial, Diamond Light Source and institutions in Korea and the US, haa hit upon a potentially revolutionary finding.

NTE is caused by atoms vibrating inside a material – these vibrations cause the atoms to move closer together. In the past, we haven't been able to control how much closer the atoms became or how quickly the process takes place.

But the work of Dr Senn and his group has revealed that it's possible to manipulate this effect in a perovskite material by changing the concentration of two key elements: strontium and calcium.

The group found that changing these two elements proved to be the key to harnessing the power of NTE in the perovskite they were studying. And if we can control that expansion and contraction, then we have a powerful new resource for engineering technology and infrastructure.

This is an early step forwards, but the findings of the Senn group have opened the door for other researchers looking to control NTE materials. We know that adjusting the elemental composition of this perovskite works: it may be that the same method could work for other materials.

Dr Senn explained the impact of the work: 'This is hugely exciting because we now have a "chemical recipe" for controlling the expansion and contraction of the material when heated. This should prove to have much wider applications.'

Dr Claire Murray is a support scientist at Diamond Light Source. Her expertise in synchrotron science allowed the group to scrutinise the very small changes on the atomic length scale occurring in the perovskite as its composition changed.

She said: 'Researchers are increasingly turning to synchrotrons like Diamond to deepen their understanding of chemical processes and, in a similar way to chefs adjusting their recipes to get a better texture or taste, scientists are adjusting the elemental composition of materials, and thereby controlling their properties and functions in ways that will bring performance and safety benefits in a wide range of areas including transport, construction and new technology.'

There may be some way to go before we start seeing NTE materials in our phones and aeroplanes, but we now know how to control this material, and that's a major step forward.

The laws of physics may sometimes be stacked against engineers, forcing them to design products that account for uncontrollable expansions and contractions, but research like this gives us just that little bit more control.

And when it comes to engineering our everyday lives – from transport to technology – that can make all the difference.

Provided by University of Oxford