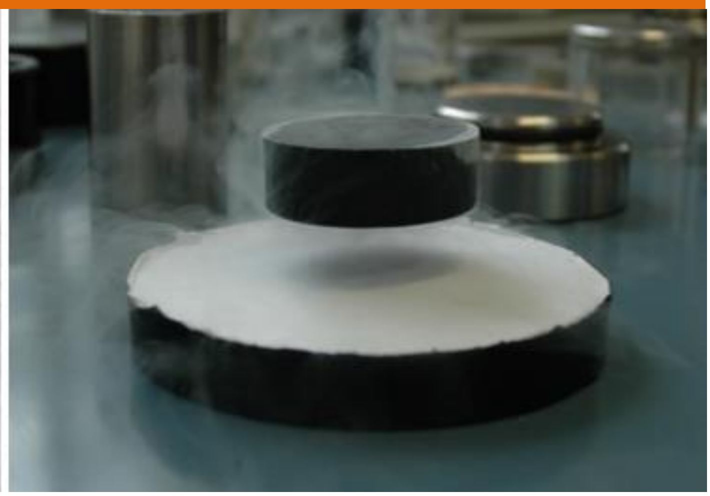
Reinforced bulk superconductors

A successful reinforcement of (RE)BCO with fibres



The Bulk Superconductivity Group at the University of Cambridge has been able to address the problems of crack formation, growth and propagation in bulk (RE)BCO superconductors in the presence of large magnetic fields by introducing special reinforcing fibres into the material. The resulting composite materials structure resists internal mechanical forces, and acts as crack stoppers and inhibitors, allowing the material to take increased loads under large magnetic fields. The team is now seeking commercial partners to develop and implement the technology.

Key benefits:

- Significant improvement in tensile strength, while maintaining superconducting properties
- Less temperature dependent than complex resin impregnation reinforcement methods
- Strong, compact (RE)BCO single grains
- Simple, scalable process

In 2014, the Bulk Superconductivity group at University of Cambridge broke a world record, by managing to 'trap' a magnetic field with a strength of 17.6 Tesla in a high temperature gadolinium barium copper oxide (GdBCO) superconductor, beating the previous record by 0.4 Tesla

http://www.eng.cam.ac.uk/news/cambridge-engineers-break-superconductor-world-record

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Background

Rare-earth based high temperature superconductors in single grain form have been of great interest because they can trap magnetic fields that are almost ten times greater than similar-sized permanent magnets. They thus have significant potential in a range of engineering and technological applications.

> *This work could herald the arrival of superconductors in real-world applications*
>
> — Professor David Cardwell

Despite this potential practical applications have been limited, since bulk superconductors are ceramics that crack very easily - particularly under the mechanical stresses caused by high internal magnetic fields. There has thus been significant technical effort to find ways to reinforce the superconductor material to make it mechanically stronger. However such reinforcing methods typically degrade the ordered crystal structure that is required for the material to remain superconducting.

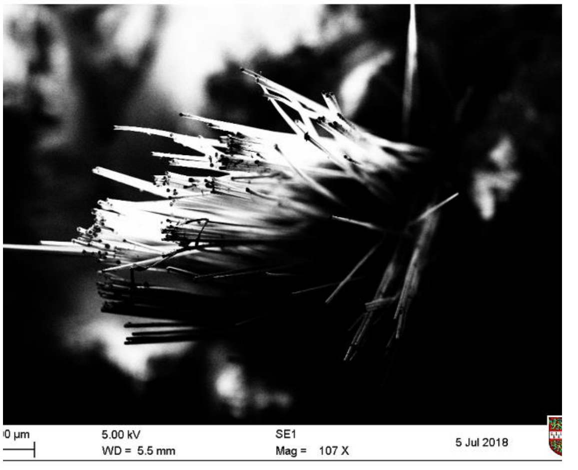

Figure 1: Electron microscopy image obtained on some of the fibres used in the present work.

Technology

The team has devised a simple method of internal reinforcement for improving the tensile strength of bulk (RE)BCO ceramics.

Special fibres are mixed with the (RE)BCO precursor powder, and the mixture subjected to melt growth techniques to obtain single grains containing reinforcing fibres. The composition of the reinforcing fibres is critical - the fibres need to survive in the aggressive liquid phase formed during the melt growth step, improve the mechanical strength of the bulk ceramic, and not interfere with the superconducting properties of (RE)BCO. The team has identified several suitable fibre compositions that lead to the production of strong ceramic (RE)BCO single grained trapped field magnets. If required, the fibre-reinforced magnets can be further reinforced using other techniques (such as external reinforcement with stainless steel rings via shrink-fit technique) to deliver robust products for real-scale applications.

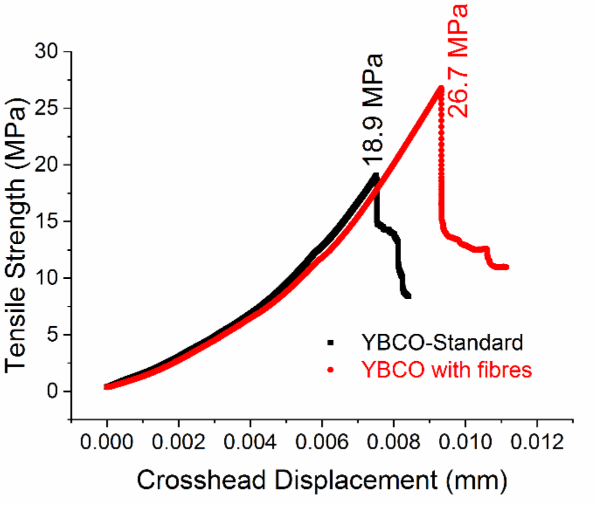

Figure 2: Enhanced mechanical strength of YBCO bulk superconductor due to added fibres in the material.

Applications

This new technology will allow rare-earth based high temperature superconducting materials to be deployed in a wide range of engineering and technological applications requiring large magnetic fields, such as compact electric motors, friction-free self-stabilizing bearings for energy storage fly wheels and trapped field magnets.

Next Steps

This technology is protected by a UK application, and we are now seeking industrial partners to help us further develop this and scale up this technology. Please contact us to explore this opportunity.