Extremely High Flux Pinning Force in Single Grain RE-Ba-Cu-O Bulk Superconductors Containing Nano-scale Pinning Centers

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Introduction

In collaboration with the Boeing Corporation, the Bulk Superconductivity Group at the University of Cambridge has developed a novel high pinning superconducting material based on $GdBa_2Cu_3O_{7-\delta}$ with pinning additions. In previous experiments conducted at the NHMFL DC Field facility we have successfully trapped magnetic fields of over 11 T in these high performance materials. Our aim during the week of experiments conducted in 2012 was to reach higher trapped fields and to understand the factors that are limiting performance. From experiments conducted in low fields at the University of Cambridge, we know that our bulk superconductors are, theoretically, capable of trapping over 20 T.

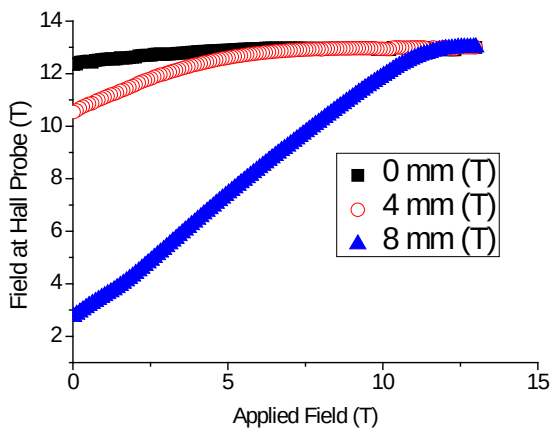

Figure 1. *Evolution of internal field profile with reducing external field in a 25mm diameter bulk. Hall Probes were positioned centrally, at 4mm from centre and at 8mm from centre.*

Experimental

We used the SCM-2 18/20 T superconducting magnet to perform the experiments. This system has the advantage of allowing superconducting bulks of up to 25 mm diameter to be measured and slow magnetic field ramp rates to be employed. In our experiments we first applied a large external field with the sample held at 100 K and then slowly cooled to a temperature between 20 K and 40 K. The resulting trapped field profile was then measured using an array of hall probes. Our experimental requirements were not accommodated using existing sample mounts available at the NHMFL so a holder suitable for our relatively large samples was designed with assistance from NHMFL staff.

Results and Discussion

Previous improvements to our samples that resulted from the work in 2011 meant that no significant sample heating was observed. We were able to successfully trap a field larger than 12 T in an Ag- doped $GdBa_2Cu_3O_{7-\delta}$ bulk. **Figure 1** shows how the magnetic field measured in our sample varied as the external applied field was reduced from 13 T. The field profile observed indicates that the sample was not near to being fully penetrated. Attempts to trap larger fields resulted in sample failure. The failure mode of the samples was investigated by examining the trapped field distribution after low field charging (77 K, 1.5 T) on our return to Cambridge. As can be seen in **Figure 2**, which is representative, the sample has cracked into two regions, both of which continue to superconduct.

Conclusions

Our experiments at NHMFL in 2012 have allowed us to demonstrate a small increase in trapped field. Analysis of sample failure has indicated that, as suspected, the failure mode is due to crack propagation in these brittle ceramic materials. In the year ahead we expect that greater reinforcement pre-stress and epoxy impregnation will allow us to mitigate this cracking problem.

Acknowledgements

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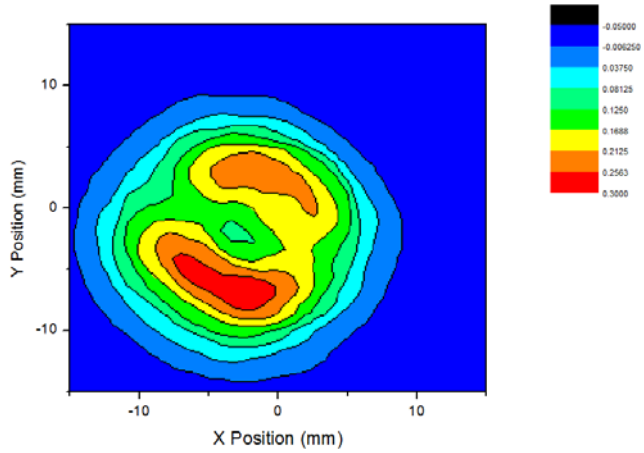

Figure 2. *Trapped field profile of a failed $GdBa_2Cu_3O_{7-\delta}$ superconducting bulk after charging at 77 K in a 1.5 T field.*