THE EFFECT ON UPPER CRITICAL FIELD OF TERNARY AND QUATERNARY ADDITIONS TO SUPERCONDUCTING Nb_3Sn

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Introduction

During a very successful 30T magnet run in January 2003, twelve Nb_3Sn wire samples, two filaments and two Nb_3Sn bulk samples were characterized over the complete H-T phase boundary, to 1.4K. The results have been published in *Superconductor Science and Technology* [1], and submitted to *Journal of Applied Physics* [2].

As a result of this work, the importance of alloying additions is now unclear. A binary Nb_3Sn composite strand, as well as an binary bulk needle both performed to within 0.5 T of alloyed conductors at 0 K, yielding a maximum $\mu_0 H_{c2}(0) = 29.5 \pm 0.5$T. These results defy conventional wisdom, but warrant further investigation since binary (or more lightly alloyed) conductors may be significantly more cost-efficient than alloyed conductors. To investigate the true influence of composition on the field-temperature behavior, additional high field data is required on binary and ternary bulk Nb_3Sn samples.

Experimental

One cm-long bulk samples of binary, Cu-alloyed, and (Cu + Ta)-alloyed Nb_3Sn were characterized resistively using a variable temperature, four-point resistivity technique. Details of the experimental apparatus may be found in [1]. Measurements were performed in a 32 T resistive magnet at the National High Magnetic Field Laboratory in Tallahassee, FL. Field sweeps at 0.6 T/min were performed through the entire available field space for each sample at temperatures ranging from 1.5 K – 18 K. The superconducting transition was taken to be as 50% of the normal state resistivity.

Results and Discussion

The zero temperature upper critical field values ($\mu_0 H_{c2}$) of each sample investigated appear in Table 1. Two important observations are immediately apparent. First, the 10 at.% Ta sample outperformed any other sample by almost 1 T. This trend was consistent over the entire H(T) space.
Second, the binary sample performs extraordinarily well vs. the low-alloyed samples. No H_{c2} enhancement is seen in either Cu-alloyed sample or the low Ta-alloyed samples. This suggests that high-quality binary Nb_3Sn can indeed perform (in H_{c2}) at a level near that of low-doped ternary material.

Table 1. H_{c2} distribution in strain-free, binary and alloyed Nb_3Sn

Sample	0 K $\mu_0 H_{c2}$ (T)
Binary Nb_3Sn	29.1
1.7 at.% Cu	27.5
5.0 at.% Cu	28.6
1 at.% Ta	28.9
2 at.% Ta	29.0
10 at.% Ta	29.8

Conclusions

Expensive, highly Ta doped Nb_3Sn is clearly a superior material for maximizing upper critical field. This is consistent with the results of Suenaga *et al.* [3]. However, good quality binary Nb_3Sn is shown to perform at the same level as low Ta-doped alloy, and may be a suitable replacement for such material if it can be made with sufficient chemical homogeneity.

Acknowledgements

This work was supported by the US Dept. of Energy, Division of High Energy Physics (DE-FG02-91ER40643), and also benefited from NSF-MRSEC (DMR-9632427) supported facilities. The authors thank R. Lund and R. Sakidja for sample fabrication assistance, and T. Gerczak for resistive characterization assistance.

References

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