EFFECTS OF CARBON DOPING AND NEUTRON IRRADIATION ON THE UPPER CRITICAL FIELD OF MgB_2

R. Wilke (ISU, Ames Lab), D. Finnemore (ISU, Ames Lab), S. Bud'ko (Ames Lab), P. Canfield (ISU, Ames Lab), S. Hannahs (NHMFL), R. Suplinskas (Specialty Materials), J. Farmer (MURR)

Introduction

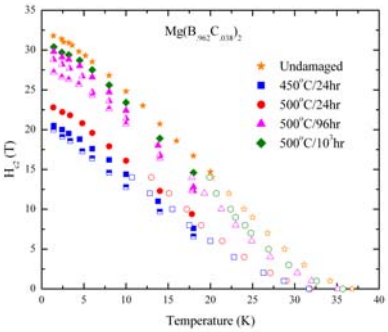
MgB_2[1] is a conventional phonon mediated BCS superconductor with the unconventional property of having two superconducting gaps[2]. Three scattering rates associated with the two (σ and π) bands influence the temperature dependence of the upper critical field. Theoretical calculations predict different developments of H_{c2} if the scattering rates can be selectively tuned[3]. The enhancement of H_{c2} through carbon doping[4] has been attributed to an increase in scattering in the π band[5]. Neutron damage studies on pure MgB_2 wire segments show a suppression of H_{c2} that approximately scales with T_c[6]. We have irradiated $Mg(B_{.962}C_{.038})_2$ to study the interplay between two different types of defects.

Experimental

Carbon doped boron filaments were prepared using a chemical vapor deposition system at Specialty Materials. Filaments were converted to MgB_2 by exposure to magnesium vapor at elevated temperatures. These samples were exposed to fluences of ~10^{18} thermal neutrons at the Missouri University Research Reactor. Upper critical field values were determined using the onset criteria in transport measurements. Resistance versus temperature was measured in fields up to 14T in a Quantum Design PPMS at Ames Laboratory and resistance versus field was measured using a lock in technique in a 32.5T resistive magnet at NHMFL in Tallahassee, Fl.

Results and Discussion

The ~10^{18} fluence fully suppressed superconductivity in the $Mg(B_{.962}C_{.038})_2$ samples. Superconductivity was restored by post exposure annealing for various times and temperatures. For example, a 24 hour anneal at 300ºC gave T_c near 20K. Figure 1 presents H_{c2} data for samples which had $T_c > 30K$. $H_{c2}(T=0)$ scales with T_c for each of the irradiated samples. This behavior is analogous to the case of neutron damaging in pure MgB_2 and in contrast to the effects of carbon doping alone. The effects of scattering, resulting from defects introduced by exposure and subsequent annealing, appear to act independently of the effects produced by the presence of carbon.



Conclusions

The transition temperature for neutron damaged carbon doped MgB_2 filaments was tuned by the post exposure annealing. For the full range of T_cs accessed by this method, $H_{c2}(T=0)$ approximately scaled with T_c, suggesting neutron damage acts to globally suppress superconductivity and doesn't selectively enhance any specific scattering channel.

Acknowledgements

Ames Laboratory is operated for the U.S. Department of Energy by Iowa State University under Contract No. W-7405-Eng-82. This work was supported by the Director for Energy Research, Office of Basic Energy Sciences.

References

[1] Nagmatsu, Jun, *et al*., Nature (London, United Kingdom) **410**, 6824 (2001).
[2] Fisher, R. A., *et al*., Physica C, **385,** 180-191(2003).
[3] Gurevich, A., Phys. Rev. B, **67**, 184515 (2003)
[4] Wilke, R.H.T., *et al*., Phys. Rev. Lett. **91,** 217003 (2004).
[5] Angst, M., *et al*., LANL preprint archive, 0410722 (2004).
[6] Wilke, R.H.T., *et al*., unpublished.