H_{C2} OF C-DOPED MgB_2 SUPERCONDUCTOR

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The superconductor MgB_2 has large potential for technological applications due to its high T_c (~39K), low cost of raw materials, chemical simplicity and absence of weak-links limitations to the critical current density. One of the most important remaining challenges is to increase the upper critical field H_{c2}, which in the case of undoped MgB_2 is too low ($H_{c2}(0)$~ 14-20T) for most possible applications. The H_{c2} can be significantly increased by doping with carbon. The purpose of our study is to determine the H_{c2} and the irreversibility field H_{irr} of bulk MgB_2 doped with various amounts of single-walled carbon nanotubes as the source of C. The study also has fundamental value as MgB_2 is the best known example of a two gap superconductor, and the effects of doping on H_{c2} (due to the shift from clean limit to dirty limit superconductivity) are currently a topic of large interest.

We used the 50 T mid-pulse magnet to perform four-probe transport measurements in bulk $Mg(B_{1-x}C_x)_2$ samples (x = 0.05, 0.075, 0.1, 0.15) doped with single wall C-nanotubes. Samples were prepared in Bariloche as described elsewhere.[1] $H_{c2}(T)$ for C-doped samples, as determined by the onset criteria of the measured resistance as a function of field curves, are shown in Fig. 1 (a). For comparison we also included a SiC doped sample previously measured. The $H_{irr}(T)$ of the same samples is plotted in the inset of this figure.

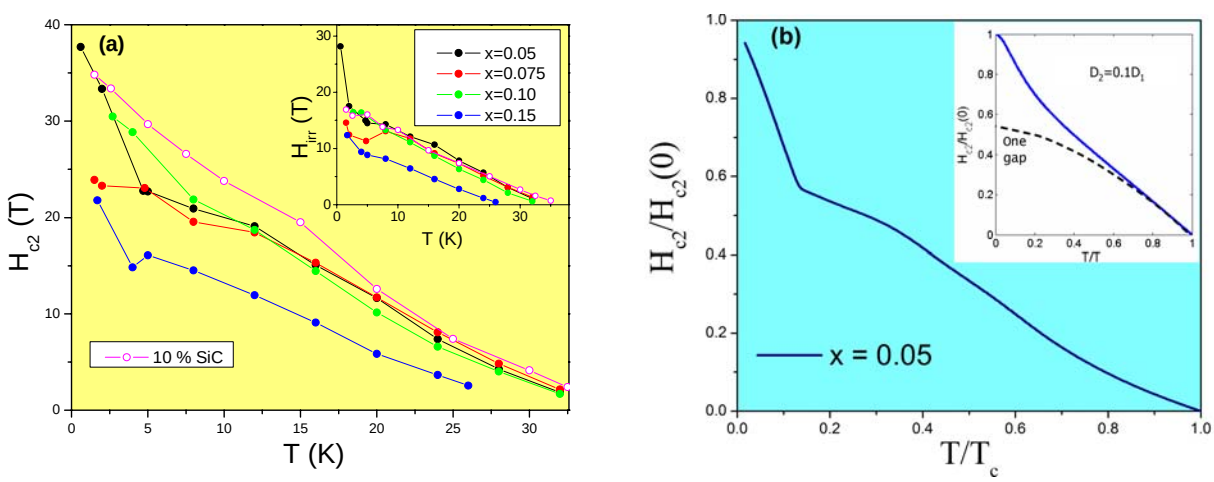

Fig. 1. (a) Temperature dependence of $H_{c2}(T)$ and $H_{irr}(T)$ of $Mg(B_{1-x}C_x)_2$ samples. (b) $H_{c2}/H_{c2}(0)$ vs. T/T_c for sample with x = 0.05, the inset shows the predicted behavior within the two gap superconductivity framework.[2]

It can be observed that there is a clear enhancement of H_{c2} and H_{irr} for samples in the C-doping range between 5 and 10 %, especially in the low temperature region. The C substitution in the B site causes strong scattering, leading to enhancement in H_{c2}. The normalized $H_{c2}/H_{c2}(0)$ as a function of the reduced temperature T/T_c plotted in Fig. 1(b) does not follow the temperature dependence described for a one-gap type II dirty superconductor but can be described well by the result of a recent theoretical calculation for a two-gap dirty superconductor. [2]

For sample with x =0.15, a higher concentration of impurities results in a higher resistivity and a T_c reduction, with the consequent deterioration in the H_{c2} performance. It is necessary to find an optimum concentration of highly dispersed nanoscale precipitates that may also serve as strong pinning centers to further improve H_{irr}. Experiments in double-walled carbon nanotubes doped samples are being performed.

The extrapolated $H_{c2}(0)$~39 T for the x=0.05 sample is the highest reported value for a MgB_2 bulk superconductor sample. For a complete characterization of these samples, additional measurements of the critical currents are under way.

References

[1] Serrano, G., Ms Thesis, Instituto Balseiro, Bariloche (2005).
[2] Gurevich, *et al*., Phys. Rev. B, **67**, 184515 (2003).