High Upper Critical field of Carbon-doped MgB\textsubscript{2} Thin Films by HPCVD using TMB

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**Introduction**
We report upper critical field measurements of a series of carbon-doped MgB\textsubscript{2} superconducting thin films in magnetic fields up to 60 T. The carbon-doped MgB\textsubscript{2} films were fabricated by the Hybrid Physical-Chemical Vapor Deposition (HPCVD) method [1] using Trimethylboron (TMB) as the doping source. High parallel field $H_{c2}$ values, over 60 T at low temperature, were obtained for heavily-doped samples.

**Experimental**
Carbon-doped MgB\textsubscript{2} films of ~ 100-nm thick were synthesized by the HPCVD method. TMB was added to the gas stream as carbon precursor source. Photolithography and ion milling were used to pattern the samples into 200 µm long and 10 µm wide bridges for transport measurement. An MgO layer of about 10nm was sputtered on top of the bridge to prevent sample degradation. The resistivity was measured using the standard four-probe digital ac lock-in technique in pulsed fields up to 60 T at various temperatures in the National High Magnetic Field Laboratory of LANL. $H_{c2}$ is defined using the 90% of normal resistivity criterion.

**Results and Discussion**
Carbon-doping greatly enhances $H_{c2}$ of MgB\textsubscript{2} thin films. The $H_{c2}(T)$ in ab-plane exceeds 60 T at 15 K and acquires a downward curvature for heavily-doped samples, as shown in Figure 1(a). For the field in the c-direction, the low temperature $H_{c2}$ is close to 20 T for lightly-doped samples, and decreases with carbon content, as illustrated in figure 1(b). The anisotropy of $H_{c2}$ increases upon carbon-doping, as opposed to the reported results from other carbon-doping techniques.

![Figure 1: $H_{c2}$ versus temperature of carbon-doped MgB\textsubscript{2} thin films with different doping levels for field in ab-plane (figure a) and in c direction (figure b).](image)

**Conclusions**
Using TMB as dopant, carbon-doped MgB\textsubscript{2} thin films fabricated by HPCVD technique shows greatly enhanced $H_{c2}$, over 60 T at low temperatures for parallel field. The $H_{c2}$ anisotropy increases with carbon content, suggesting yet another and a different doping mechanism can operate in these versatile, two-gap films.

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**References**