Enhancement of $H_{c2}$ in c-Doped MgB$_2$ by Precipitation

Jian Zhou (FSU, Mechanical Engineering); David Larbalestier (FSU, Mechanical Engineering)

Introduction

Recently, many dopants, from metals to non-metals, were added into magnesium diboride (MgB$_2$) to discover their capabilities to enhance critical current density ($J_c$), critical temperature ($T_c$), irreversibility field ($H^*$) and upper critical field ($H_{c2}$). Previously we have studied the effect of carbon on increasing $T_c$ and $J_c$ in bulk MgB$_2$. Now, we are using aging (heat treatment) to drag out carbon as precipitation after sintering carbon into MgB$_2$ lattice. $H_{c2}$ are expected to be raised in the way of precipitation working as the electron scattering center to shorten cooper pairs.

Experimental

The experiments include sample fabrication and characterization. Fabrication began with high energy ball milling of MgB$_2$ powder, boron powder and carbon powder at the nominal bulk composition Mg(B$_{1-x}$C$_x$) for the specified time, then being cold pressed into pellets, sealed in evacuated 304 stainless steel or Nb tubes, and heat treated in hot isostatic press machine up to 1500°C and 29kpsi. Nitrogen-filled glove box and chambers or vacuumed chambers were used through the whole fabrication process to avoid water and oxygen.

Samples have been being characterized by different methods. A diamond saw was used to cut pellets into thin slices and small pieces for the magnetic measurements. Resistivity measurements were made in magnetic fields at maximum 9T in Quantum Design Physical Properties Measurement System (PPMS) and high-field measurements in a 33 T magnet at the National High Magnetic Field Laboratory (NHMFL). $H_{c2}$ were defined by 90% points on the resistivity transition curves. The superconducting quantum interference device (SQUID) magnetometer carried out the sensitive $T_c$ measurement. X-ray diffraction was used for lattice parameter measurement and grain estimation, also actual C- content in the sample. Scanning electron microscopy (SEM) will be used to observe microstructures for the determination of grain and particle size.

Results and Discussion

Nominal X for B507, J600 and J612 are 0.04, 0.06 and 0.06. The sintering temperatures for above samples are 1150°C, but ball milling time of B507, J600 and J612 are 600, 60 and 1200 mins respectively. The $H_{c2}$ plot before and after aging is showed in Figure 1. Planned aging temperatures are 700°C, 900°C, 950°C, 1000°C and 1050°C respectively. The last 3 temperature points have not been finished for all samples. $H_{c2}$ in 33T high field for J600 after 700°C and 900°C aging are 38T and 36.6T respectively.

Conclusions

Aging increased $H_{c2}$ for most cases; however, the last 3 points of B507 were not consistent with others. Further work is needed to make an explicit conclusion.

Acknowledgements

The work is supported by the NSF through the Focused Research group on Superconductivity in MgB$_2$ and by the Department of Energy, Office of Plasma Fusion Science (award # DE-FG02-06ER54881). Also, I would like to thank Ben Senkowicz and Jianyi Jiang who gave me a lot of help on research and Bill Starch who kept facilities running well. And thanks go to undergraduate Malaica Nicolas who gave me a hand on experiments.

References