Upper Critical Field Improvement in MgB_2 by Mechanical Alloying

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The new superconductor magnesium diboride (MgB_2) shows great promise for fusion applications because it has a higher Tc (39K) than Nb_3Sn, does not suffer from grain boundary weak links due to grain orientation, is potentially inexpensive, and can be made as round multifilament wires. The main challenge for MgB_2 research has been to improve upon the relatively modest upper critical field of the pure material (generally <15T at 4.2K). Recent studies of magnesium diboride thin films have obtained $H_{c2}(0)^{\parallel}$ (H parallel to the Mg and B planes) approaching 70T and $H_{c2}(0)^{\perp}$ about 40T in carbon-doped samples with anomalous c-axis lattice parameters [1]. Bulk, untextured carbon-doped samples fabricated by a CVD method had upper critical fields in excess of 30T at 4.2K [2], about a factor of two lower. Collectively these data show that alloyed MgB_2 can exceed the performance envelope of any Nb-base superconductor at any temperature or field. Our present work involves the synthesis of alloyed MgB_2 powder for high-field wires. We have found that high energy milling of magnesium diboride pre-reacted powder can render the material largely amorphous through extreme mechanical deformation and that it is suitable for mechanically alloying MgB_2 with dopants including carbon. We have found that the slope dH_{c2}/dT is enhanced from 0.51 T/K to 1.08 T/K by milling in the presence of C, consistent with $H_{c2}(0)^{\parallel}$ of 33 T. Detailed studies of the C and process dependence of the superconducting properties and the recrystallization kinetics are underway and will be reported at the meeting.

[1] Braccini et al. Cond Mat 0402001 (2004)
[2] Wilke et al. Cond mat 0312235 (2003)