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$_3$Sn, 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.