Abstract of Presentation

Microstructure control and critical current density of MgB2 tapes and wires

Abstract :

A Powder-In-Tube(PIT) method is the most popular method to fabricate MgB2 tapes and wires. However, PIT processed tapes and wires show relatively low Jc values due to the low density and, hence, low connectivity of MgB2 cores. Some hydrocarbon addition to the starting powder is effective to increase the connectivity of MgB2 grains and Jc values. We found that the addition of C9H12 to the powder mixture(MgH2+B) significantly increased Jc from 3,3kA/cm2 to 13kA/cm2 at 4.2K and 10T. Co-addition of C9H12 and SiC is more effective to enhance Jc values. Malic acid (C4H6O5) addition is also reported to be effective to enhance the connectivity of MgB2 grains and Jc values. However, these Jc values are still far below the practical level.

Recently, we succeeded in the fabrication of MgB2 tapes having high density MgB2 core applying a hot pressing. Starting tapes were prepared by an in situ PIT process. The mixture of boron powder and MgH2 powder was put into Fe tube, and cold rolled into tape with 5mm in width and 0.5mm in thickness. We tried out co-doping of nano-sized SiC powder and C9H12 to the powder mixture in order to improve superconducting properties. The tapes were hot-pressed under 100MPa at 630oC in argon gas atmosphere for 1 to 10 hours. For comparison conventional 1 atm. heat treatment using a tube furnace was also carried out. The reduction of MgB2 cross sectional area was obtained by the hot pressing, ~0.44mm2 for the hot pressed tape and ~0.55mm2 for the conventionally heat treated tape. This indicates the increase of the MgB2 core density from ~50% for the conventional heat treatment to ~70% for the hot pressing. MgB2 grain connectivity estimated by the Rowell's method was also improved from 17.4 to 21.7 by the hot pressing. Hot pressed pure MgB2 tape showed Ic of 38A at 4.2K and 10T which was about three times as large as the Ic of conventionally heat treated tape. Ic of the hot pressed and conventionally heat treated tapes with co-doping were 200A and 140A at 4.2K and 10T, respectively. These Ic values correspond to the Jc(for MgB2 layer) values of 45kA/cm2 and 25kA/cm2 in 10T, respectively. The magnetic field dependence of Jc of the hot-pressed tape is almost equal to that of the conventionally heat treated tapes, suggesting that the improvement in Jc is due to enhanced grain connectivity associated with the increase in the MgB2 density rather than to the introduction of pinning centers. These results clearly indicate that the hot pressing is effective in increasing the density of MgB2 core and hence, in enhancing Jc values of PIT processed MgB2 tapes. Further enhancement of connectivity and Jc values may be obtained by the optimization of hot

Abstract of Presentation

pressing conditions.

Another effective method to increase MgB_2 core density is an internal Mg diffusion (IMD) process. We applied this process to the fabrication of MgB_2 round wires. A pure Mg rod was placed at the center of a Ta tube, and the space between the Mg rod and the Ta tube was filled with B powder or with B-SiC mixed powder. The composite can be cold worked into wire with ~1mm diameter at room temperature. We also fabricated 7- and 19-filamentary wires applying similar method. Finally the wires were heat treated at 600 ~ 700 ^{o}C for 0.25-10hr. During the heat treatment, Mg diffused into the B layer and reacted with B to form MgB_2. The reacted layer is not MgB_2 single phase but contained some amount of impurity phases such as MgB_4. Reacted MgB_2 layer thickness is sensitive to the heat treatment conditions. The thickness of MgB_2 layer rapidly increases with increasing the heat treatment temperature. However, higher J_c can be obtained for lower heat treatment temperature probably due to the small grain size. Furthermore, reproducibility of J_c values becomes worse when the heat treatment temperature is higher than 650^{o}C(melting point of Mg). Vickers hardness of MgB_2 layer in the IMD processed wires is around 1300 which is much higher than that of PIT processed wire. This suggests that the density of MgB_2 layer is much higher than that of PIT processed wire. The highest J_c values(calculated for the reacted layer) are 100kA/cm^2 in 10T at 4.2K for 7-filamentary wires and 4.9kA/cm^2 in 5T at 20K for 19-filamentary wire. These J_c values are much higher than those of usual PIT processed wires. The increase of the number of filaments, i.e. the decrease of the MgB_2 layer thickness will further increase the J_c values. Now the filaments in the wire have irregular shape because we firstly apply groove rolling with square cross section and then we apply drawing with dies for the wire fabrication. The decrease of this irregularity of filament shape will be effective in increasing the J_c values. The void formation at the center of each filament is one of the problems that should be solved in the future.