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Improvement of Critical Current Densities of MgB_2 Tapes and Wires

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Impurity addition is an effective method to improve J_c of MgB_2 wires and tapes, and many impurity additions are now being tried out in the world. Among many kinds of impurities, additions of carbon compounds such as nano-SiC and hydrocarbon are particularly effective. We found that the additions of ethyltoluene(C_9H_{12}) to the starting powder of *in situ* processed Powder-In-Tube(PIT) MgB_2/Fe tapes is more effective in enhancing J_c value than other hydrocarbon additions in spite of smaller amount of carbon substitution for boron site. The slope of J_c-B curve of ethyltoluene-added tape is almost equal to that of pure MgB_2 tape. These results suggest that the dominant mechanism of J_c enhancement for ethyltoluene-added tape is different from carbon substitution for boron. The analysis by the Rowell's method indicates that the connectivity of MgB_2 is improved by the ethyltoluene addition. The addition of both ethyltoluene and SiC nano powder to the starting powder is much more effective in increasing J_c values. This is because both mechanisms of J_c improvement--one comes from the addition of ethyltoluene, and the other comes from the carbon substitution for boron by the SiC addition--work together. The highest J_c values at 4.2K reached 32,000A/cm^2 in 10T and 14,000A/cm^2 in 12T for 10mol% ethyltoluene and 10mol%SiC-added tape. However, these J_c values are still below the practical level due to the low density of MgB_2 cores. Recently, we succeeded in the fabrication of MgB_2/Fe wires having high density MgB_2 core applying the internal Mg diffusion (IMD) process with pure Mg rod and pure B powder or nano-SiC added B powders. A pure Mg rod with a diameter of 2 mm was placed at the center of a Fe tube with an outer diameter of 6mm and inner diameter of 3.5 mm, and space between the Mg rod and the Fe tube was filled with B powder or B-SiC mixed powder. The composite was successfully cold worked into 0.8 ~ 1.2 mm wire at room temperature without any breakage. The wires were heat treated at 650 ~ 800 ^{o}C for 1 ~ 10 hrs under Ar gas atmosphere. During the heat treatment, liquid Mg infiltrated into the B layer and reacted with B to form MgB_2. X-ray diffraction analysis indicated that the major phase in the reacted layer is MgB_2. SEM analysis of the heat treated wire clearly indicated that the density of MgB_2 layer in the wire was higher than that of a PIT processed wire. The J_c at 4.2K of the IMD-processed wire increased with decreasing the heat treatment temperature from 800 ^{o}C. Transport J_c values of the SiC added wire heat treated at 670^{o}C reached 1.1 x 10^{5}A/cm^2 in 8T and 43,000A/cm^2 in 10T at 4.2K. These J_c values are much higher than those of usual PIT processed wires. These high J_c values can be attributed to the high density MgB_2 layer obtained by this diffusion method. Thus, the densification of MgB_2 layer is effective in enhancing J_c of MgB_2 wires.

Keywords: impurity addition, ethyltoluene, critical current density, diffusion method

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