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Contribution of simultaneous SiC and TaB_2 additions on the MgB_2 superconducting properties

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Abstract – In the present work it is described a methodology to optimize the critical current densities J_c of MgB_2 bulk superconductors. We present a study of the effect of different additions in the microstructure and J_c of MgB_2 samples. The aim of the work is to identify the ideal nanoscale defects to optimize J_c under different applied field regimes.

The use of MgB_2 in superconducting applications that uses large magnetic fields depends on the development of a material where current-carrying performance (i.e. the critical current densities J_c) and critical magnetic field (H_{c2}) are optimized simultaneously. The best results for increasing J_c and the irreversibility field (H_{irr}) in bulk samples are related to an improvement in grain connectivity but also to the addition of suitable defect nanoparticles or doping [1,2].

Many groups around the world work to improve the current transport properties of MgB_2 at high fields (above 10T) aiming its use in magnets for particle accelerators and systems for nuclear fusion tests. On the contrary, modern magnetic resonance imaging systems work in the range 0.5 to 2.0T. It is interesting to combine the different defects to enhance not only the high-field current carrying performance but also the low-field one. In the present work it is described the production of MgB_2 samples by using the mixture of the MgB_2 with other diborides, like TaB_2 [1], which have the same C32 hexagonal structure as the MgB_2, and SiC, that may contribute with C, to replace B in the crystalline structure of the matrix [2]. The mechanical mixture of the powders, obtained by ball milling, has a positive influence in the final crystalline structure, maintaining the hexagonal structure, and generating intragranular and intergranular pinning centers. Microstructural characterizations through SEM and XRD, were used to determine the distribution and composition of the superconducting phase with the different additions. Magnetization J_c was used to determine the best composition of the mixture and heat treatment profile.

It could be concluded through the X-ray analysis (Figure 1) that the ball milling was efficient and contributed with the final crystalline structure, maintaining the hexagonal structure, and generating new phases that, possibly, are acting as pinning centers. The fabrication process of this MgB_2 superconductors and the doping with TaB_2 and SiC were efficient, improving J_c under applied magnetic fields, maintaining the critical temperature at high values (between 36 and 37 K). Figure 2 shows that the J_c values were improved for all samples, in comparison with [2], and it could be seen that the samples with just TaB_2 addition obtained high values of J_c under low magnetic fields, while the samples with simultaneous SiC with TaB_2 additions showed the best values of J_c under high magnetic fields. The more efficient heat treatment was at 600ºC/2h.

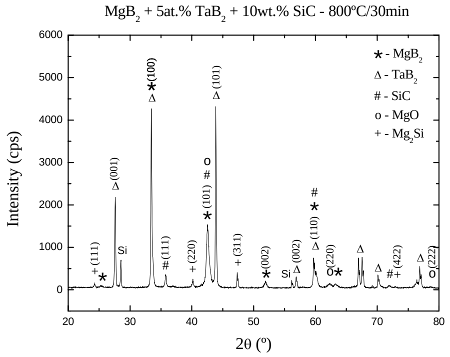

Figure 1: X-ray diffractogram of the MgB_2 + 5at.%TaB_2 + 10wt.%SiC sample heat treated at 800ºC/30min.

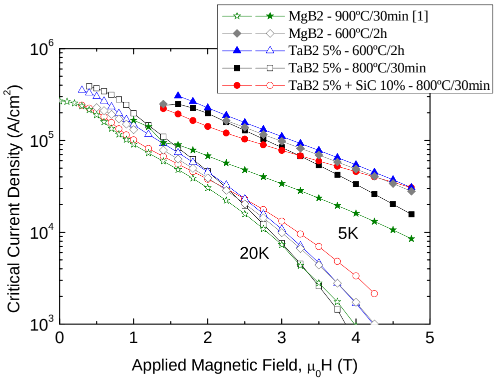

Figure 2: Critical current densities J_c versus applied magnetic field for MgB_2 samples.

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