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Anelastic parameters of MgB_2 obtained by mechanical spectroscopy

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Abstract – MgB_2 is an intermetallic compound that shows a high Tc (39 K) compared with nonoxide superconductors, and, as it is a granular compound, the knowledge of the mechanisms of the interaction of the defects and the crystalline lattice is of great importance in the study of the physical properties of this material. In this sense, mechanical spectroscopy measurements constitute a powerful tool for this study. In this paper, the samples were prepared for the PIT method and were characterized by density, X-ray diffraction, scanning electron microscopy, electrical resistivity, and magnetization. The measures of mechanical spectroscopy showed complex spectra, and eight relaxation processes due to dislocations, interstitials, and grain boundaries were identified.

The discovery of superconductivity at 39 K in magnesium diboride (MgB_2) has created a new frontier in the application of superconductors [1]. The MgB_2 is an intermetallic compound that shows a high Tc (39 K) compared with nonoxide superconductors. An interesting property of this material is that it presents two gaps of energy (7 meV and 2 meV), which is responsible one for superconductivity in this material [2]. As MgB_2 is a granular compound, knowledge of the mechanisms of interaction between the defects and the crystalline lattice is of great importance in the study of the physical properties of this material. In this sense, mechanical spectroscopy measurements constitute a powerful tool for this study because important information regarding phase transitions and the behavior of interstitial or substitutional elements, dislocations, grain boundaries, diffusion, instabilities, and other imperfections of the lattice can be obtained [3].

For this study, the samples were prepared for the powder in tube (PIT) in Australia [4], by reacting Mg and B in a sealed stainless steel tube at 850 °C for 2 h. The samples were then quenched at a rate of 10 °C/min for 30 min. The samples were measured in the as-received condition and then annealed at 450 °C in UHV for 30 min. The prepared samples were characterized by density, X-ray diffraction, scanning electron microscopy, electrical resistivity, and magnetization. Anelastic parameters were obtained by mechanical spectroscopy techniques using a torsion pendulum.

The annealing did not modify the superconducting properties of the samples. The DRX results showed a hexagonal structure and traces of MgO, but this phase not did not influence the Tc, as verified in the results of electric resistivity and magnetization. The SEM results showed a microstructure with large porosity and the presence of open and closed pores, which was waited in function of the processing of the samples. The mechanical spectroscopy results showed complex relaxation structures (Figs. 1 and 2) that were resolved into its constituent relaxation processes. The nature of these processes is related to the motion of defects in the crystalline lattice of the material, such as grain boundaries, dislocations, diffusion of interstitial and substituted impurities, and other interactions of a complex nature.

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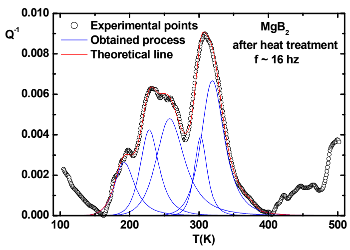

Figure 1: Anelastic spectrum from MgB_2 as received.

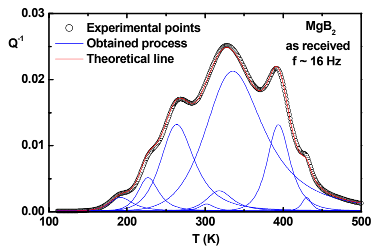

Figure 2: Anelastic spectrum from MgB_2 after heat treatment.

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