Thermoelectric power of hot deformed MgB_2

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Abstract

The thermoelectric power and the electrical resistivity have been measured for a MgB_2 sample, textured by hot deformation, in the range from 100 K up to 800 K. Above 200 K, the electrical resistivity exhibits a slight negative deviation from the linear behaviour with temperature. The thermopower rises from 2.1 μV/K at 100 K to a maximum value of 6.9 μV/K at 400 K and then decreases to 5.0 μV/K at 800 K. While the resistivity can be described by a one-band Grüneisen formula, no simple explanation exists for the thermopower.

Key words: thermopower; electrical resistivity; MgB_2

1. Introduction

After the discovery of superconductivity up to about 40 K in MgB_2 [1] extensive investigations of its physical properties have been performed. Although its crystal structure is quite simple it is strongly layered and electronic characteristics are anisotropic with a low density of states at the Fermi surface [2]. MgB_2 seems to belong to a new class of intermetallic superconductors that derives its high superconducting transition temperature T_c from extremely strong coupling from only a small fraction of the phonons to a limited part of the Fermi surface. This behaviour can be described by a two-band model that accounts properly for the upper critical field and some other properties [3]. Strong electron-phonon interaction and peculiarities of the Fermi surface should also be remarkably reflected in the thermal and electronic normal state properties. A lot of investigations of resistivity and thermoelectric power have been performed below room temperature [4–8], however, to our knowledge, there are no results at higher temperatures. Therefore, in the present work we extend our previous investigations [9] up to 800 K.

2. Experimental details

The investigations were performed on bulk textured MgB_2 material of nearly full density, obtained by hot deformation of a stoichiometric MgB_2 pellet prepared by a gas-solid reaction [10]. A small *c*-axis alignment along the axis of deformation was found from x-ray diffraction pattern. In the investigated sample the heat flow was perpendicular to the direction of the *c*-axis alignment. The resistivity and thermopower measurements above 100 K were performed using a unique set-up for high temperatures [11].

3. Results and discussion

The results of the resistivity measurements are shown in Fig. 1. The resistivity of the investigated sample was found to increase from 5.6 $\mu\Omega$cm at 40 K

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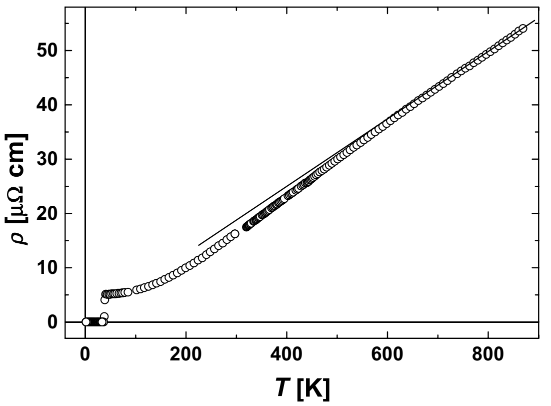

Fig. 1. Temperature dependence of the electrical resistivity for hot deformed MgB_2. The straight line is a guide for the eyes.

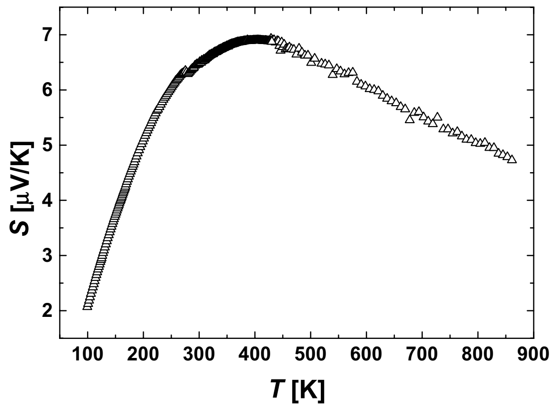

Fig. 2. Thermopower of hot deformed MgB_2 in the temperature range 100 K$<T<$ 800 K.

to 18 $\mu\Omega$cm at 300 K resulting in a residual resistance ratio of approximately 3.2. The superconducting transition temperature was 38.6 K. As the low temperature behaviour has already been investigated in detail, we restrict our discussion on the high temperature part. The data above 600 K fit to a straight line that extrapolates to the zero of the resistivity and temperature coordinates, indicating the validity of the Grüneisen law up to the highest investigated temperatures. Thus, no saturation effects were observed. This behaviour is characteristic for systems with not too strong electron-phonon interaction. Therefore, according to the two-band model it is concluded that the high temperature resistivity is dominated by the weakly coupled electrons from a limited part of the Fermi surface, that give only a minor contribution to superconductivity.

The low temperature thermopower of MgB_2 has been investigated by several groups [7,8]. At the superconducting transition temperature it jumps to about 0.5 μV/K and then rises nearly linearly with temperatures up to 100 K, with a small positive curvature due to a small contribution of phonon drag. There has been some controversy regarding the sign and temperature dependence of the phonon drag contribution [9,12]. In order to get more insight into the dominating mechanisms we measured the thermopower between 100 K and 800 K. The results are shown in Fig. 2. The thermopower exhibits a peak of 7 μV/K at 400 K. The peak cannot be derived from the phonon drag as this effect is supposed to be relevant at lower temperatures. Thus, it must be of electronic origin. It may be the result of the complicated electronic band structure which represents itself more pronounced in the thermopower than in the electrical resistivity.

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