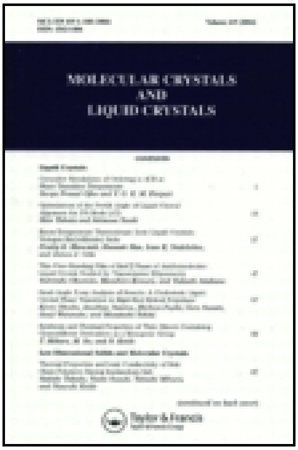

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Transport and Electrochemical Properties of $Bi_2Sr_2CaCu_2O_8$ Superconductors

J. Molenda [a] , I. Nowak [a] , L. Jedynak [a] , J. Marzec [a] & A. Stokłosa [a]

[a] Department of Solid State Chemistry, Stanislaw Staszic University of Mining and Metallurgy, Al. Mickiewicza 30, 30-059, Cracow, Poland

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Transport and Electrochemical Properties of $Bi_2Sr_2CaCu_2O_8$ Superconductors

J. MOLENDA, I. NOWAK, L. JEDYNAK, J. MARZEC
and A. STOKŁOSA

Department of Solid State Chemistry, Stanislaw Staszic University of Mining and Metallurgy, Al. Mickiewicza 30, 30–059 Cracow, Poland

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Electrical conductivity and thermoelectric power measurements (77–300K) of both the pure and electrochemically doped with lithium $Bi_2Sr_2CaCu_2O_8$ system, are presented. Clear correlation between transport and electrochemical properties of $Li_xBi_2Sr_2CaCu_2O_8$ was shown.

Keywords: $Bi_2Sr_2CaCu_2O_8$; lithium intercalation; transport properties

INTRODUCTION

Discovery of high-temperature superconductivity opens new possibilities both for the investigation of oxygen ceramic materials and for their technology. In spite of a very great amount of works dealing with the Bi-Sr-Ca-Cu-O system, the structure of ionic and electronic defects in this material remains unexplained. The role of oxygen non-stoichiometry is not determined in full. A maximum of critical temperature Tc is observed for a given oxygen nonstoichiometry which corresponds to an optimum concentration of electron holes[1,2]. An attempt to modify the electronic properties of $Bi_2Sr_2CaCu_2O_8$ has been made in this work by introducing lithium into the structure of this oxide. Results of the investigation of electric conductivity and thermoelectric power of $Bi_2Sr_2CaCu_2O_8$ system at temperatures within the range 77-300K as well as experiments on its electrochemical properties in a cell of $Li/Li^+/Li_xBi_2Sr_2CaCu_2O_8$ type are presented in this paper. Furthermore, investigations were carried out on the electrical properties of the $Li_xBi_2Sr_2CaCu_2O_8$ system as a function of doping level x_{Li}.

RESULTS AND DISCUSSION

Figs.1 and 2 show the temperature dependencies of the electrical resistivity and thermoelectric power for six samples annealed at identical conditions (1070K, air). It can be noticed that the characteristics of electrical conductivity of the samples differ one from another (Fig. 1). This can be due to the difference of the microstructure (i.e. texture, porosity, grain boundaries) of each pellet. There is no difference in thermoelectric power as it is microstructure independent, volume effect (Fig. 2).

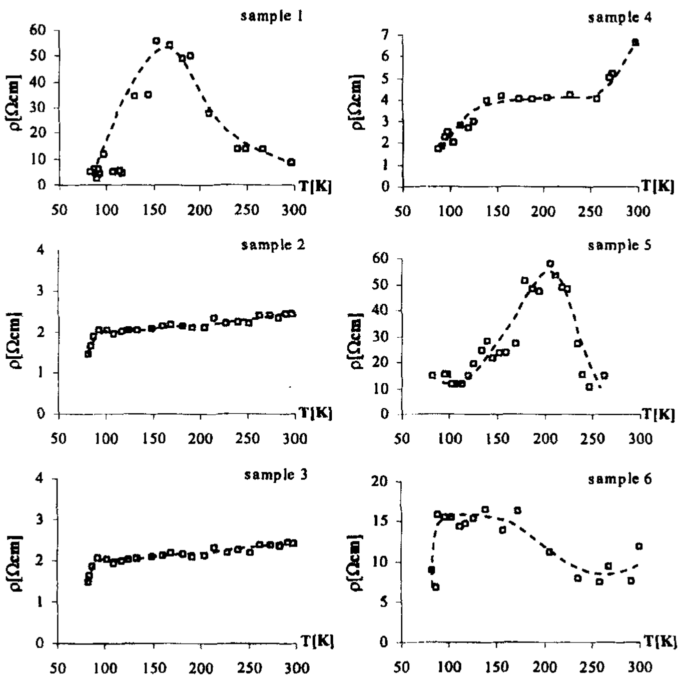

FIGURE 1. Temperature dependence of the electrical resistivity of $Bi_2Sr_2CaCu_2O_8$

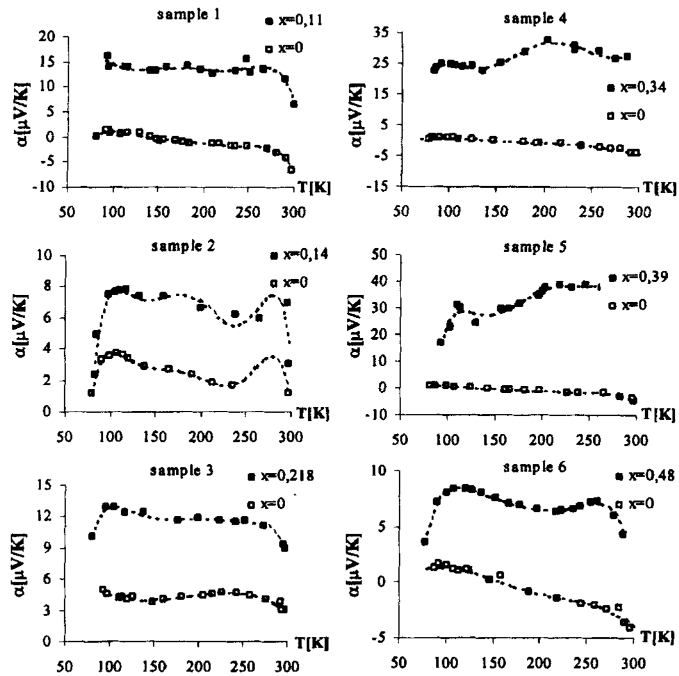

FIGURE 2. Temperature dependence of the thermoelectric power of $Li_xBi_2Sr_2CaCu_2O_8$ before and after intercalation of lithium

The character of the thermoelectric power dependence together with the results of electrical resistivity (Fig. 1) shows that in the temperature range $T > T_C$ the charge transport takes place in the effective band through carries with energies close to the Fermi energy.

An example discharge curve (OCV) for $Li/Li^+/Li_xBi_2Sr_2CaCu_2O_8$ cell for sample 6 is shown in Fig. 3. In an agreement with the electronic model of the intercalation process[3], which in the above system can be presented as follows:

$$xLi^+ + xe^- + Bi_2Sr_2CaCu_2O_8 \Leftrightarrow Li_xBi_2Sr_2CaCu_2O_8$$

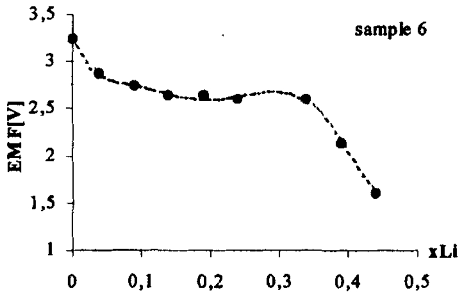

FIGURE 3. Discharge curve (OCV) for $Li/Li^+/Li_xBi_2Sr_2CaCu_2O_8$ cell

The introduced electrons (together with lithium ions) occupy the available states at the Fermi level and raise it in a way corresponding to the states density function N(E). The change in the electromotive force of the $Li/Li^+/Li_xBi_2Sr_2CaCu_2O_8$ cell, for which the anode potential is constant, corresponds to the change in the electrochemical potential of electrons in $Li_xBi_2Sr_2CaCu_2O_8$ [3]. The obtained monotonic character of changes in the cathode potential of $Li^+/Li_xBi_2Sr_2CaCu_2O_8$ suggests a monotonic change in the position of a Fermi level during intercalation process, which is in agreement with the thermoelectric power measurements (Fig.2), referring to the position of the Fermi level inside the effective energy band. Thermoelectric power measurements and X-ray studies of $Li_xBi_2Sr_2CaCu_2O_8$ indicate that its crystal structure remains unchanged upon Li intercalation ($x < 0.5$). To illustrate the effect of lithium on electrical properties of the bismuth superconductor, the dependence of electrical conductivity and thermoelectric power has been presented as a function of lithium content at constant temperature (Fig.4).

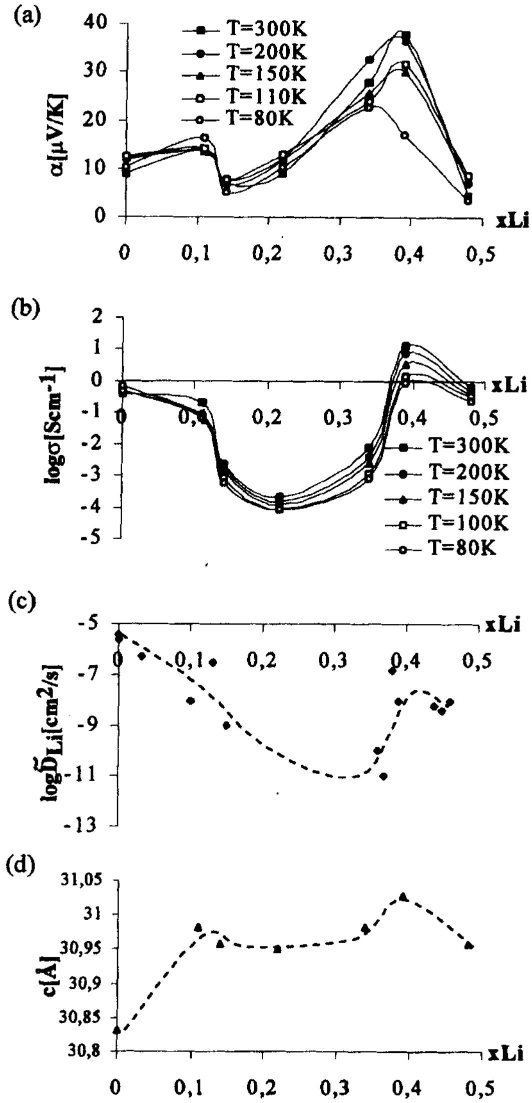

FIGURE 4. Dependence of thermoelectric power (a), electrical conductivity (b), chemical diffusion coefficient (c), lattice parameter „c" (d) of $Li_xBi_2Sr_2CaCu_2O_8$ on the concentration of lithium

In Fig.4 there are also given the results of chemical diffusion coefficient of lithium in $Li_xBi_2Sr_2CaCu_2O_8$ and lattice parameter „c" in function of lithium concentration. The shape of all dependencies (Fig.4) are similar what indicates a correlation between structural, electronic and transport properties of $Li_xBi_2Sr_2CaCu_2O_8$ system. It demonstrates the best electronic properties for a lithium contents of 0.4. For the similar concentration of lithium the maximum of chemical diffusion coefficient of lithium is observed[4]. This indicates that effectiveness of the intercalation process (D_{Li}) is related to the transport properties of electron carriers.

Acknowledgement

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