High Ionic Conductivity of $Li_2O:B_2O_3:V_2O_5$

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Z. Naturforsch. **47a**, 1011 – 1012 (1992); received March 5, 1992

Lithium ion conducting solids have been of great interest in recent years [1–5]. We have also been active in this direction [6–8]. This paper reports on the electrical transport and phase transition of $Li_2O:B_2O_3:V_2O_5$. The compound was prepared by solid state reaction technique. The measurements of the electrical conductivity (σ), thermoelectric power (S), dielectric constant (K) and molar magnetic susceptibility (χ_M) are performed from 500 to 1110 K. The details of these measurements are described in [9, 10]. The σ and S variations are shown in Fig. 1 as $\log \sigma T$ and S vs. $1/T$ plots. Both the plots show three linear regions, namely, 500–850 K, 900–960 K, and 980–1110 K. The activation energy (E_a) and heat of transport (Q) for the third temperature range are 0.39 eV and 0.58 eV, respectively. σ jumps by a factor of 180 around 855 K, and again jumps by a factor of 4 around 970 K. Thus this material seems to have two phase transition temperatures: one around 855 K and the other at 970 K. The sign of S indicates that current is carried by positive charge carriers. The time variation of the dc electrical conductivity (the results are not shown) shows that σ is completely ionic in the temperature range 980–1110 K. Ions are also the dominant charge carriers at lower temperatures but in general σ is mixed (ionic and electronic). Lithium seems to be the mobile ion of the solid. σ in the temperature range 980–1110 K is high, being $150\,\Omega^{-1}\,m^{-1}$, and it is totally ionic, hence this is the superionic phase of the solid. The phase transitions around 855 K and 970 K are also reflected in K and χ_M vs. T plots, as shown in Figs. 2 and 3, respectively. The room temperature K value is not high, being about 30 around 300 K. It increases slowly up to 700 K but rises steeply above 855 K and becomes of the order of 3.2×10^7 at 900 K. It drops by a factor of 3 around 970 K and then remains almost constant. It

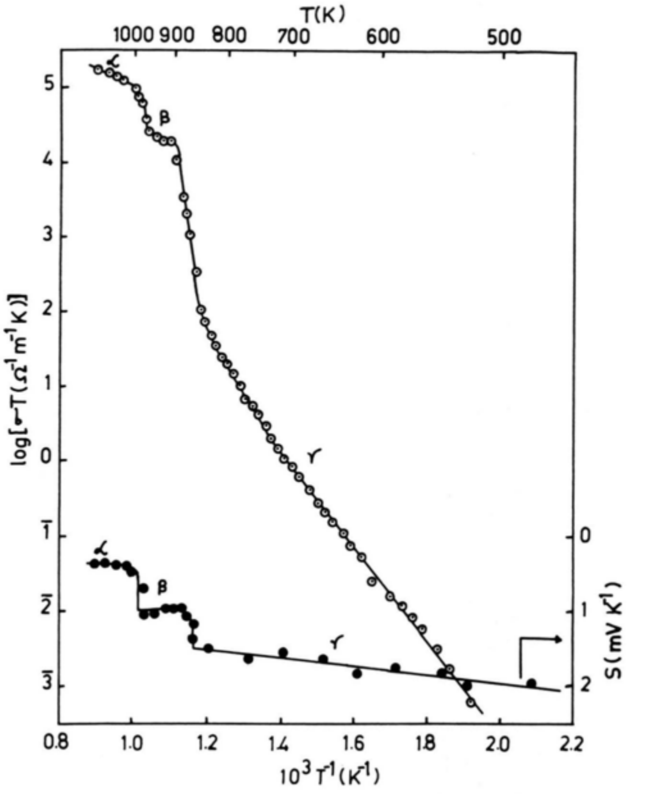

Fig. 1. Plots of $\log \sigma T$ and thermoelectric power (S) against inverse temperature (T^{-1}).

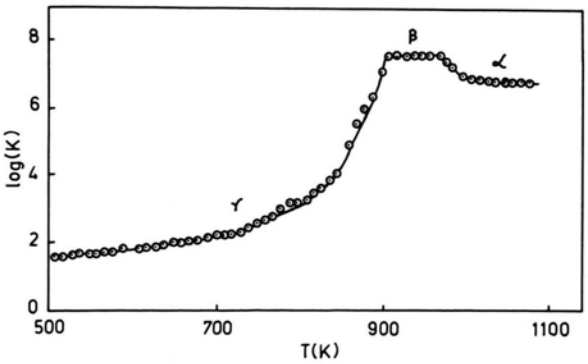

Fig. 2. Plot of logarithm of dielectric constant ($\log K$) against temperature (T).

is seen from the χ_M vs. T plot that χ_M is negative and is almost independent of temperature up to 855 K but shows a downward drop above this temperature. Around 970 K, χ_M jumps abruptly and then increases slowly with temperature. The reason for the negative

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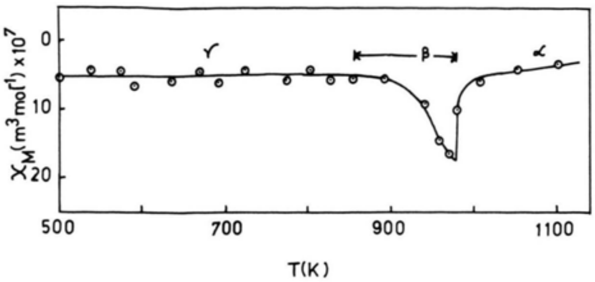

Fig. 3. Plot of molar magnetic susceptibility (χ_M) against temperature (T).

value, drop and rise in χ_M is that this material does not contain magnetic ions and χ_M for such solids depends upon their bonding configuration. The onset of disordering at the phase transition disrupts the bonding configuration of the solid. This leads to specific changes in χ_M at this temperature. Q is larger than E_a in the superionic phase. This is against the trend $E_a > Q$ observed for Ag^+ and Cu^+ active superionic solids. This indicates that the mechanism of ion conduction in this solid differs from that usual ionic solids.

Acknowledgement

Authors are thankful to CSIR, India for financial assistance.

[1] S. Pizzini, J. Appl. Electrochem. **1,** 153 (1971).
[2] M. Lazzari and B. Scrosati, J. Power Sources **1,** 333 (1976/1977).
[3] R. A. Huggins, Electrochemica Acta **22,** 773 (1977).
[4] B. B. Owens, Int. Symp. Solid Ionic and Ionic Electronic Conductors, Rome, Sept. (1976).
[5] H. V. Venkatasetty, Lithium Battery Technology, John Wiley and Sons, Inc. (1984).
[6] Kanchan Gaur, A. J. Phatak, and H. B. Lal, J. Mat, Sc. **23,** 4257 (1988).
[7] H. B. Lal, Kanchan Gaur, and A. J. Phatak, J. Phys. D. **22,** 305 (1989).
[8] H. B. Lal, Kanchan Gaur, and A. J. Phatak, J. Mat. Sc. **24,** 1159 (1989).
[9] Kanchan Gaur, Ph.D. Thesis, Gorakhpur University, Gorakhpur, India (1984).
[10] A. K. Tripathi, Ph.D. Thesis, Gorakhpur University, Gorakhpur, India (1981).

Verantwortlich für den Inhalt: A. Klemm
Satz und Druck: Konrad Triltsch, Würzburg