ELECTRICAL PROPERTIES OF NONSTOICHIOMETRIC $Al_{2+x}O_3$

V. Gotovac

Department of Physics, Faculty of Chemical Technology, University of Split, Split

B. Lovreček

Institute of Electrochemistry, Faculty of Technology, University of Zagreb, Zagreb

In the present article the attempt has been made to find the correlations between the electrical properties and the chemical composition of the sintered nonstoichiometric $Al_{2+x}O_3$ semiconductors.

The specimens were made by mixing aluminium and aluminium oxide in ratios 1:3, 1:5, 1:10, 1:20 and 1:50[1]. The mixtures were molded into small cylinders, which were fired in nonoxidizing atmosphere at about 1500°C for 80 minutes. Based on our previous experimental observations $Al_{2+x}O_3$ specimens were classified as metal-excess n-type semiconductors. The electrical dc and ac conductivity of these specimens was measured as a function of temperature and departure from stoichiometry. The temperatures and frequencies ranged from 20°C to 1200°C and from 50 Hz to 500 kHz respectively.

The low temperature part of σ_{ac} was slightly dependent on temperature and proportional to ω^s with $0.7 < s < 1.0$. We attributed σ_{ac} here to hopping conduction through states at the Fermi level. The density $N(E_F)$ calculated from the Austin-Mott relation[2] was of the order of 10^{20} eV^{-1} cm^{-3} for all specimens with different metal excess. At the temperatures above $600^{o}C$ σ_{ac} and σ_{dc} were thermally activated indicating change of the mechanism into the transport by the carriers in localized states in the donor band. The conduction process appeared to be predominantly electronic and controlled by the metal excess. The high temperature conductivity decreased as the metal excess in nonstoichiometric specimens decreased. The preexponential factors changed in the same manner. The activation energies were also influenced by the metal excess. We suppsed that the electron carrier concentration was proportional to metal excess. We were able to represent compositional and temperature dependence of the electrical conductivity of nonstoichiometric $Al_{2+x}O_3$ in the high temperature range by the following expression[3]:

$$\sigma_{dc} = 0.003\ x \exp\left[-\frac{E(x)}{kT}\right] \tag{1}$$

where E(x) was approximated by

$$E(x) = 0.86 - 0.54\ x\ (eV) \tag{2}$$

The departure from stoichiometry x was determined analytically.

References:

1) V.Gotovac, Ph.D.Thesis, University of Zagreb, 1973.
2) I.G.Austin and N.F.Mott, Adv.Phys.18 (1969)41
3) R.N.Blumenthal and R.A.Sharma,J.Chem.Solids 13(1975)360