Electrical characterisation of thick film NiMn2O4+ d NTCR thermistor ceramics

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Abstract

The direct current resistance vs temperature characteristics and the alternating current impedance of thick screen-printed films made of ceramic NiMn2O4+ d thermistor material have been analysed to determine the electron conduction mechanism. In the literature direct current electron transport in spinel NTCR thermistors is commonly described by an Arrhenius hopping model (R T exp(T0/T)) for nearest neighbour hopping or by different variable range hopping models (R T^{2p} exp(T0/ $T)^p$. In screen printed films direct current conduction was well described by variable range hopping with p 0.5, indicating that the shape of the density of states was parabolic probably due to a Coulomb type gap around the Fermi level. The T0 values ranged from 1.90 1.97 105 K. Impedance spectroscopy was carried out at a frequency range of 5 Hz 6 MHz, at different temperatures between 60°C and 220°C. For frequencies below 2.7 MHz the complex impedance was well described by a standard equivalent circuit, containing one Resistance-Capacitance element. The loci of negative imaginary versus real part of the impedance (- Zvs Z) showed one regular semicircle, and the capacitance and the resistance of the equivalent circuit element were determined and plotted vs temperature. The capacitance was found to be in the range of 1 10-12 F at all temperatures, indicating a typical bulk effect. The resistance vs temperature characteristics were in very good agreement with the direct current results and followed the same variable range hopping model with p 0.5. At frequencies above 2.7 MHz the Z-Z loci indicated that the impedance could not be described by a standard RC element here.