Effect of scale on the variability of R-T measurements in PTC thermistors

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Abstract

BaTiO3-based PTC thermistors undergo a large and rapid increase in resistance just above the Curie temperature, TC. The resistance increase is predominantly associated with an increase in grain boundary barrier height, although there is ample evidence for variations in the magnitude and form of PTC behaviour between individual grain boundaries.

In the current study the microstructural, compositional and electrical properties of a commercial Ca, Sr, Pb doped BaTiO3 PTC thermistor were characterised on the macroscopic, mesoscopic and microscopic scales.

Bulk pellet responses were found to be highly consistent with only small variations in the shape of the R-T curve in the temperature range just above TC, which were attributable to smearing of TC by variations in the amount of surface lead volatilisation during sintering.

R-T measurements were made on the meso-scale by surface deposition of ohmic electrodes, spaced 25mm (6 grain diameters) apart. In the central region R-T data showed good consistency after an initial conditioning run. Slight inhomogeneity was observed in the gradient of the PTC slope between pads, possibly due to the effect of variations in microstructure, most notably porosity, on current flow pathways between electrodes. An increase in pre-switching resistance and a decrease in switch point was observed in the Pb depleted surface region.

R-T measurements across individual high angle grain boundaries showed significant inhomogeneity. Although the magnitude of the PTC effect was similar for all grain boundaries, the field dependence varied from less than one order of magnitude, to about two orders of magnitude. Additionally, the shape of the R-T curve above TC and the field dependence of the onset of NTC behaviour also varied between grain boundaries.

The possible factors affecting the inhomogeneous response at the individual grain boundary level will be discussed.