Localized Relaxation in Stabilized Zirconia

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Zirconia is of great current interest because of its potential application as an ionic conductor. Although the structure of the material at room temperature is naturally monoclinic, it is stabilized in the cubic phase by doping with divalent or trivalent oxides such as Y_2O_3, or CaO over a wide temperature range. The dopant ions substitute for Zr ions on cation sites, whilst O vacancies occupy anion sites. It is well known that long-range transport of O ions is due to hopping between anion sites via the oxygen vacancies. However, in earlier work we found evidence suggesting that some oxygen vacancies also exist in bound, localized states in YSZ. In the present paper we report temperature measurements of internal friction made using 400Hz torsional vibrations in yttria-stabilized zirconia (YSZ) with 9.5mol%Y_2O_3 and calcia-stabilized zirconia (CSZ) with 12mol%CaO, which support this suggestion and give further information about the binding mechanism.

From the results shown in Figure 1(a) it is seen that internal friction overall exhibits anisotropy with respect to the directions of both the central sample axis (k) and the torsion direction (t). Detailed analysis resolves the data into two separate peaks. One of these displays isotropic behaviour, indicating that it is due to diffusion relaxation, which is known to be responsible for the long-range transport and is isotropic because of the overall cubic symmetry of the crystal. The second peak due to localized relaxation exhibits significant anisotropy which it is proposed reflects the symmetry of the local environment of the site into which the oxygen vacancy is bound. The strength of the internal friction reflects the binding state of the vacancy, and it is seen from Figure 1(b) that the strength depends on the nature of the dopant ions, suggesting that the binding mechanism is affected by both ionic size and effective charge of the dopant.

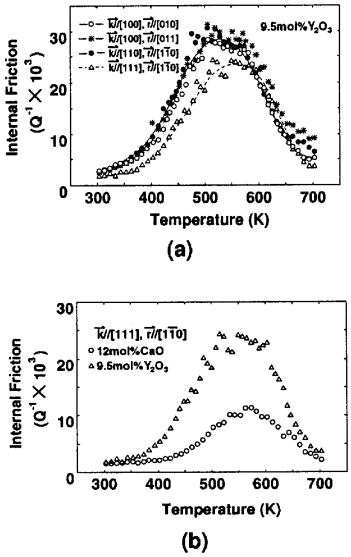

Figure: Temperature dependence of the internal friction in YSZ and CSZ for torsional vibration.