ENHANCED IONIC CONDUCTIVITY OF 8 MOL% YTTRIA STABILISED ZIRCONIA BY FLASH SINTERING

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The high conductivity of O^{2-} ions in YSZ has led to its selection as the preferred electrolyte in many solid oxide fuel cell and oxygen sensor applications[1] because of its good chemical and structural stability under the temperature and environmental conditions in operational fuel cells[2]. The addition of yttria to zirconia increases the concentration of oxygen ion vacancies, as the principal mechanism of charge compensation on replacement of Zr^{4+} by Y^{3+} leads to enhanced ionic transport in the electrolyte. The highest conductivity is obtained in the cubic phase of zirconia containing 8-10 mol% Y_2O_3.
There is much current interest in flash sintering as a novel, rapid sintering method which has evolved from initial studies on YSZ[3]. It was reported[4] that partially-stabilized, tetragonal YSZ ceramics of composition 3 mol% Y_2O_3, prepared by both conventional sintering and field-assisted flash sintering, developed similar microstructures. Impedance measurements showed the presence of grain and grain boundary components and at a given temperature of 300 °C, the conductivities of flash-sintered samples were 2 to 3 times higher than those of conventionally-sintered samples. This increase appeared to be not due to microstructural effects or changes; it was presumed, but not confirmed, that the conductivity increase was ionic. It has been suggested that flash sintering generates defect concentrations far above equilibrium values[5], some of which may be retained after flash. The increased conductivities were attributed to increased carrier (oxygen vacancy) concentration, although the mechanism by which these extra carriers were created was unclear. Experimental measurements of residual lattice expansion after flash were attributed to the creation of a high concentration of oxygen Frenkel defects during flash; first principles calculations showed that oxygen-related defects may be produced in much higher concentration than Zr-related defects[6].

In the present work, the ionic conductivity of flash-sintered, polycrystalline 8 mol% yttria stabilized zirconia (8YSZ) is investigated. Flash sintering was carried out at a furnace temperature of 850 °C with an electric field of 100 V cm^{-1} to initiate flash, the current density limit was varied between 60 and 100 mA mm^{-2}. Post-flash impedance spectroscopy measurements over the range 215–900 °C showed that both bulk and grain boundary conductivities had increased with the increased current density limit which was set prior to flash. The conductivity increases post-flash were ionic, not electronic, although electronic conductivity probably occurred, in addition to ionic conductivity, during flash and were not attributable to sample densification or microstructural changes. The higher ionic conductivities are attributed to a change in YSZ defect structure that led to an increased concentration of mobile charge carriers.

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