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Glass-ceramics in the system RO-BaO-SiO_2 (R= Mg, Zn) for sealing SOFC

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Abstract

One important challenge in the advance of planar solid oxide fuel cells (SOFC) relates to the development of suitable sealant materials to separate the cathode and anode chambers, and to maintain gas-tightness of the system at elevated temperatures, 600-1000ºC. Seals are applied to the cell edges between interconnect and electrolyte and/or electrodes, depending on the system design, an also to the gas manifolds to bond them to the sintered electro-active components. This talk is a summary of the results obtained of a family of glass-ceramics in the systems RO-BaO-SiO_2 where R= Mg and Zn which present a promising combination of physicochemical properties, including suitable dilatometric characteristics and sintering/crystallisation behaviour which resulted in dense materials with the desided microstructure at temperatures around 850ºC. For these glass-ceramics, sealing of planar SOFC may be performed at 700-800ºC via sintering of the glass powder during start-up; further treatment at the operation temperature induces the precipitation of crystalline phases which generatre a rigid seal with good thermal, chemical and mechanical stability. The study of the crystallisation behaviour of some compositions was completed by DTA and DSC at different heating conditions and particle sizes, and the main crystalline phases were determined. Impedance spectroscopy studies in air showed that these materials behave as insulators in the entire temperature range relevant for SOFC, 500-1000ºC. Additional work lead to the complete electrical and electrochemical characterization of the glass-ceramic sealants selected in the RO-BaO-SiO_2 systems, with special emphasis on oxygen permeability and conductivity in various atmospheres, properties which are of key importance for practical applications. By the other hand, the chemical stability versus the cell components in the different cell atmospheres was studied stabilising the corrosion mechanism and the characteristics of adherence, union and gas-tighness. The study allowed evaluating the long term stability of the seals, through the effect of the degradation on the materials structure and properties, and interfacial reaction products.Further modifications substituting SiO_2 for B_2O_3 and PbO, and part of MgO for ZnO will be also presented. All the glasses present a suitable thermal expansion coefficient for use in SOFCs. The addition of B_2O_3 produces the expected decrease of viscosity and a delay in the crystallisation, which gives a better wettability of the glasses on the steel and a better union, inhibiting the direct reaction between chromium oxide and the barium rich crystalline phases to form BaCrO4. At 850◦C, barium silicates crystallize in all the glasses. The seals are pore-less, strongly adherent to the steel and present elongated crystals which are homogeneously distributed in the glass matrix.