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Development of Alternative Seal Materials for Solid Oxide Fuel Cells (SOFCs): Li_2O-ZrO_2-SiO_2-Al_2O_3 (LZSA) Glass-ceramic Seal Prepared by Tape Casting

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Abstract – The slip based on LZSA glass-ceramic was prepared and tape cast to produce the seal material for planar SOFC. The optimized slip showed pseudoplastic behavior with an average viscosity of 2076 mPa·s at the 0,02-50 s^{-1} range of shear rate and the sintered density of the tape reached to 96 % of the theoretical density. Moreover, the thermo-mechanical compatibility of the new sealant was tested by post-firing the LZSA on the yttria-stabilized zirconia (YSZ) substrate. However, the preliminary results showed delamination at the interface, which requires further materials optimization.

Seal material selection is a critical part of the SOFC fabrication process. The sealant has to operate at a wide range of oxygen partial pressures at the anode and the cathode and it has to be thermo-mechanically and chemically compatible with other SOFC components. Glass and glass-ceramics are so far the mostly applied seal materials since they provide high adherence and mechanical integrity [1, 2]. These materials are characterized mainly by two parameters: the glass transition temperature (T_g) above which the glass flows and accommodates stresses arising from thermo-mechanical gradients and the coefficient of thermal expansion (CTE) that can be tailored over a wide range of temperatures [3].

In this work, the seal material of the SOFC was prepared by tape casting in two steps: in the first step, which is known as dispersion milling, the LZSA powder and the dispersant were ball-milled in de-ionized water for 24h. In the next step, the binder was added and the mixture was ball-milled for another 24h. The slip was de-aired and its rheological behavior was characterized by a rheometer with cylinder-plate system, which confirmed pseudoplasticity (shear thinning) and a viscosity of 2076 mPa·s at the 0,02-50 s^{-1} range of shear rate. The slip was tape cast after the optimization of the doctor's blade height to give a dried thickness of approximately 130μm. The tapes were laminated in 10-layers, pressed iso-statically at 25 MPa and fired in furnace at a peak temperature of 750 °C for 1 h, which yielded a relative density value of 96 % (Fig. 1).

In the second part of the work, LZSA slip was deposited on the previously-fired YSZ substrate, which was also prepared by tape casting and fired at 1350 °C for 1 h reaching up to 94 % of the theoretical density. Following deposition, the bi-layer was fired at 750 °C for 1 h (post-firing). However, the scanning electron microscopy (SEM) images showed apertures at the YSZ-LZSA interface (Fig. 2), which were ascribed to insufficient wetting and adherence of the LZSA on the YSZ substrate during firing. Therefore, the parameters to verify for the next phase of the work are the chemical interaction of both materials at the interface and the crystallization temperature/grade of the LZSA glass-ceramic.

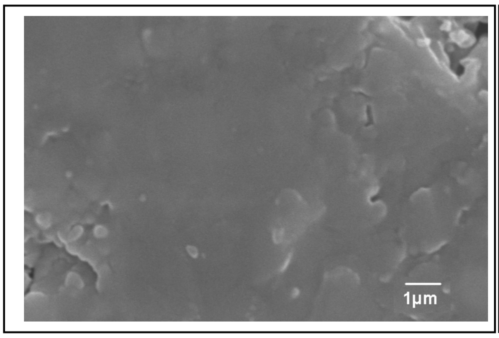

Figure 1: Surface of the LZSA seal.

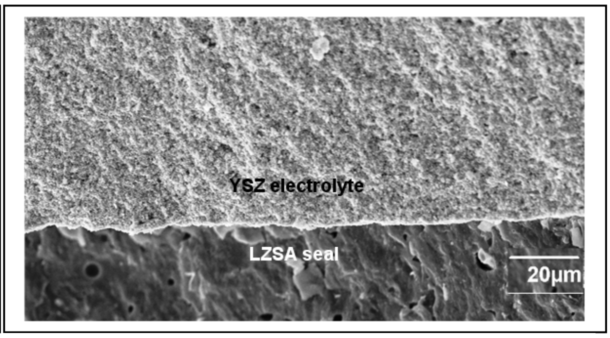

Figure 2: YSZ-LZSA bi-layer and the delamination at the interface

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