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Mechanical Properties at room and elevated temperatures of zirconia tapes used for electrolyte supported solid oxide fuel cells

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For solid oxide fuel cells (SOFCs) one key aspect is the structural integrity of the cell and hence its thermo-mechanical long term behavior.

In a first step failed cells from several operated cell stacks were fractographically evaluated. The respective findings were then set into a larger picture including an analysis of the present stresses acting on the cell like thermal and residual stresses and the measurements regarding the temperature dependent electrolyte strength. In a second step to assess the reliability of a zirconia tape with respect to a specific stress distribution and environment, the strength had to be properly characterized. Therefore a selection of several commercial highly ionic conductive tapes, including scandia doped zirconia tapes, were investigated regarding their strength under inert and humid conditions at room temperature, which required the determination of the elastic constants and the fracture toughness as well. Further, the impact of the temperature on the strength and the fracture toughness of electrolytes as well as the change of the elastic constants were investigated. Additionally, 3YSZ and 6ScSZ materials were characterized regarding the influence of sub critical crack growth (SCCG) as one of the main lifetime limiting effects for ceramics at elevated temperatures. Finally, the reliability of different zirconia tapes was assessed with respect to temperature and SCCG.

It was found that the strength is only influenced by temperature through the change in fracture toughness. SCCG has a large influence on the strength and the lifetime for intermediate temperature, while its impact becomes limited at temperatures higher than 650 °C. In this context the tetragonal 3YSZ and 6ScSZ behave quite different than the cubic 10Sc1CeSZ, so that at 850 °C it can be regarded as competitive compared to the tetragonal compounds.

Keywords: SOFC, electrolyte, thermo-mechanical properties, reliability, lifetime