Degradation mechanisms and advanced characterization and testing

Suitable new ceramic glass compliant sealants for SOFC stacking

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In solid oxide fuel cell (SOFC) stacks the sealing is a critical element which has to ensure gas tightness between different gas streams as well as electrical insulation in several parts of the system depending on its design. It has therefore to establish stable interfaces with different materials such as the ferritic stainless steel (FSS) used for interconnects frame or gas manifolds and the ceramic materials of the cell electrolytes [1, 2]. Therefore, sealants have to be chemically and mechanically stable in contact with such materials at the SOFC working conditions in terms of temperatures, thermal and stress gradients, and exposition to different gas compositions.

Glasses and crystallizing glass sealings are widely used as sealing material because of their thermal expansion characteristics, mechanical properties, the possibility to obtain gas tight structures and ease of application. However, due to the operating temperatures, reactions and diffusion processes can occur at the interfaces resulting in the formation of undesirable crystal phases that could compromise the glass properties increasing the risk of failures. The application of a barrier layer between the two components is considered as suitable countermeasure avoiding the migration of elements at the interfaces [3].

In this study a testing protocol for SOFC glass compliant sealants has been proposed consisting in standardized sample preparation and testing method. It has been applied for testing 7 possible new compositions compared with a reference, state-of-art, material. Additionally, the barrier properties and compatibility at the interfaces of Yttria-stabilized zirconia (YSZ) were investigated. YSZ layers have been applied by means of plasma spraying on as-rolled FSS substrates.

All the glass compositions, applied on substrates with and without YSZ coating, have been tested at 780°C in static air up to 1000 hours.

The characterization focused on the interaction of glasses with the substrate, the evolution of the interfaces and the bulk of the materials. Microstructural changes and migration of elements have been characterized post-experiment in cross-section by means of scanning electron microscopy- energy dispersive X-ray analysis.

As result, three different trends in the crystallization behavior have been identified, bringing to the increase and stabilization of such value to a different extent before 1000 hours.

Two compositions have been selected as promising for application in stacks considering their high microstructural stability, adhesion to the substrate and low diffusion of elements at the interfaces.

The YSZ layer resulted porous and characterized by inhomogeneous thickness. Its porosity decreased constantly up to 1000 hours from 5% to less than 1%. At the FSS/YSZ interface the formation of a Cr-rich layer was observed. Such layer thickened up to 500 hours of aging reaching a stable value of 3µm. For all the tested compositions, the YSZ layer resulted compatible with the glass material enhancing, in some cases, the adhesion to the substrate. Such coating resulted effective as barrier layer preventing the element migration from the metal substrate toward the sealing material.

References

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