Metallic Components for a Plasma Sprayed Thin-Film SOFC Concept

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At the German Aerospace Center (DLR) in Stuttgart a plasma sprayed thin-film concept has been developed for producing a thin-film SOFC with lower ohmic cell losses and hence an increased power density. In the DLR concept the entire MEA ("Membrane-Electrode-Assembly") is deposited onto a porous metallic substrate by an integrated multistep vacuum plasma spray (VPS) process. In this concept, the substrate-supported cell is generally fitted into a frame between the interconnectors and sealed by a glass sealant layer. Sealing is also possible by laser welding. In this case, the substrate and frame are brazed and welded together directly onto the interconnector. This sealing procedure is performed prior to the manufacture of the entire MEA structure. The DLR SOFC concept with relatively thick bipolar plates was originally designed for stationary application. In current developments this stack technology is modified for mobile application by using thin stamped metal sheets for the interconnect.

Cell operating conditions are highly demanding of metallic SOFC components. High temperatures and the oxidizing gas atmospheres necessitate many world wide material developments, tests and investigations to find a suitable material for conventional and low cost bipolar plates. At DLR various ferritic steel materials from different suppliers were investigated and tested under SOFC relevant conditions. Results indicate that steels with high chromium contents (~ 20 wt. %) and low manganese contents (~ 0,02 - 0,05 wt. %) show an adequate corrosion stability.

The requirements of the porous metallic substrate are much higher. Besides the material features, such as high electrical conductivity, adequate corrosion stability and an adapted thermal expansion coefficient (~ 11 x 10^{-6} K^{-1}, 30 - 1000 °C), structural properties have to add. These are such as high gas permeability (porosity (~ 80 vol. % and higher) for a sufficient fuel gas supply to the anode, mechanical strength for cell support and a thin (200 - 300 µm) and fine porous top layer (pore size distribution 5 - 40 µm) to deposit planar and closed MEAs. The combination of all these requirements in one integral substrate structure has turned out to be a key problem in the plasma sprayed SOFC concept. Therefore, the DLR performs several parallel substrate developments with different partners from other research establishments and from industry.

Oxidation processes on the metallic components during stack operation as well as the kind of cell integration (by glass sealant or by brazing and welding) play a decisive role on the electrochemical stack performance. To investigate these influences I-V characteristics of short stacks were performed with different integrated substrate-supported cells.

The paper provides an overview of material investigations at metallic components and describes the substrate development processes at DLR. Furthermore, I-V characteristics of short stacks with different integrated substrate-supported cells are presented.

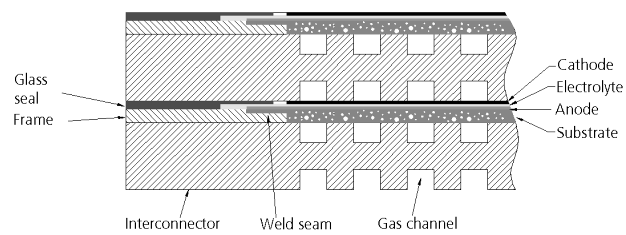

Fig. 1: Integration of substrate-supported cells in metallic housing

Substrate	Knit fabric	Foams	Woven wire structures
Material	Fe-23Cr-0,5Mn	Fe-22Cr-5Al-0,1Y	Fe-20Cr-5Al
Thickness / [mm]	~ 1,1	~ 1,8	~ 1,0
Porosity / [Vol. %]	~ 90	~ 80	~ 60
Supplier	Rhodius, Weißenburg	Technetics, Florida	Haver & Boecker, Oelde

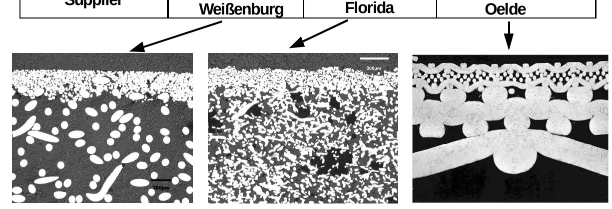

Fig. 2: Porous metallic substrates used for plasma sprayed SOFC concept

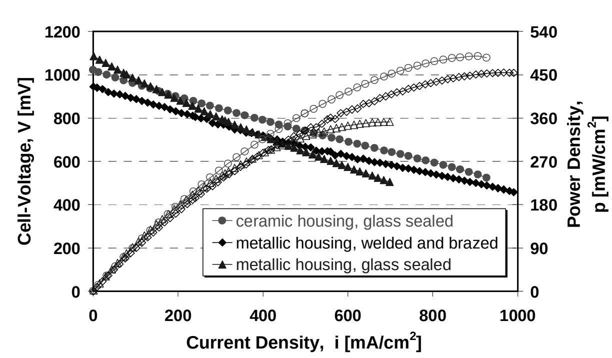

Fig. 3: I-V characteristics of plasma sprayed short stacks (10 x 10 cm²) with FeCrAl-type metallic foam substrate measured with different stack integration at 900 °C with H_2 and O_2