Development of Thin-Film SOFC for Stationary and Mobile Application by Using Plasma Deposition Technology

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Conventional sintering techniques such as tape casting, screen printing and wet powder spraying with subsequent sintering steps are usually applied SOFC manufacturing technologies. At the German Aerospace Center (DLR) in Stuttgart an alternative concept for planar SOFC using a metallic substrate support and thin-film layers which are deposited by plasma spray processes has been developed. This "spray concept" enables the fabrication of the entire membrane-electrode assembly in a single consecutive spray process without any sintering step or other thermal post-treatment after spraying, thus promising fast and cost-effective cell production. Main advantages of the metallic substrate support are its excellent electrical and thermal conductivity and the ability of multiple rapid thermal cycling which is an important precondition for SOFC application as on-board auxiliary power unit (APU) in the automotive industry.

Based on this concept an adequate stack design and stack technology for the assembly of stacks in the power range of 1-5 kW has been developed for both stationary and mobile applications. Internal manifold for fuel gas and air is used with gas distribution in counter flow mode. For stationary application machined interconnector plates of ferritic steel are used whereas for APU application a modified stack design by using thin stamped metal sheets forming a cassette arrangement is applied. In both cases the porous metallic substrate is brazed onto the interconnect and the layers of the cell are then plasma sprayed onto this interconnect/substrate unit. Sealing is done by glass or ceramic seals.

The vacuum plasma spray technology and the special features of the installation used to produce thin dense electrolyte layers in the range of 30 µm thickness and porous electrode layers by using powder feedstock of conventional SOFC materials (YSZ, NiO, LSM) is presented. In the course of the scale-up process from laboratory scale cells with an area of some cm² to the targeted final size of 300-400 cm² plasma sprayed cells with an area of 5x5 cm² and 10x10 cm² are currently fabricated and electrochemically investigated in metallic housings and shortstack arrangements.

The nature of the cell supporting substrate has a significant influence on the electrochemical performance of plasma sprayed cells. Thus, substrate development is a key issue with the "spray concept". The application of different substrate materials and structures, their influence on the electrochemical performance and the development of novel substrates is emphasized. For electrochemical evaluation I-V characteristics and impedance spectroscopy measurements were performed at different operating temperatures, fuel gas compositions and gas flow rates. Also thermal cycling and fast start-up experiments were carried out. Results on all electrochemical investigations are reported.

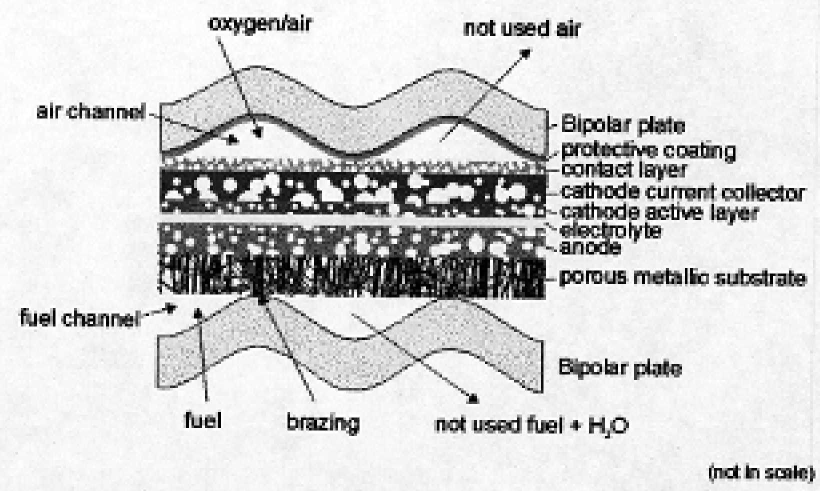

Fig.1: Principle of planar SOFC design according to DLR "spray concept"

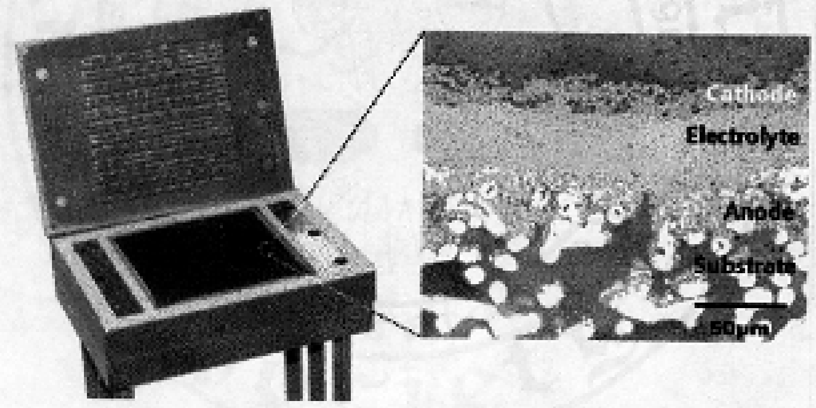

Fig. 2: Set-up of plasma sprayed single cell (10x10 cm²) in metallic housing

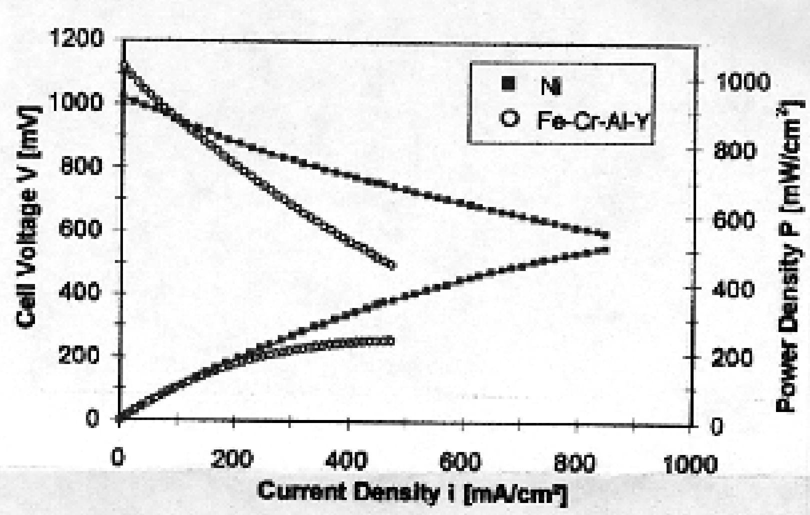

Fig. 3: I-V characteristics of plasma sprayed cells (10x10 cm²) on different metallic substrates (Ni felt and FeCrAlY foam) at 900 °C with H_2 and air