MATERIALS AND ELECTROCHEMISTRY IN THE DEVELOPMENT OF SOFC ELECTRODE MATERIALS

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Solid oxide fuel cell (SOFC) is an all solid device to convert gaseous fuels such as hydrogen, natural gas and gasified coal to electricity through electrochemical process. The reliability and efficiency of SOFC is critically dependent on the performance and stability of its components including anode, cathode and electrolyte. In this paper, specific examples are given to demonstrate the importance of materials and electrochemistry issues in the development of high performance Ni/Y 2O 3-ZrO 2 (Ni/YSZ) cermet anodes and (LaSr)MnO 3 (LSM) based cathodes.

Ni/Y 2O 3-ZrO 2 cermet anodes are the most common anode materials for SOFC and the anode performance is critically dependent on the microstructure and distribution of Ni and YSZ phases. 1,2 The microstructure and phase distribution in turn is dependent on the fabrication process and the characteristics of the starting NiO and zirconia powders. Conventionally, the development of fabrication process for Ni/zirconia cermet anodes follows the traditional approach by the selection and optimization of various fabrication process parameters, as shown in Fig.1 for the development of Ni/YSZ cermet anodes. The most important conclusion from this kind of evaluation and optimization exercise is that the electrode performance is critically dependent on the selection of various process parameters and they are all very closely inter-related in their effect on the electrode performance and its stability. The Ni/zirconia cermet anode fabricated based on the optimized procedure showed good electrochemical performance of $\eta \leq \sim 50 \text{ mV at } 250\text{mAcm}^{-2}$ and 1000°C and good stability. 2

To understand the most important microstructural factors in the development and optimisation of Ni/YSZ cermet anode, understanding of the electrochemical issues related to the reaction mechanism and kinetics of hydrogen oxidation becomes important. Fig.2 shows schematically the hydrogen oxidation reaction at Ni/zirconia cermet anode. 3,4 This indicates the important role of the three phase boundaries in the kinetics of the hydrogen oxidation reaction. Optimization of the three phase boundary areas led to the identification of the most important stages in the fabrication of Ni/zirconia cermet anodes in the development of the cermet microstructure, i.e., the high temperature sintering and reducing stages before the use as fuel electrodes, and to the application of ion impregnation method in the enhancement and optimization of Ni/zirconia cermet structure (see Fig.3). In the case of Ni/TZ8Y cermet anode, ion impregnation treatment practically reduced the operation temperature of the Ni/TZ8Y cermet anodes by \sim 200°C. Ion impregnation method is equally effective in the enhancement of the microstructure and electrode performance of Ni/TZ8Y cermet anodes and LSM cathodes. The materials and electrochemistry related to the development of LSM-based cathodes are also discussed.

Reference