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Nanostructured ceria-based anodes for IT-SOFCs

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Abstract – We present new nanostructured ceria-based anodes for IT-SOFCs operated under hydrogen or hydrocarbons. Ceria-based materials are mixed ionic/electronic conductors under reducing atmosphere, so fuel oxidation can be produced in their entire surface. These new nanostructured anodes exhibit high performance probably due to the dramatic increase of the number of active sites for fuel oxidation caused by the increase of the specific surface area.

One of the most important challenges of Solid-Oxide Fuel Cells (SOFCs) technology is the reduction of the operating temperature. While new electrolytes and cathodes exhibiting high performance at intermediate temperatures have been found in the last years, the main problem lies in the anode, particularly if hydrocarbon fuels are used. Conventional anodes for methane oxidation are based on internal reforming using nickel as catalyst, but this mechanism is efficient only at high temperatures. For these reasons, two new concepts have been recently explored [1]: SOFCs operated via direct electrochemical oxidation of hydrocarbons and the single-chamber SOFCs. For both cases, CeO_2-based anodes have proven to exhibit excellent performance. The interest in these materials relies on the fact that they are mixed ionic/electronic conductors (MIECs) under reducing atmosphere and, therefore, fuel oxidation can take place on its entire surface, while it only occurs in the [anode/electrolyte/gas] interface (triple-phase boundaries) for electronic conductors.

In this work, we present our recent investigations on the performance of nanostructured CeO_2-based anodes for IT-SOFCs. Nanostructured materials are not employed in conventional SOFCs since grain growth is expected to occur at the typical operation temperatures of these devices. However, their use in intermediate-temperature SOFCs (IT-SOFCs) is currently under evaluation [2]. Anodes based on nanostructured MIECs are particularly interesting because the number of active sites for fuel oxidation is expected to increase dramatically due to the increase in the specific surface area. Two applications of these new anodes will be discussed:

(i) Anodes based on cermets of nickel and nanostructured Gd_2O_3-doped CeO_2 (GDC) or ZrO_2-doped CeO_2 (ZDC) for IT-SOFCs operated using hydrogen as fuel.
(ii) Ni/ZDC cermets for anodes of single-chamber SOFCs operated under mixtures of methane and air.

Our results showed that the proposed nanostructured CeO_2-based anodes exhibit high performance, which increases with decreasing grain size of the GDC or ZDC phase. In addition to the increase of the specific surface area mentioned above, this enhanced performance could be related to the increase of the ionic conductivity for decreasing grain size recently reported for nanostructured CeO_2-based ceramics [3].

References

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