

## Ni-YSZ Anodes with 3-Dimensional Ordered Macropores for Direct Carbon Fuel Cells

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Direct carbon fuel cells (DCFCs) have been receiving increasing attention in recent years, since they have potential advantages over other fuel cells, including higher thermodynamic efficiency and direct use of carbons (coals). In principle, complete oxidation of carbon to gaseous  $\text{CO}_2$  in a DCFC is accompanied by almost no entropy change, which means that the thermodynamic efficiency is close to 100% [1]. The electrochemical oxidation of carbon proceeds *via* mechanisms that vary with cell design and electrolyte. In a DCFC with a solid oxide electrolyte (*e.g.*, yttria-stabilized zirconia, YSZ), carbon oxidation occurs over three-phase boundaries; however, there is very little interaction between the solid carbon and the Ni-YSZ anode. A so-called “hybrid” DCFC design combines advances in the solid oxide and molten carbonate fuel cell technologies: (i) a solid oxide electrolyte separates the cathode and anode compartments; and (ii) molten carbonates facilitate transport of carbon toward the active sites.

In this paper, we report Ni-YSZ anodes with ordered macropores for a hybrid DCFC. Thin Ni-YSZ anodes with 3D-distributed macropores are prepared in an attempt to enhance mass transport kinetics as well as to improve the contact between the solid carbon fuel and the anode. PMMA particles with different diameters are used as a pore-former (i) to produce macropores in the Ni-YSZ anode layer and (ii) to control their porous structures. The relationship between microstructures and cell performance is analyzed using various characterization studies, such as mercury porosimetry, image analysis, electrochemical polarization and ac-impedance measurements, and gas chromatography.

## Reference

[1] S. Giddey, S.P.S. Badwal, A. Kulkarni, C. Munnings, *Prog. Energy Combust. Sci.* 38 (2012) 360.

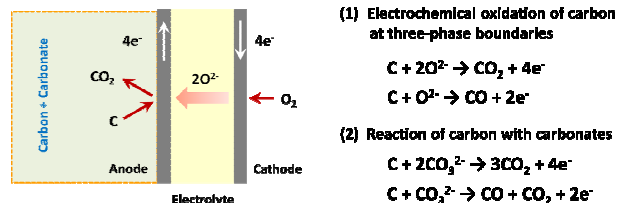


Fig. 1. Operation principle of a hybrid DCFC and the reactions occurring at the anode.

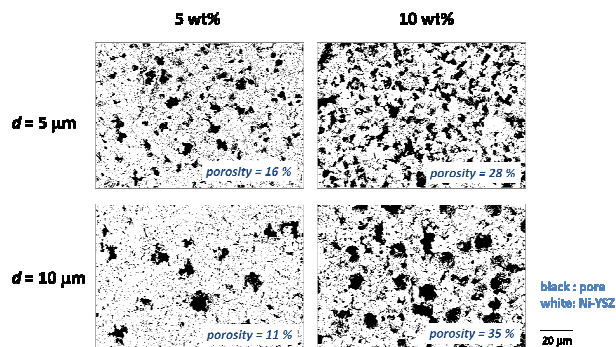


Fig. 2. Binary images transformed from the SEM micrographs of the Ni-YSZ anode surfaces.