Technical University of Denmark

Ni based solid oxide cell electrodes

Mogensen, Mogens Bjerg; Holtappels, Peter

Published in:
Proceedings

Publication date:
2010

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Mogensen, M. B., & Holtappels, P. (2010). Ni based solid oxide cell electrodes. In P. Connor (Ed.), Proceedings European Fuel Cell Forum.

Ni based solid oxide cell electrodes

Mogens Mogensen, Peter Holtappels
Fuel Cells and Solid State Chemistry Division
Risø National Laboratory for Sustainable Energy, The technical University of Denmark
DK-4000 Roskilde, Denmark
Tel.: +45-46775726, Fax: +45-46775858
momo@risoe.dtu.dk

Abstract

The Ni-cermet with either yttria stabilised zirconia (YSZ) or doped ceria has so far been the unbeatable anode in SOFCs in spite of the many problems associated with this electrode. The main reason for this is the excellent catalytic an electrocatalytic property of Ni for steam reforming of natural gas and for electrochemical oxidation of H_2 and CO. These properties have been so good that they have overshadowed several drawbacks such as the sensitivity to sulphur poisoning and mechanical instability in case of redoxing. Furthermore, the electrode is fully reversible, i.e. works equally well in fuel cell and in electrolysis mode.

This paper is a critical review of the literature of nickel based electrodes for application in solid oxide cells at temperature from 500 – 1000 °C. The applications may be fuel cells or electrolyser cells. The reviewed literature is that of experimental results on both model electrodes and practical composite cermet electrodes. A substantially longer three-phase-boundary (TPB) can be obtained per unit area of cell in such a composite of nickel and electrolyte material, provided that two interwoven solid networks of the two phases are obtained to provide a three dimensional TPB throughout the electrode volume.

Variables that are used for controlling the properties of Ni-cermet-electrodes are: 1) Ni/YSZ volume ratio, and 2) porosity and particle size distribution which is mainly affected by raw materials morphology, application methods and production parameters such as milling and sintering possible followed by infiltration of nano sized electrocatalytic active particles. The various electrode properties are deeply related to these parameters, but also much related to the atomic scale structure of the Ni-electrolyte interface, which in turn is affected by segregation of electrolyte components and impurities as well as poisons in the gas phase.

Main emphasis will be put on the following subjects: a) electronic conductivity of cermets, b) dimensional and thermodynamic stability including redoxing, c) thermal expansion coefficient matching, e) chemical compatibility with stack components and gaseous reactants, f) sensitivity towards impurities in the fuel, and g) electrode reaction mechanism and polarisation resistance including the reports on model electrodes. Data on relations between cermet structure and polarisation resistance will be presented and discussed.

A brief discussion of main concepts in the modelling literature will be given in context of the latter subject.