Introduction

Solid oxide fuel cell (SOFC) and solid oxide electrolysis cell (SOEC) technologies are key fields of research and development at DTU Energy Conversion. In both SOFC and SOEC cells nickel and doped zirconia are fundamental materials in the fuel electrodes, chosen for their materials properties and for the fact that they normally do not interact. In particular, it has been thought that nickel and zirconia do not wet each other, but quite unexpectedly we discovered how to unlock wettability in these materials, while studying the degradation process of SOEC-cells.

Experimental

Post mortem HRSEM of the fuel electrode revealed unusual zirconia nano particles located on Ni grains at the electrochemically active sites at the interface between the YSZ electrolyte and the active Ni/YSZ composite cathode. The nano particles appeared as islands intimately bonded on the surface of nickel particles (see image above). The presence and the shape of the zirconia nano particles indicated that a reaction had unlocked wettability in the two materials that under normal operating conditions would not react.

The emergence of the zirconia nano particles is attributed to an electrochemical reduction of zirconia at the interface of the composite cathode and the electrolyte, followed by dissolution of zirconium in Ni, diffusion of Zr in a Ni particle to a Ni surface location, and subsequent oxidation of Zr at the surface, forming zirconia nano particles. The diffusion of zirconium through nickel is thought to be the key enabler for achieving epitaxy and thus unlocking the wettability of zirconia on the rough nickel surface.

Results and discussion

High resolution TEM study revealed that the mismatch between the lattice of the cubic zirconia nano particles and that of Ni grains was within 3 %, and that an epitaxial relationship was formed between the new yttrium containing zirconia nano particles and the micrometer-scale Ni grains [2]. This can effectively reduce the interfacial energy and promote wettability.

References


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