Electrochemical characterization of solid oxide electrolysis cells with modified Ni-8YSZ hydrogen electrodes

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The solid oxide electrolysis cell (SOEC) is one of the most efficient technologies for producing hydrogen without emitting greenhouse gases. Green hydrogen has been proposed as a key substance for energy storage in helping to reach the high decarbonization targets set by countries worldwide.[1] In addition, green hydrogen has huge potential to decarbonize a vast part of the chemicals industry, such as ammonia synthesis and iron refining, which contribute 2% and 7% to global CO_2 emissions respectively.[2,3,4]

While the SOEC is a very efficient technology, the state-of-the-art (SoA) SOEC suffers from degradation issues related to the Ni-8YSZ material used as the hydrogen electrode. A number of materials have been shown to enhance the performance or durability of the Ni-8YSZ cermet by either alloying the nickel with iron[5,6] or cobalt[5,7] or by enhancing the 8YSZ with GDC[8].

In this work the authors have integrated the above-mentioned materials into the Ni-8YSZ hydrogen electrode of commercially produced SoA SOEC devices (Ni-3YSZ|Ni-8YSZ|8YSZ|GDC|LSC). The modifications were introduced during the manufacturing procedure and with limited changes to the overall manufacturing procedure and final architecture of the device.

The electrochemical characterization of the produced cells included electrochemical impedance spectroscopy (EIS), cyclic voltammetry and galvanostatic methods. Operating parameters like temperature, current density and feed gas steam content were varied to study how the modifications affect SOEC performance at different operating conditions. The results indicate that at mild conditions the best performance was obtained using SOEC with unmodified Ni-YSZ hydrogen electrode, but at high steam content and elevated temperatures the highest current density (-3.7 A/cm^2 at -1.4 V) was achieved using SOEC modified with iron.

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