

### Sr-rich chromium ferrites as electrode materials for symmetrical solid oxide electrolysis cells

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In recent years, there has been great interest in the development of solid oxide electrolysis cells (SOECs) for the conversion of H<sub>2</sub>O to H<sub>2</sub> or the co-electrolysis of H<sub>2</sub>O + CO<sub>2</sub> to syngas [1-3]. SOECs are usually operated at high temperatures (750-950 °C) and therefore have both thermodynamic and kinetic advantages over low temperature electrolysis systems, such as PEM and alkaline electrolyzers. Most previous SOEC studies of the electrolysis of H<sub>2</sub>O and/or CO<sub>2</sub> are based on conventional Ni-YSZ fuel electrodes, a YSZ electrolyte, and an LSM-YSZ oxygen electrode. However, it has been shown that this combination is susceptible to degradation and loss of performance during the electrolysis process. This is due to such issues as the redox instability of the Ni-YSZ fuel electrode in high steam and pure CO<sub>2</sub> environments [4] and the delamination of the LSM-YSZ oxygen electrode due to an increase in O<sub>2</sub> partial pressure at the electrolyte-electrode interface [5]. Therefore, current research in this field is moving towards the use of mixed ionic and electronic conducting oxides, which have been shown to be redox-tolerance at the fuel electrode and also more stable as oxygen electrodes. [5, 6].

Previous research in our group has been focused on the development of a symmetrical SOFC, based on the La<sub>0.3</sub>Sr<sub>0.7</sub>Cr<sub>0.3</sub>Fe<sub>0.7</sub>O<sub>3-δ</sub> (LSFCr) mixed ionic-electronic conducting perovskite. The structure of LSFCr is stable down to a pO<sub>2</sub> of 1.9×10<sup>-21</sup> atm, which makes it suitable for operation as either an anode or cathode. In fact, LSFCr exhibits excellent electrochemical activity for both fuel oxidation and oxygen reduction, related to its high electrical conductivity (180 and 0.43 S/cm at 700 °C in air and 10 % H<sub>2</sub> + N<sub>2</sub>, respectively) and good ionic conductivity [7]. Also, our preliminary data have shown that the LSFCr catalyst is stable in CO<sub>2</sub> atmospheres.

Because of these advantageous characteristics of the LSFCr material, the electrochemical activity towards CO<sub>2</sub> reduction and oxygen evolution is now being examined. In this study, a symmetrical SOEC, involving LSFCr as both the oxygen and fuel electrodes, was operated on CO<sub>2</sub> and/or H<sub>2</sub>O. In this configuration, a GDC (gadolinium doped ceria) buffer layer was screen-printed on both sides of the 300 μm YSZ electrolyte-support (to prevent deleterious reactions between the electrodes and the electrolyte). Subsequently, the LSFCr electrodes were screen-printed on top of a GDC buffer layer, followed by firing at 1100 °C in air. The resulting cells were fixed in a FCSH-V3 cell holder for the purpose of potentiodynamic, long-term potentiostatic, and impedance spectroscopy measurements.

The performance of the LSFCr/GDC/YSZ/GDC/LSFCr symmetrical full cells, operated at 700-800 °C in a varying CO<sub>2</sub> environment with constant CO and humidified N<sub>2</sub> (3 % H<sub>2</sub>O) content in both the SOFC and SOEC modes, was then investigated. As the CO<sub>2</sub> content was increased, a higher current density output was obtained at a given power density in the SOEC mode. In

the SOFC mode, the power density decreased with increasing CO<sub>2</sub> content, as expected. The data also showed that, with only CO and humidified N<sub>2</sub> (3 % H<sub>2</sub>O) present, the cells perform well in the SOEC mode. This is not surprising because the humidified N<sub>2</sub> contained about 3% H<sub>2</sub>O, which was reduced to H<sub>2</sub>. It is also possible that, through the water gas shift reaction (CO + H<sub>2</sub>O => CO<sub>2</sub> + H<sub>2</sub>), some CO<sub>2</sub> was produced and subsequently oxidized to CO. Further work is being carried out to investigate the electrochemical performance of these LSFCr symmetrical cells during the co-electrolysis of varying ratios of CO<sub>2</sub> and H<sub>2</sub>O and also quantifying H<sub>2</sub> and CO production using on-line mass spectroscopy.

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