

## Novel sulfur-tolerant anode catalyst for SOFC

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### Introduction

Solid oxide fuel cells (SOFCs) have received extensive attention in recent years as they can be used for stationary power generation and have fuel flexibility using a variety of oxidizable fuels. However, several prospective anode materials suffer serious degradation under harsh operating conditions, especially H<sub>2</sub>S, a highly corrosive and toxic contaminant that is often present in natural gas [1]. The conventional anode material, Ni-YSZ, reacts rapidly with H<sub>2</sub>S to form a sulfide or to poison the catalyst surface, even at low concentrations [2]. Therefore, developing sulfur-tolerant anode materials becomes necessary. In this work, we focused on a 7% Co doped La<sub>0.3</sub>Sr<sub>0.7</sub>TiO<sub>3-δ</sub> (LSCT) anode catalyst with high catalytic activity and excellent stability in the H<sub>2</sub>S-containing feeds. For comparison, un-doped La<sub>0.3</sub>Sr<sub>0.7</sub>TiO<sub>3-δ</sub> (LST) was also tested under the same conditions. Metallic Co nano-particles precipitated onto the oxide surface can be observed after reduction, and the effect of this nanostructure on the anode performance was studied.

### Experimental

Both LST and LSCT catalyst powders were prepared using solid state synthesis. The powders were initially calcined in air at 1300 °C for 5 h and then calcined in 10% H<sub>2</sub>-N<sub>2</sub> at 1400 °C for 5 h. Phase purity was determined using X-ray diffraction. The configuration of the fuel cells was LSCT (LST) + YSZ | YSZ | LSM+YSZ. The membrane electrode assembly was presintered in air at 1200 °C for 1 h.

Field emission scanning electron microscopy (FESEM) studies were carried out on the microstructure of the as-prepared powders. Chemical stability tests were conducted using powdered samples of anode materials in a quartz tube in 0.5% H<sub>2</sub>S-H<sub>2</sub> at 900 °C for 48 h. XRD, XPS and SEM were used to examine the chemical stability of the samples. The fuel cells were tested in both H<sub>2</sub> and 0.5% H<sub>2</sub>S-H<sub>2</sub>.

### Results and discussions

Co nano-particles were precipitated onto the LSCT surface after it was reduced in H<sub>2</sub> at 850 °C for 24 h (Fig. 2). The performance of SOFCs with LSCT anodes was significantly improved over those with LST anodes both in pure H<sub>2</sub> (Fig. 1a) and in 0.5% H<sub>2</sub>S-H<sub>2</sub> (Fig. 1b), indicating that Co nano-particles had an electrocatalytic effect that resulted in the improved catalyst activity. When 0.5% H<sub>2</sub>S was present in H<sub>2</sub>, the power densities were considerably improved for each of the anodes (Fig. 1b), indicating that the addition of H<sub>2</sub>S enhanced anode activity. In the case of LSCT, in either H<sub>2</sub> or 0.5% H<sub>2</sub>S-H<sub>2</sub>, there was a strong dependence of performance on temperature, and the performance increased by ca. 100% when the temperature was increased from 800 °C to 900 °C.

Both XRD and XPS analyses revealed that the LSCT catalyst was chemically stable in the reducing environment as well as in the H<sub>2</sub>S-rich environment. No sulfide peaks were found after the long-term stability test (Fig. 3), showing that LSCT is a good sulfur tolerant catalyst.

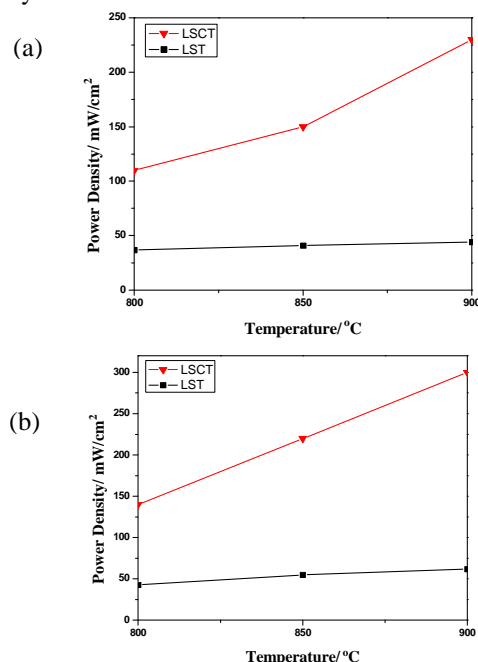


Figure 1. Maximum power densities for the cells with different fuels: (a) H<sub>2</sub> (b) 0.5% H<sub>2</sub>S-H<sub>2</sub> as anode feed at different temperatures.

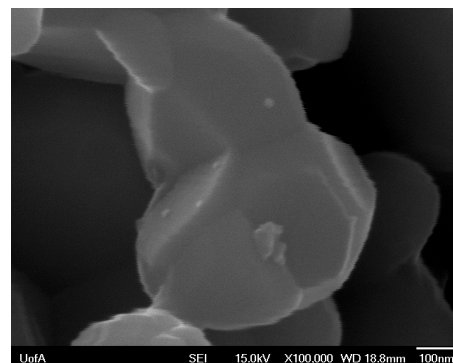


Figure 2. Co nano-particles were precipitated on the LSCT surface after reduction in H<sub>2</sub>.

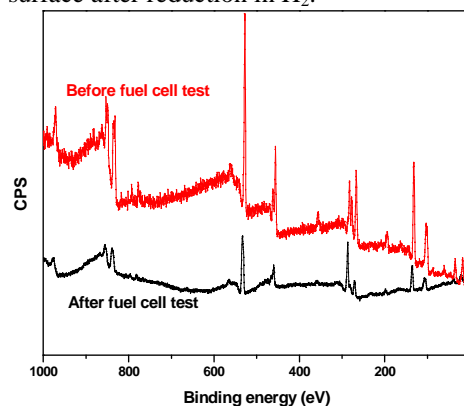


Figure 3. XPS spectra for comparison of fresh and used catalysts at full range.

### References

- [1] J.L. Gadon, Rev. Inst. Fr. Petr. 2 (1987) 685-693.
- [2] J.F. Rasmussen, A. Hagen, J. Power Sources 191 (2009) 534-541.