Conductivity and electrochemical performance of a new perovskite-type SOFC anode material

Shanwen Tao and John T. S. Irvine*

School of Chemistry, University of St Andrews, Fife KY16 9ST, Scotland, UK

The solid oxide fuel cell (SOFC) is a highly promising fuel cell system. It is an all-ceramic device operating at high temperatures. Present development of SOFCs is mainly based on the yttria-stabilised zirconia (YSZ) electrolyte because it exhibits good thermal and chemical stability, high oxide-ion conductivity and mechanical strength at high temperature.[1] The most commonly used anode materials for zirconia-based SOFCs are Ni/ZrO_2 cermets, which display excellent catalytic properties for fuel oxidation and good current collection but do exhibit disadvantages, such as low tolerance to sulphur[2] and carbon deposition[3] when using hydrocarbon fuels and poor redox cycling causing volume instability. The nickel metal in the cermet tends to agglomerate after prolonged operation, leading to a reduced three-phase-boundary and increasing resistance. A redox stable anode which can sustain redox cycling is in demand for SOFC for the application of portable fuel cells and fuel cell engines. In a previous investigation, we found $La_{0.75}Sr_{0.25}Cr_{0.5}Mn_{0.5}O_3$ is a good SOFC anode material. In this report, a new redox stable perovskite anode material $La_{0.75}Sr_{0.25}Cr_{0.5}Fe_{0.5}O_3$ (LSCF) in investigated. This materials exhibits an orthorhombic structure with $\sqrt{2}a \times \sqrt{2}a \times 2a$. It retains the perovskite structure after heating in 5%H_2 at 900°C for 120 hours. The conductivity of LSCF is 14 and 0.21S/cm in air and 5%H_2 respectively at 900°C (Fig. 1). The low conductivity in reducing atmosphere limits the application of this materials as a SOFC anode. The anode polarisation is 0.98Ωcm^2 at 900°C in 97%H_2/3%H_2O at open circuit voltage; however, the fuel cell performance is not ideal (maximum 180mW/cm2 at 900°C using wet H_2 as fuel) because of the relatively large series resistance. Good catalytic effects for methane-reforming were observed with LSCF but accompanyed with carbon deposition. Therefore, LSCF itself is not a good SOFC anode material although it is redox stable in reducing atmosphere at high emperatures and exhibits good catalytic effects for methane-reforming.

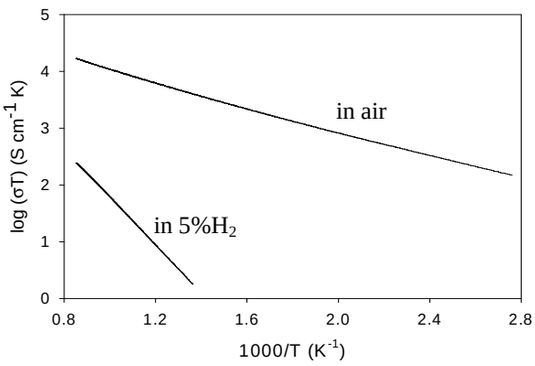

Fig. 1 Conductivity of $La_{0.75}Sr_{0.25}Cr_{0.5}Fe_{0.5}O_3$

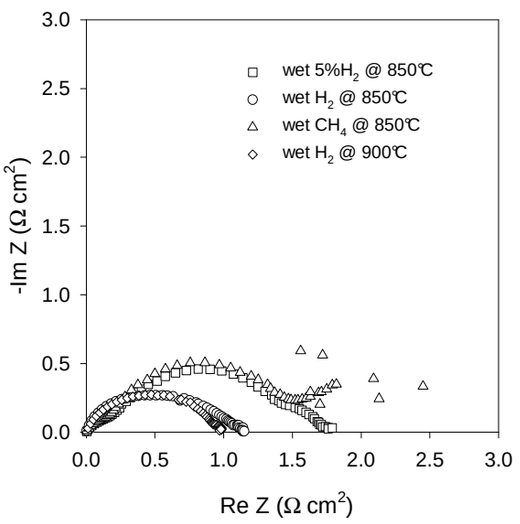

Fig. 2 Anode performance of $La_{0.75}Sr_{0.25}Cr_{0.5}Fe_{0.5}O_3$

References:

1. N. Q. Minh, Ceramic fuel-cells. *J. Am. Ceram. Soc.* **76**, 563-588 (1993).
2.Y. Matsuzaki and I. Yasuda, *Solid State Ionics* **132**, 261-269 (2000).
3. B. C. H. Steele, I. Kelly, H. Middleton, and R. Rudkin, *Solid State Ionics* **28-30**, 1547-1552 (1988).