**Electrochemical characterisation of a $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ cathode for IT-SOFCs**

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The electrical properties of an $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) cathode were assessed so as to determine its efficacy as a cathode for intermediate temperature solid oxide fuel cells (IT-SOFCs), and to gain a better understanding of the factors limiting performance.

Two-electrode impedance and three-electrode measurements were carried out to investigate the kinetics of the oxygen reduction reaction under various temperatures, oxygen partial pressures and polarisations. An area specific resistance (ASR) as low as 0.03 Ω $cm^2$ and 0.23 Ω $cm^2$ at 801°C and 650°C respectively, were obtained in air. Fig. 1 shows a typical impedance spectra obtained in different oxygen/nitrogen atmospheres at 702°C. The ASR increased with decreasing oxygen content and at low oxygen content (10% or less), gaseous diffusion limitations in the porous structure could be observed. The three-electrode measurements revealed a high catalytic activity, corroborating the literature. A typical i-η curve under different $pO_2$ is shown by Fig. 2 Exchange current density values around 92 mA $cm^{-2}$ at 725°C (z=4) were determined.

A change in the rate determining step at temperatures around 600°C was suggested by the results (Fig. 3). It is proposed that the LSCF behaves as mixed ionic electronic conductor (MIEC) in the highest temperature range. Under these conditions, oxygen reduction takes place throughout the electrode thickness, stimulated by the formation of oxygen vacancies, and adsorption and surface exchange are proposed as rate determining steps. However at temperatures below 600°C, we suggest that the creation of vacancies and therefore the bulk diffusion through the cathode limits the reaction, which probably happens at the triple phase boundary, similar to a pure electronic conductor.

The electrochemical characterisation of LSCF led to preliminary conclusions on its behaviour as a cathode for IT-SOFCs. The microstructure is an important factor for optimisation. For a small particle size and a sintering temperature of 850°C, good contact and minimal limitation in transport of oxygen from 700°C downwards were obtained. A better understanding of the mechanisms involved in the oxygen reduction is needed. For this purpose more work at the interface of the electrochemical measurements and materials properties (surface exchange coefficient and diffusion coefficient) will be undertaken.

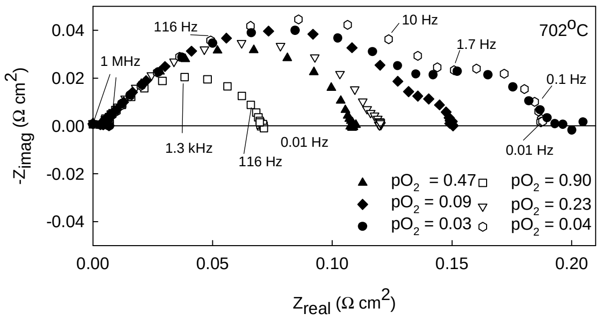


**Figure 1. Impedance spectra of LSCF measured under different oxygen/nitrogen atmospheres at 702°C with a two-electrode impedance set-up.**

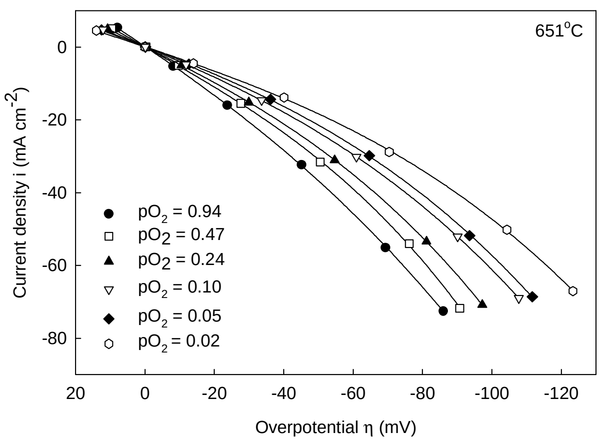


**Figure 2. i-η curve of LSCF measurement in different oxygen/nitrogen atmosphere mixture at 651°C.**

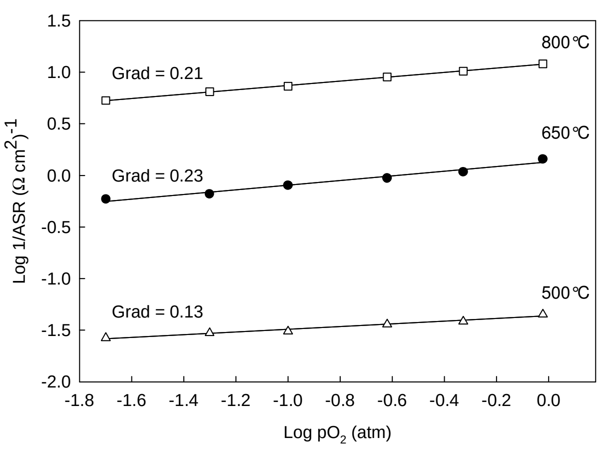


**Figure 3. Log ASR versus log $pO_2$ for the OCV values of LSCF measured at different temperatures.**