

SERC report

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Stability of the cathode-electrolyte-interface at realistic operation conditions

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Plan for the coming 6-12 months

The core topic of this PhD project is the stability of the cathode – electrolyte interface. State-of-the-art screen-printed lanthanum strontium manganite – yttria stabilized zirconia composite cathodes [LSM25,5-YSZ composites, where LSM25,5 = $(\text{La}_{0.75}\text{Sr}_{0.25})_{0.95}\text{MnO}_{3-\delta}$ and YSZ = ZrO_2 with 8 mol% Y_2O_3] on stabilized zirconia, SZ, electrolyte will be the primary platform used in this project. The topics are listed in order of priority, and are planned to be carried out during the 6 – 12 first months of the PhD.

1. Initial performance and degradation studies – effect of T and $p\text{H}_2\text{O}$

Symmetrical cells will be prepared using $\sim 200\ \mu\text{m}$, YSZ tape, and tested in air at selected temperatures (*e.g.* 650, 750, 850 °C) and water partial pressures (*e.g.* dry air, 0.1 %, 1%). The degradation will be monitored by electrochemical impedance spectroscopy measurements. The impedance response as a function of partial pressure of oxygen will also be measured.

In order to establish the relationship between observations made using symmetrical cells and full cells, full cells using the same electrolyte and cathode material will be prepared and investigated under similar operating conditions (zero bias, similar oxidant composition).

2. Degradation and the effect of $p\text{O}_2$

As the partial pressure of oxygen influences the stability of Sr- and La- zirconates, it is of interest to study the impact of conditions under which zirconate is thermodynamically stable/unstable on degradation. It is desirable to run degradation experiments under selected conditions where zirconate formation is favoured or not favoured, to distinguish the effect the zirconate formation has on the degradation rate. This involves changing the $p\text{O}_2$ dramatically.

By changing $p\text{O}_2$, a volume change of LSM is expected. At low $p\text{O}_2$ oxygen is extracted from LSM, leading to Mn^{4+} ions to change valance to Mn^{2+} . As Mn^{2+} has a larger radius than Mn^{4+} , the O^{2-} deficient LSM will expand. The expansion may induce irreversible mechanical degradation, *e.g.* loss of contact with the electrolyte/electrolyte particles. Thus, it was deemed necessary to investigate the expansion properties of LSM25,5 at an early stage in the project.

In order to determine the volume change as a function of $p\text{O}_2$ for LSM25,5 will be investigated by isothermal dilatometry and high temperature x-ray diffraction.

3. Degradation at $p\text{O}_2$ where La- and Sr- zirconate formation is thermodynamically stable/unstable

Under certain circumstances lanthanum zirconate (LZO, $\text{La}_2\text{Zr}_2\text{O}_7$) and strontium zirconate (SZO, SrZrO_3) are known to form at the interface of LSM and YSZ¹. LZO and SZO have a significantly lower conduction than LSM, degrading the performance of the cell by insulating the interface.

A systematical investigation of the conditions under which LZO and SZO are formed will be performed. These experimental data will be compared with theoretical thermodynamical calculations, ongoing in our group. The theoretical calculations predict the $p\text{O}_2$ -temperature regions where LZO and SZO are stable

Further plans:

Afterwards, the influence of manganese on the degradation of the electrolyte/cathode interface will be investigated. Manganese may diffuse into the electrolyte material, possibly inhibiting the formation of LZO¹. However, loss of Mn from the cathode is detrimental due to the lower stability of LSM25,5 moving towards its stoichiometric composition. In order to prevent loss of Mn from the LSM25,5, enrichment of the electrolyte material with Mn will be carried out, before screen printing of the cathode onto the electrolyte. The effect of this treatment on long term stability of the cell will be investigated.

¹ A. Mitterdorfer, L.J. Gauckler, Solid State Ionics, 111 (1998), pp 185-218