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ABSTRACT

Spatial mapping of Co valence as a function of bias for an LSCF cathode

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Using soft X-ray absorption spectroscopy (XAS), the electronic structure of transition metal elements at the near surface region of relevant SOFC materials can be studied in an element resolved manner with high sensitivity and good spatial resolution (250 μm). Employing a test facility that uses a symmetric cell (two back-to-back identical half cells) through which an oxygen ion current is driven not by a chemical potential as in a complete cell, but by a bias voltage, allows for superior control of the electrochemical environment occurring within the cells.

We have spatially mapped the Co valence of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ films with 250 μm resolution under different bias conditions (in the as-grown state, after 50 hours at 850 °C and 0 V bias, and after 50 hours at 850 °C and 500 mV bias). The LSCF films are deposited by pulsed laser deposition on a GDC layers on a YSZ substrate. The as-grown films are stoichiometric, but are oxygen deficient. The spatial mapping shows all the Co to be in the Co^{2+} valence, consistent with the oxygen deficient nature of the as-grown films. After annealing at 850 °C for 50 hrs with the contacts held at 0 V, the average Co valence changes to Co^{3+}, but varies substantially. The Co valence is observed to be spatially dependent on the oxygen availability during annealing as demonstrated by the ring pattern centered on the single oxygen inlet of the test rig (no gas was flowing during the anneal). Subsequent operation for 50 hours at 850 °C and 500 mV bias showed a 10% degradation of the cell performance which we attribute to Sr out-diffusion which can be well mapped to the Co valence. Sr segregation is observed to be larger on the oxygen dissociation side (cathode or positive contact) where the average Co valence is observed to be nearer to Co^{2+} with a distribution again dependent on oxygen availability while on the oxygen recombination side (anode or negative contact) the average Co valence is nearer to Co^{4+} with a similar spatial distribution.