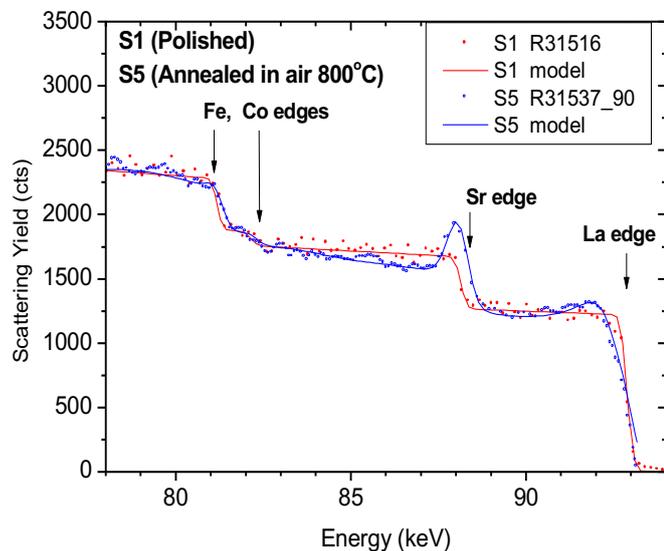


**Solid Oxide Fuel Cells (SOFCs)** are electrochemical conversion devices that produce electricity directly from oxidizing a fuel such as H<sub>2</sub> or a hydrocarbon. A ceramic solid oxide electrolyte kept at a very high temperature conducts O<sup>2-</sup> ions, produced at the cathode where the oxygen reduction reaction (ORR) takes place, to the anode where the fuel is oxidised. **Mixed Ionic-Electronic Conducting (MIEC)** perovskite materials such as **La<sub>0.6</sub>Sr<sub>0.4</sub>Co<sub>0.2</sub>Fe<sub>0.8</sub>O<sub>3-δ</sub> (LSCF)** are much used as air electrode (cathode) materials, due to their excellent oxygen reduction and incorporation properties. It is vital to understand the exchange kinetics across the gas-solid interface at the cathode, especially its dependence on the near surface distributions of the LSCF components at high temperatures due to the formation of surface passivating phases during operation.

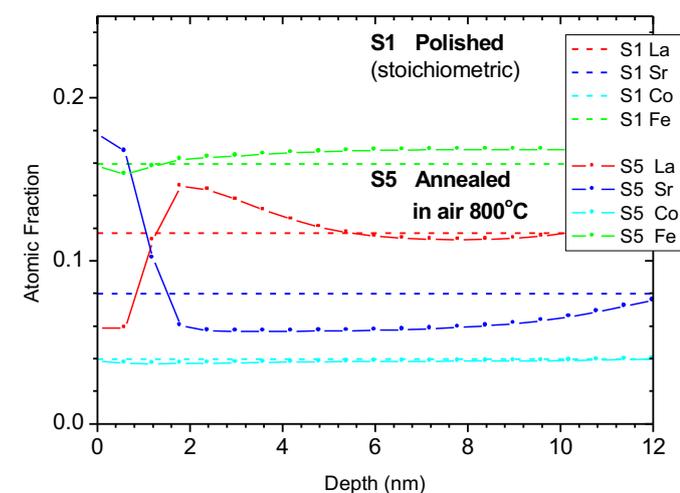
**MEIS depth profiling analysis** using 100 keV He<sup>+</sup> ions and a 125° scattering configuration together with a spectrum simulation (a macro running within the IGOR PRO<sup>®</sup> graphing software package) has been used to elucidate Sr and La segregation and depletion behaviour in the first few nm of the surface region of LSCF after annealing. A comparison of the spectra for an **as-polished reference sample S1** with one **annealed in air at 800 °C for 8 hrs sample S5** reveals the changes in the near surface region.



**MEIS energy spectra** (data points) & best fit model simulations (lines) for Reference samples **S1** & **S5**

- The spectrum of **Reference sample S1** shows up as amorphous-like where the ion yield due to each lower mass is superimposed on the backscattering yield of the higher mass(es) causing an edge in the spectra for each of the masses La, Sr, Co and Fe.
- Sample S1 model input: a uniform distribution of the La<sub>0.6</sub>Sr<sub>0.4</sub>Co<sub>0.2</sub>Fe<sub>0.8</sub>O<sub>3</sub> constituents or fractions:  
**La: 0.12; Sr: 0.08; Co: 0.04; Fe: 0.16; O: 0.6** gives an excellent fit to the spectrum, validating the simulation mode
- The changes in the spectrum of sample S5 indicate the elemental mass redistribution in the surface region

**Fractional depth profiles of La, Sr, Co and Fe** obtained from best fit spectra simulations for S1 & S5



- Annealing causes substantial **segregation of Sr** in the 1 nm depth and its depletion in the next 10 nm
- Also a corresponding **La depletion** in the first 1 nm depth and a fractional **increase** in the next 3-4 nm, followed by some deeper La depletion
- Annealing causes little change in the Co and Fe depth profiles
- Surface segregation of Sr cations blocks sites for the O<sub>2</sub> reduction reaction and thus these changes are relevant for understanding the changing cathode surface behaviour with operation at high temperatures

**Conclusion:** MEIS has revealed the nature and magnitude of the redistribution of critical LSCF perovskite elements such as Sr and La in the first 10 nm of the cathode material, important for their reliable operation.

Work carried out in collaboration with Imperial College (John Kilner, Matt Niania)