**Probing LSCF cathodes exposed to contaminants (H2O, CO2 & Cr) using**

**surface enhanced Raman spectroscopy (SERS) and**

**synchrotron-based X-ray analyses**

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Cathode durability is critical to long-term SOFC performance for commercial deployment. The contaminants commonly encountered in air (e.g., CO2 and H2O) and/or Cr-containing interconnect materials may activate or accelerate the degradation of LSCF cathodes. Correlating the electrochemical performance with the structures and compositions of LSCF electrodes under operating conditions is a vital step toward unraveling the degradation mechanisms and developing an effective strategy to mitigate the stability issues. In this study, the electrochemical behavior of LSCF cathodes was characterized as a function of contaminant concentration, polarization condition, and the position of the Cr-containing interconnect with respect to the cathode. In addition, surface enhanced Raman spectroscopy (SERS) and synchrotron-based X-ray absorption spectroscopy (XAS) and X-ray photoelectron spectroscopy (XPS) were used to study the LSCF cathode under various conditions. The *in operando* characterization and analyses provide us with important insights into the degradation mechanism of LSCF electrodes, thus offering the scientific basis for rational design of more efficient catalyst coatings to mitigate the effects of the contaminants.