Elucidating Microstructural Evolution in SOFC Cathode Processing by Transmission Electron Microscopy

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When it comes to portable, off-grid power, fuel cells are a compelling technology. With an infinite supply of oxygen from ambient air, they will convert chemical potential energy from a fuel, *i.e.* some form of hydrogen, to generate electricity. Despite subverting the need for expensive metal catalysts, solid oxide electrolyte fuel cells (SOFCs) require high operating temperatures to offer impressively high efficiencies. Improving SOFC performance at lower temperatures, while preserving the high energy conversion efficiency, has motivated numerous innovative engineering design solutions for SOFC materials, such as the development of nanocomposite electrodes. One example is a cathode that allows the gas phase to directly contact 2 nano-sized solid phases, $La_{0.8}Sr_{0.2}MnO_3$ (LSM) and Sm-doped CeO_2 (SDC), simultaneously. Oxygen is reduced at this 3-phase junction, where it forms oxygen ions with electrons supplied from LSM, and these ions are transported through the SDC percolation path to the electrolyte. Because a longer 3-phase contact line would increase the reaction density, we sought to produce cathodes composed of LSM and SDC nanoparticles. Our hypothesis was that the optimal system could be produced by a Pechini-based approach, by annealing an amorphous, homogeneous gel coating. Our goal was to understand the processing parameters to control the induced crystallization of nanoparticles of 2 phases simultaneously. Thus, for feedback on the microstructural evolution of such a morphologically and chemically complex system, we performed high resolution imaging and spectroscopy analyses on FIB-milled lamellae in a spherical aberration-corrected scanning transmission electron microscope (STEM). Spectrum imaging using characteristic x-ray and primary electron energy loss signals allowed us to evaluate local variations in stoichiometry and segregation due to differences in ionic diffusivity.

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