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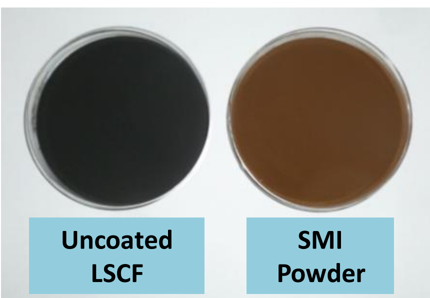
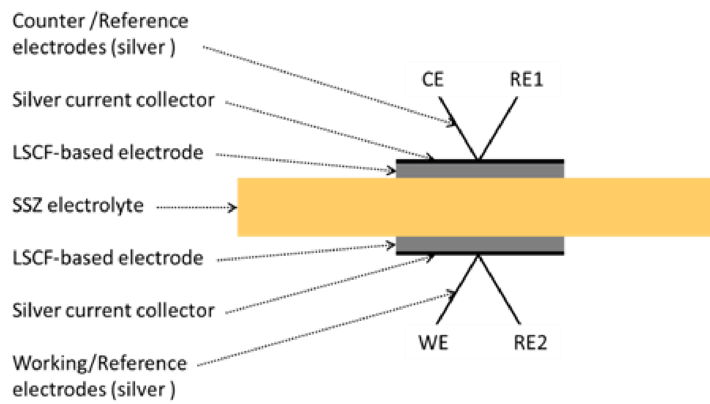
Recent works have shown the benefits of using surface functionalized powders for fabrication of solid oxide fuel cell (SOFC) cathodes. With this approach, the best characteristics of two different materials can be fully optimized and exploited. The present state of the art for surface functionalization uses an aqueous process to infiltrate the cathode after sintering. Multiple liquid infiltration and annealing cycles are required, which are both time consuming and expensive to implement in commercial production. SMI has developed an alternative dry approach for production of surface functionalized cathode powders prior to sintering. The resulting surface functionalized powders represent a "drop-in" replacement for presently available cathode powders, and can be seamlessly integrated into industrial SOFC manufacturing.




Structured Materials Industries, Inc. (SMI) has demonstrated technical feasibility of this approach and now offers R&D scale quantities (up to 1 kg) of surface functionalized powders (Product name *SFSOFC19*) as well as the dry coating process as a service, to explore related compositions tuned to specific needs. While present material is produced at test quantity scales, the process is easily scaled for low-cost, high volume production.

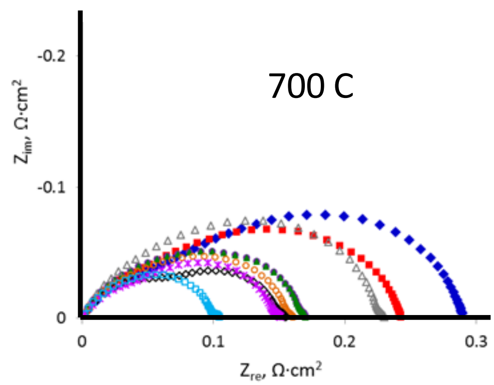

The SMI surface functionalization process produces uniform coatings on powders. In addition to our own *SFSOFC19* product; a wide range of coating compositions can be produced. A wide range of base powder materials and particle sizes can be processed as can a wide range of materials for functionalization coatings. *SFSOFC19* uses 0.7 µm average particle size, $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) for the base material powder. The first image shows uncoated material (left) and a typical powder after surface functionalization by the SMI process on the right. The second image shows packaged *SFSOFC19* sample powder.

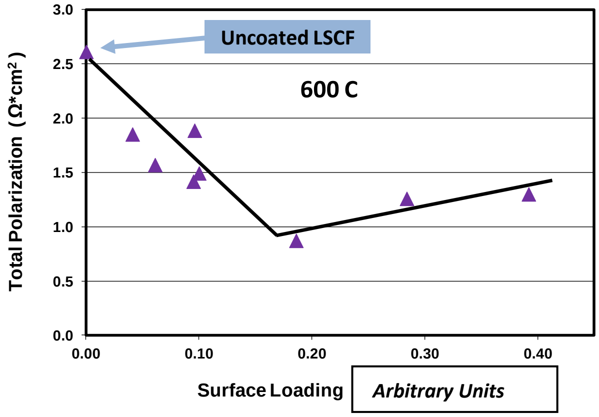
Electrochemical characterization of the surface functionalized powders was performed at a major fuel cell manufacturer. Testing was done by screen printing slurries / pastes into electrodes (using uncoated powders and *SFSOFC19* powders); symmetrically screen printed onto scandia stabilized zirconia electrolyte disks (25 mm diameter and 150 µm thickness) with a gadolinium doped ceria barrier layer (2 µm thickness). A schematic diagram of the symmetrical test cell is shown in the third figure. A similar symmetrical cell was also prepared using uncoated LSCF powder, as a baseline sample.

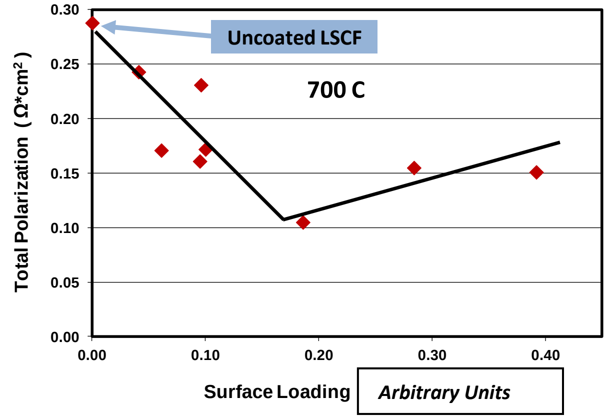


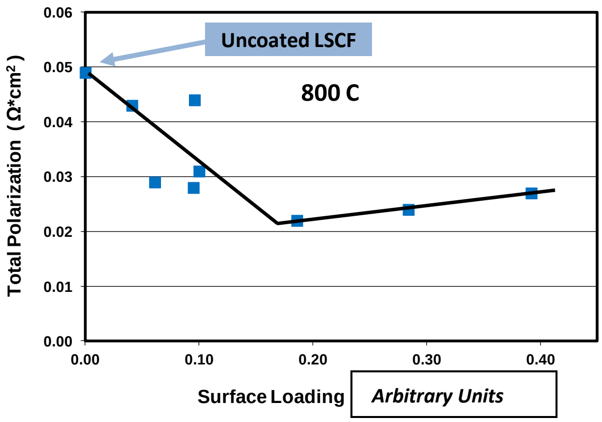

The cathode coated discs were sintered at 1000 C for 3 hours. Silver paste was applied, and used as the current collector. Electrochemical Impedance Spectroscopy (ESI) was done to characterize the electrochemical performance of the symmetrical cells under open circuit potential. Four probe tests were performed at 800 C, 700 C and 600 C in air.

The fourth figure to the right shows example results of electrochemical impedance spectroscopy at 700 C, for all samples of surface functionalized cathode *SFSOFC19* powders. The total polarization resistance is the difference between the high-frequency and low frequency intercepts with the real axis. For the sake of simplicity, the Ohmic resistance contribution has been subtracted.

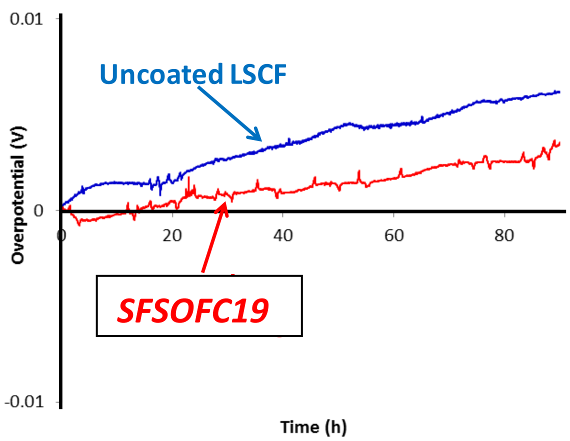





The Total Polarization resistance results for all samples tested during Phase I; at 600 C, 700 C, and 800 C. In all tests, the surface functionalized powders outperform the uncoated LSFC powder, as indicated by lower polarization resistance. The figures indicate there is an optimum surface loading.




The upper Figure shows total polarization resistance results for all samples tested during Phase I at 700 C. The lower Figure shows results of testing a symmetrical cell prepared with the optimum surface loading composition, under a constant current of 100 mA at 700 C.

The surface functionalized *SFSOFC19* powder outperforms the uncoated LSFC powder, as indicated by lower polarization resistance and lower degradation rate.

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