

Processing Advanced Ceramic Proton Conducting Electrochemical Devices with Optimized Electrode/Electrolyte Interfaces

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Abstract

Proton-conducting solid oxide electrolytes are highly appealing for electrochemical energy conversion and storage devices operating at low to intermediate temperatures. However, there exist various impediments to the deployment of these electrolytes for commercial purposes. Firstly, their refractory nature necessitates high sintering temperatures to ensure sufficient densification for gas tightness. Devices based on these electrolytes are composed of complex multilayers with different compositions and microstructures. Therefore, they require careful control over chemical incompatibilities between the cell components and their sintering shrinkages to avoid cracks, pinholes, and defects. State-of-the-art fuel electrode for these devices is generally nickel-based cermet, in which the nickel serves as electronic conductors and electro-catalysts, and the ceramic support acts as proton conductors. The most extensively studied fuel electrodes are Ni-BaZrCeY and Ni-BaZrCeYYb, known to sinter between 1450 to 1550 °C in typical protonic half-cells. Ni migration from the electrode to the electrolyte is also a potential issue. Nonetheless, its exact influence and distribution are not fully understood. In this presentation, I will discuss current investigations on our scaling-up efforts of robust and durable cells and the role of Sr and Ni at the fuel electrode/electrolyte interface in BaZr_{0.44}Ce_{0.36}Y_{0.2}O₃ proton conducting half-cells. High-resolution microscopy and energy-dispersive X-ray spectroscopy were used to resolve segregation effects along the electrode/electrolyte interface and the grain boundaries of the electrolyte. Our cells are fabricated using NiO-SrZr_{0.5}Ce_{0.4}Y_{0.1}O_{3-δ} cement, which ensures minimal warping and achieves a dense, gas-tight electrolyte layer after co-sintering at just 1300 °C for 5 hours. Using Ba_{0.5}La_{0.5}CoO_{3-δ} as the air electrode demonstrates remarkable capabilities and endurance within the 500-600°C temperature range, as indicated by its current-voltage characteristics and hydrogen evolution rates. Furthermore, based on Raman spectra analysis and mappings of the half-cell surface and cross-section (as illustrated in Figure 1), it is apparent that sintering at temperatures above 1350 degrees leads to the emergence of fresh crystal defects that alter the perovskite host lattice. These issues, together with polarization processes that impact performance in the fuel cell mode identified through impedance spectra analysis, will be presented.

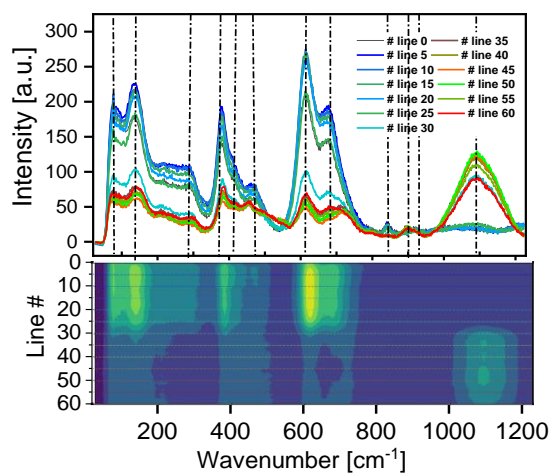


Figure 1. Line averaging Raman Spectra along the cross-section of the half-cell