Co-electrolysis of CO2 and H2O in solid oxide cells: Performance and durability

This study examines the initial performance and durability of a solid oxide cell applied for co-electrolysis of CO2 and H2O. Such a cell, when powered by renewable/nuclear energy, could be used to recycle CO2 into sustainable hydrocarbon fuels. Polarization curves and electrochemical impedance spectroscopy were employed to characterize the initial performance and to break down the cell resistance into the resistance for the specific processes occurring during operation. Transformation of the impedance data to the distribution of relaxation times (DRT) and comparison of measurements taken under systematically varied test conditions enabled clear visual identification of five electrode processes that contribute to the cell resistance. The processes could be assigned to each electrode and to gas concentration effects by examining their dependence on gas composition changes and temperature. This study also introduces the use of the DRT to study cell degradation without relying on a model. The durability was tested at consecutively higher current densities (and corresponding overpotentials). By analyzing the impedance spectra before and after each segment, it was found that at low current density operation (~0.25 A/cm² segment) degradation at the Ni/YSZ electrode was dominant, whereas at higher current densities (~0.5 A/cm² and ~1.0 A/cm²), the Ni/YSZ electrode continued to degrade but the serial resistance and degradation at the LSM/YSZ electrode began to also play a major role in the total loss in cell performance. This suggests different degradation mechanisms for high and low current density operation.

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