Electron microscopy studies of Ni/GDC fuel electrode in solid oxide fuel cell

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To increase the commercialization of solid oxide fuel cells (SOFCs), it is necessary to reduce their cost and extend their lifetime [1]. By operating SOFCs at temperatures below 650 °C, it is possible to make use of low-cost materials and reduce the performance degradation of SOFCs [2]. However, in the case of yttria-stabilized zirconia (YSZ) electrolytes, the electrochemical performance dramatically decreases at lower temperatures due to the low ionic conductivity of YSZ, leading to a high ohmic resistance [2]. The ionic conductivity of gadolinia-doped ceria (GDC) is significantly higher than that of YSZ at temperatures as low as 500 °C [3]. Ni/GDC fuel electrodes therefore provide superior properties compared to Ni/YSZ [4]. The microstructural integrity of Ni-based fuel electrodes is necessary for the long-term operation of SOFCs. Therefore, it is necessary to understand the structural and chemical degradation mechanisms of SOFCs to enhance and predict the lifetime of SOFCs [5].
In this work, the effect of operation temperature and duration on the structural and chemical degradation of Ni/GDC fuel electrodes was studied using (scanning) transmission electron microscopy ((S)TEM) and focused-ion-beam/scanning-electron microscopy (FIB-SEM) to correlate the structural and chemical evolutions with the results of electrochemical impedance spectroscopy. By using FIB-SEM, it is possible to reconstruct the 3D structure of the porous electrode to acquire structural parameters such as tortuosity, particle size distribution, specific active area, and triple-phase boundary length. The TEM sample preparation and 3D reconstruction of the Ni/GDC fuel electrodes were carried out using a Helios G4 FX dual-beam instrument (Thermo Fisher Scientific). STEM imaging and energy-dispersive X-ray spectroscopy were performed using a Tecnai OSIRIS ChemiStem (Thermo Fisher Scientific). TEM and SEM results of the Ni/GDC fuel electrodes at different aging states indicate a significant change in the microstructure, e.g. Ni agglomeration at higher operating temperatures, leading to an increase in polarization resistance.

Keywords:

FIB, SEM, TEM, SOFC

Reference:

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