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Bias-Assisted Sputtering of Gadolinia-Doped Ceria Interlayers for Solid Oxide Fuel Cells

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Abstract – The effects of both temperature and applied bias power during the sputtering of gadolinia-doped ceria (GDC) interlayers used as diffusion barriers in anode-supported solid oxide fuel cells (SOFC) were investigated. Scanning electron microscopy analysis revealed that increasing the applied bias power progressively inhibits the columnar structure typically observed in sputtered films, favoring the deposition of dense interlayers. Such feature was mirrored in the electrochemical tests of single cells that demonstrated enhanced power density for SOFC. The presented results evidenced that bias-assisted sputtering is an effective technique for the fabrication of high-performance anode supported SOFC.

Diffusion barrier interlayers, deposited onto the electrolyte, have demonstrated to be an effective way to avoid undesired reactions and preventing the degradation of the SOFC. Ceria-based oxides have been reported as convenient materials for such barriers due to good transport properties and reasonable compatibility with both yttria-stabilized zirconia (YSZ) and LSCF cathode. One of the main challenges is the fabrication of cost effective and reproducible protective interlayers, at sufficiently low temperatures in order to avoid undesired reactions. The effectiveness of the diffusion barrier is closely related to its microstructural properties, and homogeneous interlayers with high density are advantageous. Previous studies, concerning deposition techniques, evidenced that single cells with ceria-based interlayers fabricated by reactive magnetron sputtering (RMS) exhibited enhanced performance when compared to wet ceramic depositions. Such an improved performance is possibly associated with the higher density of such layers. Although sputtering is a scalable industrial process, further investigation is required for the deposition of optimized SOFC protective interlayers.

In the present study, the effects of applied bias voltage during sputtering of gadolinia-doped ceria (GDC) diffusion barriers over YSZ electrolytes were studied. Half cells comprised of Ni / YSZ anode support and functional layer, and YSZ electrolyte were used as substrates for the deposition of GDC interlayers. Coatings were carried out in a physical vapor deposition system CS 400ES (Von Ardenne Anlagentechnik). High-frequency bias voltage was applied to the metallic sample holder by controlling a fixed bias power, ranging from 0 to 300 W. Depositions were carried out at different temperatures in the 400-800°C range. Screen-printed LSCF cathodes were applied to the half cells, followed by heat treatment. The microstructure of deposited interlayers was studied by scanning electron microscopy (SEM). The electrochemical properties of single cells were investigated by I-Vcurves under H2/air flow in the 600-900 °C range.

Microstructural analyses (Fig. 1) of GDC barriers revealed that increasing the applied bias power progressively inhibits the usual columnar structure of sputtered interlayers, resulting in dense microstructures. Such a feature was reflected in the I-V curves, which showed that the performance of solid oxide fuel cell having bias sputtered interlayers is increased in the whole temperature range studied, as shown in the Fig. 2.

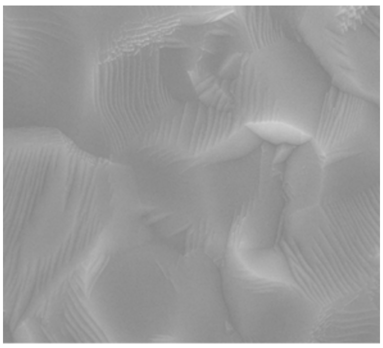

Figure 1: SEM images of GDC layer deposited by RMS with (a) 0 W and (b) 300 W applied bias power.

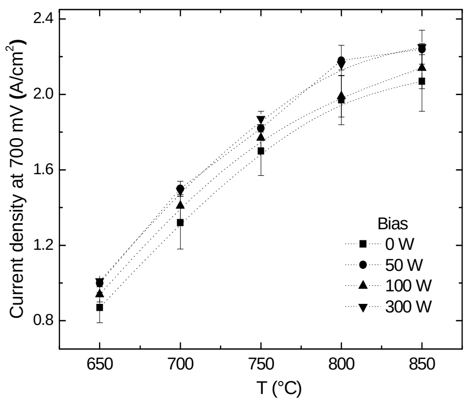

Figure 2: Temperature dependence of the average current density at 700 mV for single cells with GDC layers sputtered with different applied bias power.