Readily Processed Protonic Solid Oxide Electrolysis Cells via Inverse Tape Casting

Kwati Leonard
Electrochemical energy Conversion

[A] *International Institute for Carbon Neutral Energy Research (I2CNER), Kyushu University 744 Motooka, Nishi-ku, Fukuoka 819-0395, Japan*

Hydrogen is considered as one of the leading energy carrier expected to play a central role in replacing oil in the future. However its production is still dominated by fossil fuel reforming, which leads to greenhouse gas emission. Steam electrolysis *via* solid oxide electrolysis cell has been demonstrated to be a more efficient method to produce hydrogen using ceramics conducting electrolytes. However, due to the high electricity cost, more than two thirds of the total hydrogen production costs are still attributed to the electricity. Therefore, the electricity consumption of the electrolyzer must be further reduced to make the process competitive. Recently there has been an increased interest towards reducing the cost of electrolytic hydrogen production using proton conducting electrolytes. Although some progress has been made with small scale laboratory type protonic cells, a significant challenge has been upscaling robust and affordable planar type devices. The fabrication of such multilayered devices usually via a tape casting process requires careful control of shrinkages of individual layers to prevent warping, cracking during sintering.

My talk highlights the successfull processing of 5×5 cm^2 planar cathode-supported protonic electrolysis half-cell consisting of $Ba(Zr_{0.5}Ce_{0.4})_{8/9}Y_{0.2}O_{2.9}$ electrolyte, a functional NiO-$SrZr_{0.5}Ce_{0.4}Y_{0.1}O_{3-\delta}$ cathode layer and NiO-$Ba(Zr_{0.5}Ce0_{.4})_{8/9}Y_{0.2}O_{2.9}$ substrate using an inverse tape casting route. The smooth tri-layered green tapes produced, yielded suitably dense and gas-tight electrolyte layers after co-sintering at 1350 ºC/5h. Current-voltage characteristics and hydrogen evolution rates measured in the temperature range 500-600°C, using $Ba_{0.5}La_{0.5}CoO_{3-\delta}$ as anode, demonstrate excellent performance and durability. Electrolysis voltage as low as 1.2 V are attainable at current densities of 0.2, 0.4 and 0.5 A/cm^2 at 500, 550 and 600 ºC, achieving faradaic efficiencies close to 100% in the later, which is among the best PC-SOECs performance reported in literature. Microstructural optimized cells as well improvements in current collection also yield a current density of 1 Acm^2 at 600 ℃ at an operating voltage of 1.36 V. Beside electrochemical characteristics, the morphology of the tri-layered half-cells were also analyzed by a combination of high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) and energy-dispersive X-ray spectroscopy (EDS). We observe the precipitation of Y_2O_3 and substential amount of Sr and Ba inter diffusion as well as Ni migrates in the vicinity of NiO grain and the electrolyte interface for all half-cells sintered at 1500 ºC.

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