The Development of Nano-Composite Electrodes for Natural Gas-Assisted Steam Electrolysis for Hydrogen Production

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Electrodes are being developed for Solid Oxide Electrolyzers (SOE), especially those that could be used for Natural-Gas Assisted Steam Electrolysis (NGASE). NGASE requires electrodes that exhibit stable performance in dry methane, with low overpotentials, and allow operation at high temperatures. A variety of novel air and fuel electrodes have been developed and tested for SOE and NGASE devices. In all cases, the electrodes are made by addition of the active, electrode components into porous yttria-stabilized zirconia (YSZ) layers that had been pre-sintered with the YSZ electrolyte. Air electrodes based on Sr-doped $LaFeO_3$ (LSF) have been shown to exhibit superior performance to more traditional LSM-based electrodes but can deactivate after long times or high temperatures, apparently due to sintering of the LSF. Cu-based electrodes were found to exhibit poor thermal stability above 1073 K due to sintering of Cu, but Cu-Co electrodes prepared by Co electrodeposition onto the Cu composite had significantly improved performance. It was shown that a Cu monolayer forms at the Co surface after heating in H_2 due to free-energy considerations, so that the Cu-Co electrodes exhibit the thermal stability of Co and the chemical stability of Cu. Finally, a novel, all-ceramic electrode was developed for use in fuel environments. The ceramic electrode consists of a thin functional layer optimized for catalytic activity with a thicker conduction layer.