Carbon deposition and sulfur poisoning during CO2 electrolysis in nickel-based solid oxide cell electrodes - DTU Orbit (09/12/2018)

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Reduction of CO2 to CO and O2 in the solid oxide electrolysis cell (SOEC) has the potential to play a crucial role in closing the CO2 loop. Carbon deposition in nickel-based cells is however fatal and must be considered during CO2 electrolysis. Here, the effect of operating parameters is investigated systematically using simple current-potential experiments. Due to variations of local conditions, it is shown that higher current density and lower fuel electrode porosity will cause local carbon formation at the electrochemical reaction sites despite operating with a CO outlet concentration outside the thermodynamic carbon formation region. Attempts at mitigating the issue by coating the composite nickel/yttria-stabilized zirconia electrode with carbon-inhibiting nanoparticles and by sulfur passivation proved unsuccessful. Increasing the fuel electrode porosity is shown to mitigate the problem, but only to a certain extent. This work shows that a typical SOEC stack converting CO2 to CO and O2 is limited to as little as 15–45% conversion due to risk of carbon formation. Furthermore, cells operated in CO2 electrolysis mode are poisoned by reactant gases containing ppb-levels of sulfur, in contrast to ppm-levels for operation in fuel cell mode.

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