Tubular ceramic proton conducting steam electrolyser

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Abstract

High temperature electrolysers (HTEs) may produce H_2 efficiently utilising electricity from renewable sources and steam from solar, geothermal, or nuclear plants. CO_2 can be co-electrolysed to produce syngas and fuels. The traditional solid oxide electrolyser cell (SOEC) leaves wet H_2 at the steam side. In contrast, proton ceramic electrolyser cells (PCEC) can pump out and pressurize dry H_2 directly. Further, the danger of delamination of oxygen electrodes due to O_2 bubbles in SOECs is alleviated in PCECs. Herein, we present a new collaborative project that will develop modules based on tubular state-of-the-art Y:$BaZrO_3$ (BZY) as the proton conducting electrolyte using reactive sintering for dense large-grained films, low grain boundary resistance, and high stability and mechanical strength. Existing HTEs utilise the high packing density of planar stacks, but the hot seal and vulnerability to single cell breakdown give high stack rejection rate and questionable durability and lifetime economy. We use instead tubular segmented cells, mounted in a novel module with cold seals that allows monitoring and replacement of individual tubes from the cold side.

The approach will include development of novel materials, new scalable fabrication routes, and techno-economical evaluation for integration in renewable energy schemes such as geothermal, wind and solar power. We emphasize development of novel H_2O-O_2 anodes with embedded current collectors to alleviate ohmic losses under high current loads. The tubes are developed along 3 design generations with increasing efforts and rewards towards electrochemical performance and sustainable mass scale production. The aim is to show a kW-size multi-tube module producing 250 L/h H_2. The project will also investigate co-electrolysis in co-ionic (oxide ion and proton) mode of CO_2 to syngas with DME production.

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