AIR ELECTRODE INTERLAYER FOR PROTON CONDUCTING SOLID OXIDE CELLS

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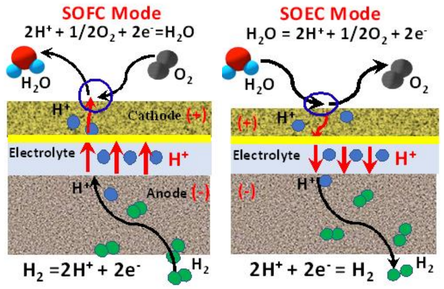
Proton-conducting cells



e.g.
- $BaZr_{0.1}Ce_{0.7}Y_{0.1}Yb_{0.1}O_{3-\delta}$
- $BaHf_{0.3}Ce_{0.5}Y_{0.1}Yb_{0.1}O_{3-\delta}$

- High ionic conductivities, especially at low-temperatures
- Producing dry hydrogen, gas separation is not necessary
- Eliminating Ni partial oxidation

500 – 650 °C operation

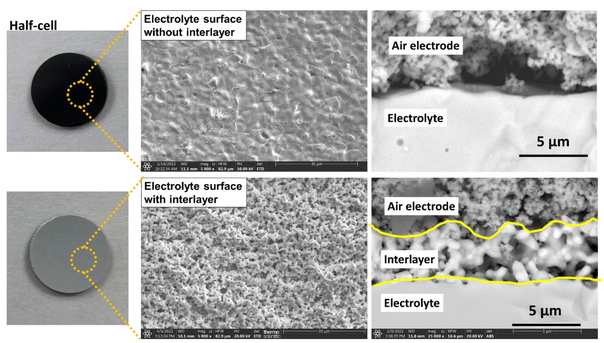
Key challenges at air electrode-electrolyte interface

- Substantial difference in thermal expansion coefficient causes week bonding and delamination
- Air electrode delamination leads to low performance and poor stability
- We propose a simple and scalable method to prevent delamination and increase contact area by introducing a thin porous and interconnected proton-conducting interlayer

Approach: Fabrication of proton-conducting interlayer

Identify key parameters for interlayer fabrication → Demonstration of improved electrochemical performance and stability in button cell and 10 cm x 10 cm cell → Further optimization of interlayer microstructures (e.g. varying composition and particle size)

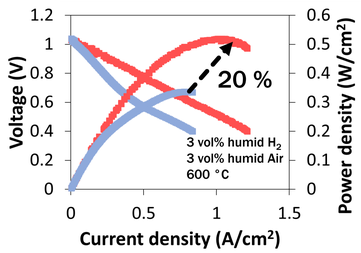
Ultrasonic spray deposition
- Controllable morphology
- High productivity
- High reproducibility
- Reduced material consumption
- Low maintenance
- Easy switch of coating materials

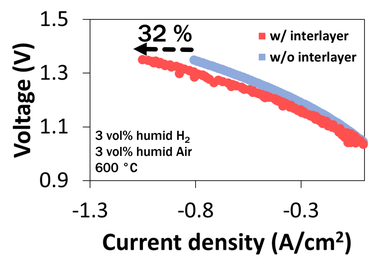


- Smooth electrolyte surface usually leads to poor bonding to air electrode, resulting in low electrochemical performance as well as defects (cracks or delamination) during cell manufacturing.
- A mesoscale porous interlayer based on proton-conducting BHCYYb was applied on the proton-conducting electrolyte layer prior to air electrode $PrBa_{0.9}Co_{1.96}Nb_{0.04}O_{5+\delta}$ (PB9CN) coating.

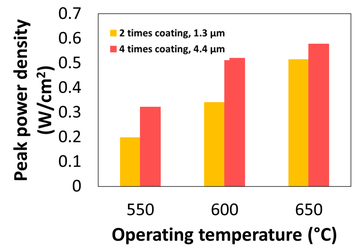
Increased performance at lower temperatures

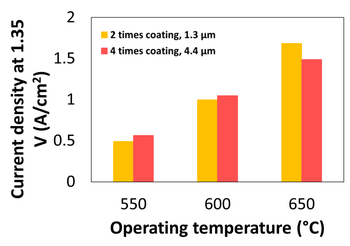
Comparison of cells with and without an interlayer

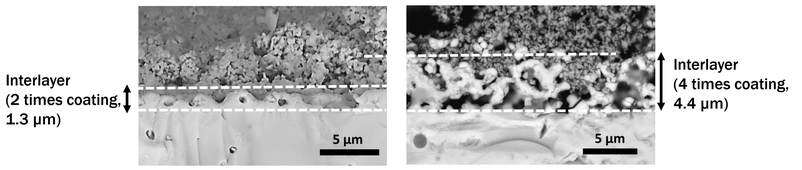




Effect of interlayer thickness

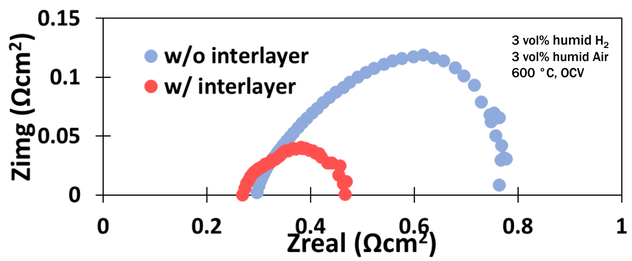


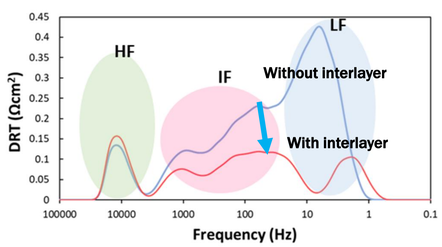




- The performance of both fuel and electrolysis cells was improved by 20 % (power density in FC) and 32 % (current density in EC) at 600 °C.
- Porous and interconnected microstructure by 4 times spray coating (4.4 μm thickness) increased the interfacial bonding and interfacial contact area.

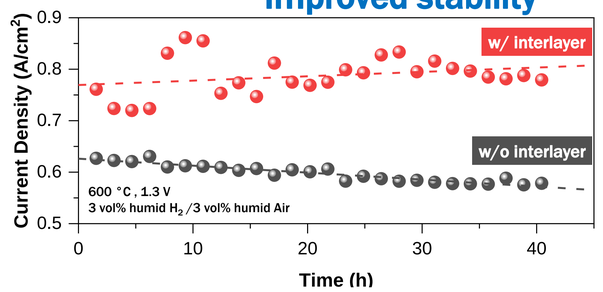
EIS analysis





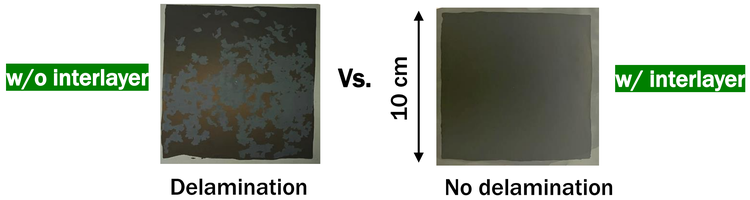
The optimized interlayer reduces both ohmic and polarization resistances by enhancing interfacial condition, facilitating gas diffusion and charge transfer reaction at low operating temperatures (i.e., ≤ 600 °C)

Improved stability

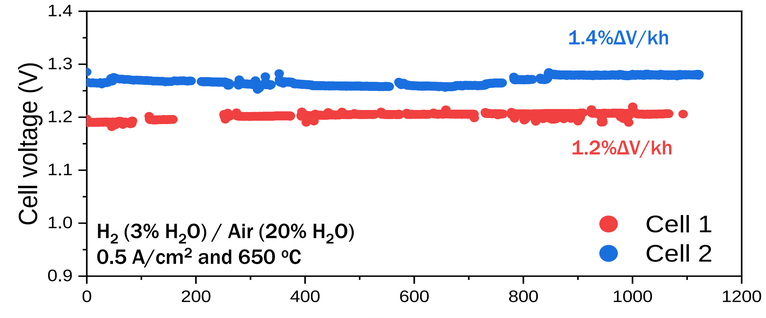


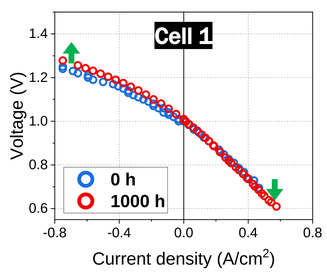
Air electrode interlayer improves cell stability as well as the performance

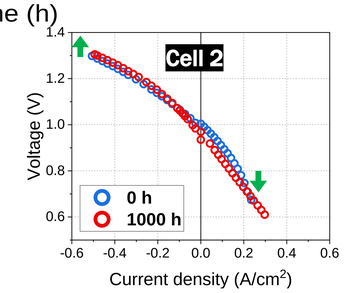
10 cm x 10 cm cell demonstration



Interlayer offers strong interfacial adhesion and prevent electrode delamination







The 1100-h operation demonstrated excellent long-term stability of large cells with an interlayer

Conclusions

- Porous interlayer was successfully fabricated using spray coating method.
- The interlayer on proton-conducting cells improves the electrochemical performance by increasing triple phase boundary (TPB) length.
- The porous interlayer also functions as scaffolds allowing for strong adhesion of air-electrode.
- Long-term durability of large area proton-conducting cells with the interlayer was demonstrated.

Acknowledgements

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