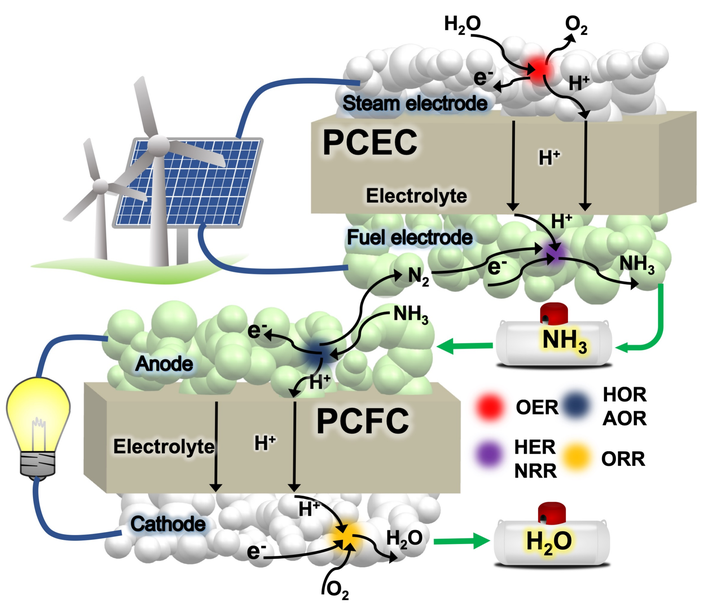
Protonic Ceramics for Energy Storage and Electricity Generation with Ammonia

Reversible Protonic Ceramic Electrochemical Cells for Long-term Energy Storage

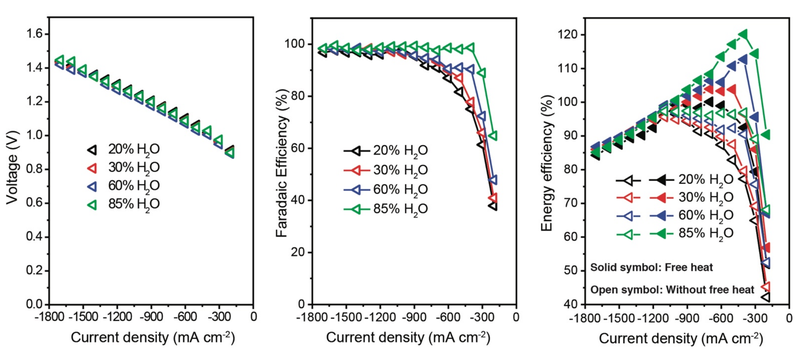
Reversible Protonic Ceramic Electrochemical Cells

Inter-seasonal Electrosynthesized Liquid Fuel Energy Storage



Highly Efficient Protonic Ceramic Electrolyzer for Hydrogen Production

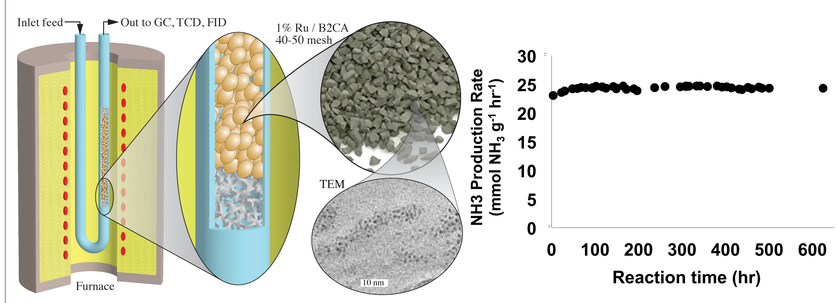
The first key for ammonia production



- High energy conversion efficiency with high H_2 production rate
- Dry hydrogen production
- Stable positive electrode in hydrothermal conditions

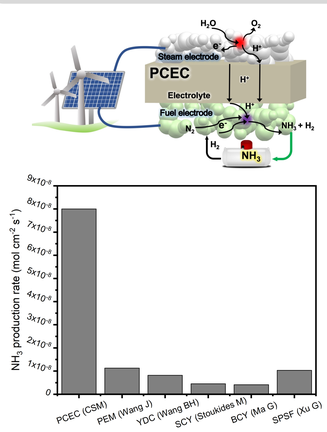
Remarkable Ammonia Synthesis Catalyst

The second key for ammonia production

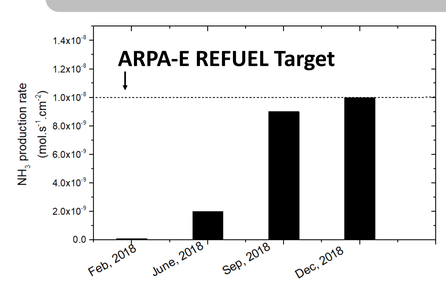


- State-of-art ammonia synthesis catalyst
- Long-term stable catalytic activity

PCECs for Ammonia Production

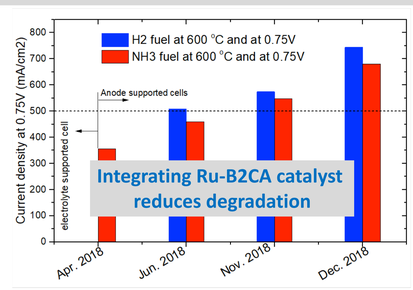


- Improved catalyst-packing techniques
- Reached 1 x 10^{-8} mol NH_3/ cm^2 s at atm. Pressure
- CSM's result with no H_2 recycle is world leading



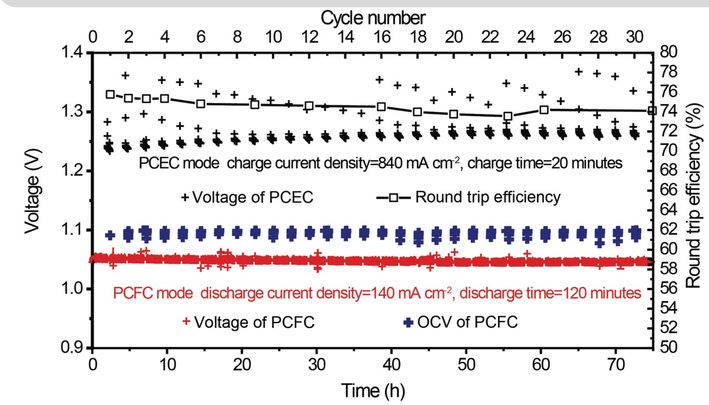
- Word record NH_3 production rate with H_2 recycled

Ammonia PCFCs for Power Generation



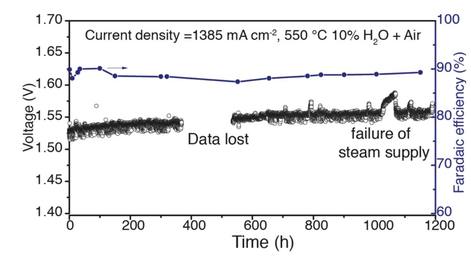
CSM's increases in fuel-cell performance under NH_3-fuel over the past year

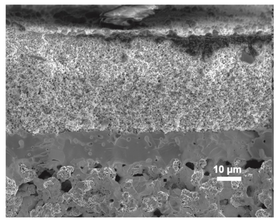
Reversible Operation of RePCECs for Energy Conversion and Storage (Hydrogen)

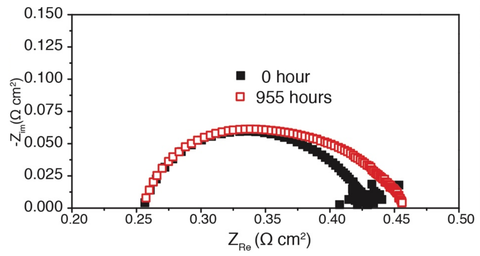


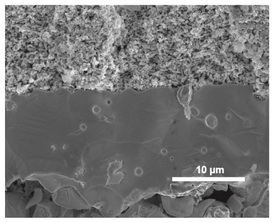
- High round-trip efficiency
- Excellent cyclability
- Long-term stable operation
- Promising seasonal energy storage technology

Long-term Operation for Fuel Production









- Long-term stable operation
- Stable negative electrode
- Optimized positive electrode should be developed for operation in more severe conditions

CHANGING WHAT'S POSSIBLE