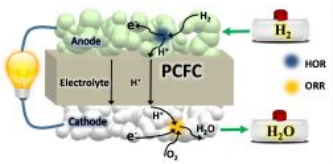
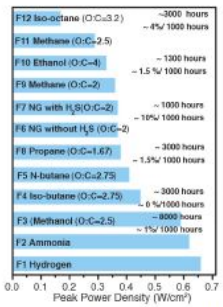
# Low-Cost Intermediate-Temperature Fuel Flexible Protonic Ceramic Fuel Cell Stack

## Expanded Utility through Manufacturable Processes and More Fuel Options

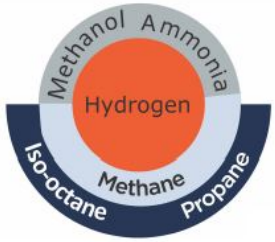
### Highly durable protonic ceramic fuel cells



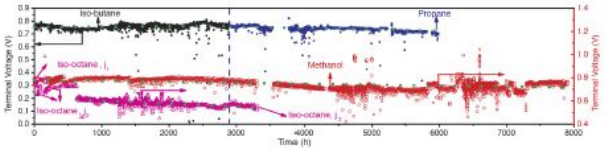

- Intermediate-temperature (400-600 °C)
- Highly durable
- Fuel flexible
- Low-cost
- High-performance
- High coking resistance
- High sulfur tolerance

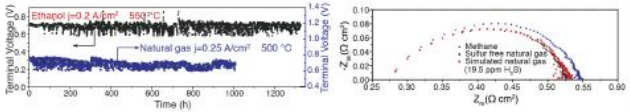



### 12 different fuel streams




### Low-degradation on multiple fuels




FlexPCFC remarkable features
- LONG stability (>8000 hours)
- Fuel-flexible (>10 fuels)
- High-performance with HCs
- High coking resistance
- High sulfur tolerance

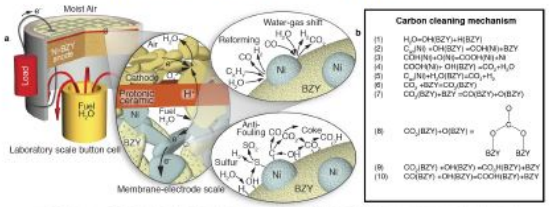
- Duan, Chuanchang, et al. Science 349.6254 (2015): 1321-1326.
- Duan, Chuanchang, et al. Nature 557.7704 (2018): 217.
- Duan, Chuanchang, et al. Nature Energy 10.1038/s41560-019-0533-2

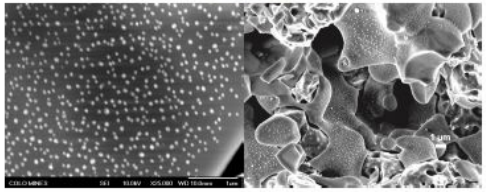


ARPA-E ENERGY WHITE PAPERS REBELS program award DE-AR0000463

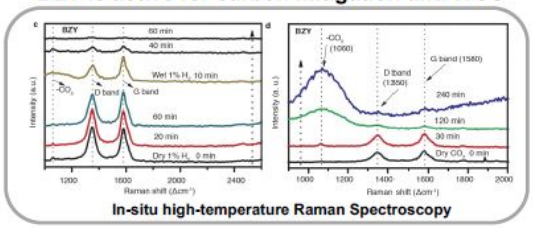

### Unique features of protonic ceramic fuel cells

#### In-situ exsolved Ni nanoparticles

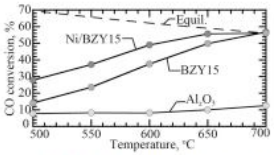


#### BZY is active for carbon mitigation and WGS



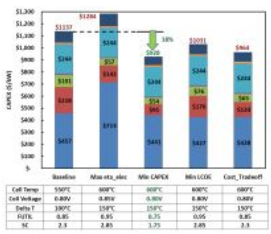

In-situ high-temperature Raman Spectroscopy




FlexPCFC remarkable features
- Engineered anode
- High HCs reforming activity

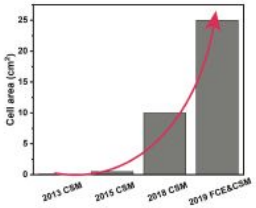

Jennings, Dylan M., et al. *Catalysis Letters* 148.12 (2018): 3592-3607.

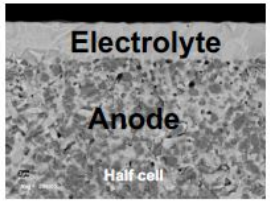

### Different system design objectives generate varying optimal PCFC stack parameter selections

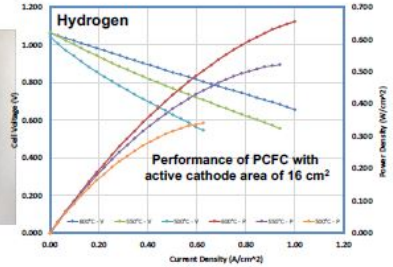



| Configuration | Possible use |
|---|---|
| Max efficiency | Military application |
| Min CAPEX | Emergency backup |
| Min LCOE | Residential use |
| Tradeoff | Recreational use |

### Scale up






ARPA-E CHANGING WHAT'S POSSIBLE

**2010**
US patent Application 14/621, 091, 2015 Development of SSRS Process for PCFCs
US patent Application 62/101, 285, 2016 Development of Triple Conducting Cathode for PCFCs

**3** First FlexPCFC Single Cell

**4** First FlexPCFC 3-Cell Stack (~1 W Power)

**Current Project Status**
Industrial Partner
Fuel Cell Energy

**5-6** Pre-commercial "quarter-stack" prototype (~100W)

**7** Commercial product prototype for remote DG applications (~1-3 kW)