Remedies for poisonous effects of coal syngas impurities on SOFC anodes

R. Bajura *(P.I.)*, I. Celik *(Tech. P.I.),* H. Finklea, B. Kang, X. Liu, E. Sabolsky, X. Song, N. Wu, J. Zondlo
Post Docs: N. Cayan, S. Pakalapati, C. Xu, Y. Vural
National Institute for Fuel Cell Technology, West Virginia University, Morgantown, WV

Objectives

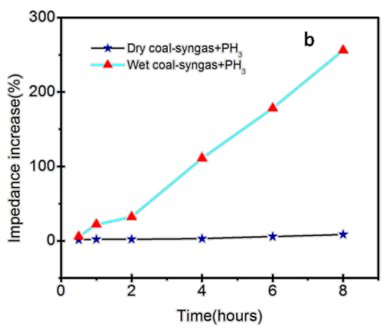
- Characterize degradation mechanisms for coal syngas impurities.
- Develop novel anode materials for improving tolerance of SOFCs to impurities.
- Predict lifetime and durability of cell and stacks.

Methodology

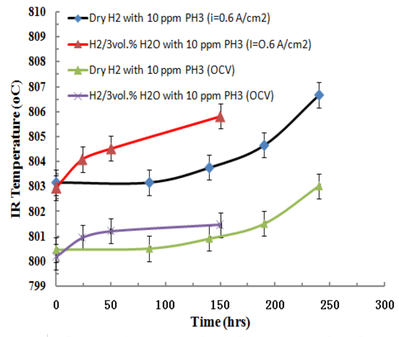
- Multi-scale, multidisciplinary approach.
- In-house cell manufacturing using novel techniques.
- Electrode and cell level testing in simulated syngas.
  - Ex-situ: SEM, XPS, XRD, TEM, Raman, EDAX
  - In-situ: EIS, CV, ESEM, MS, Van Der Pauw, temperature and deformation measurement
- Continuum level cell and stack modeling
- Phenomenological modeling based on accelerated laboratory tests to predict long term degradation.

Experiments

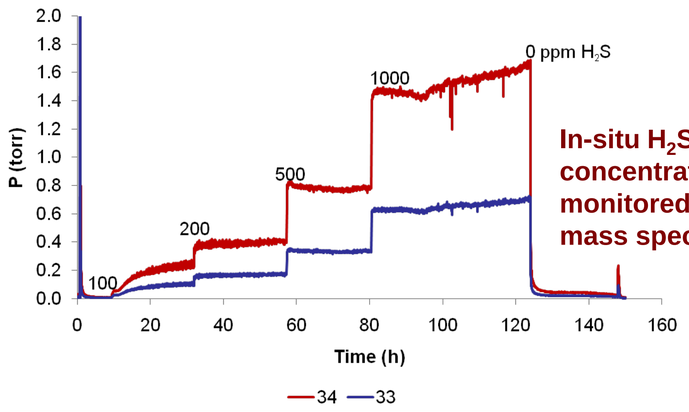
- PH_3 Effects on SOFC Performance was studied for both dry and wet conditions
- A unique in-situ test stand is developed to monitor the temperature of a button cell in time
- In-situ contaminant concentrations are measured using mass spectrometer



OC impedance measured at different times: half cell tests



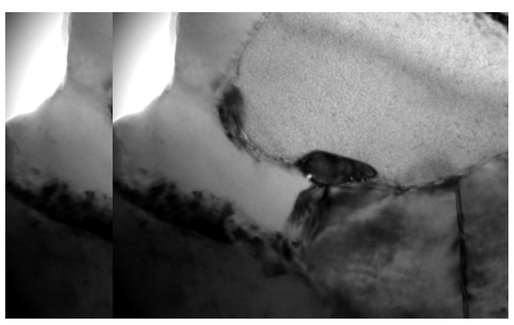
Surface IR Emission Variation under different test conditions



In-situ H_2S concentration monitored with the mass spectrometer

Nanotechnology

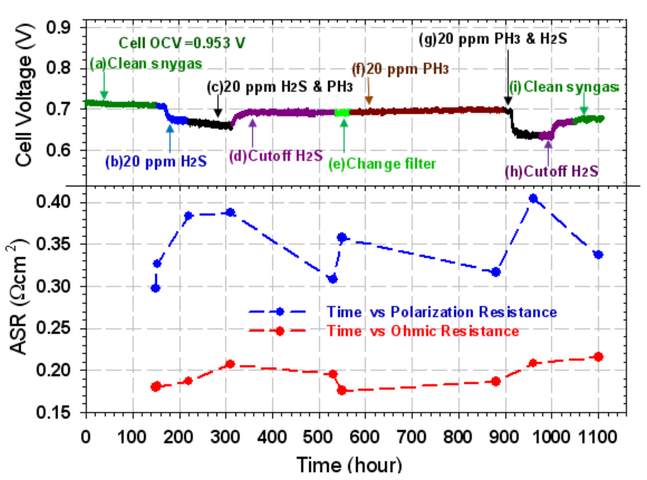
- TEM analysis revealed the crystallographic and morphological changes caused by the contaminants.



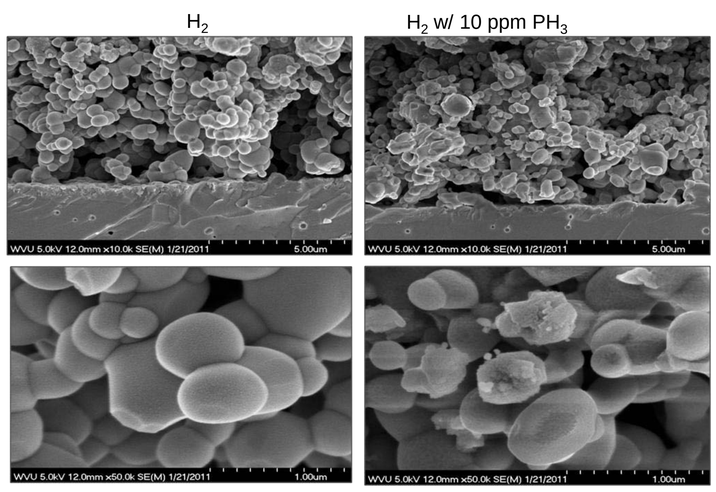
Formation of Y-P-O phase at Ni/YSZ interfac. PH_3 reacts both with Ni and YSZ

Remedies

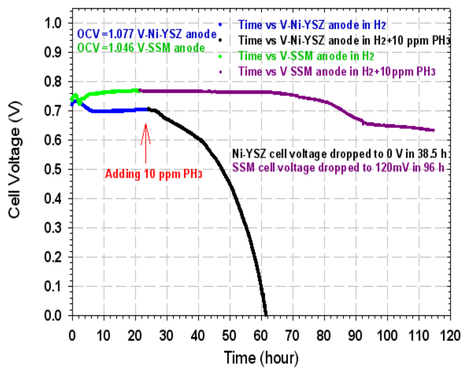
- Ni and Fe based pre-filters are developed to reduce the impact of PH_3
- A new coating is developed to improve the tolerance of SOFCs to H_2S
- Novel anode materials are developed for better tolerance under contaminated coal syngas operation



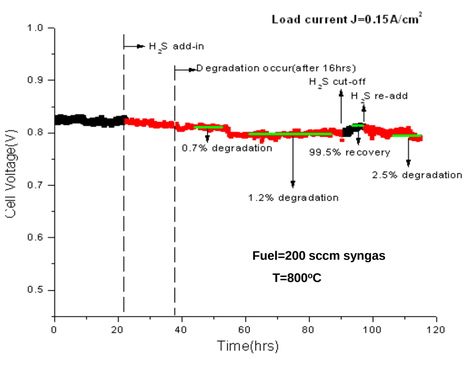
Voltage and ASR vs time with the pre-filter shows that filter is effective in reducing the impact of the impurities.



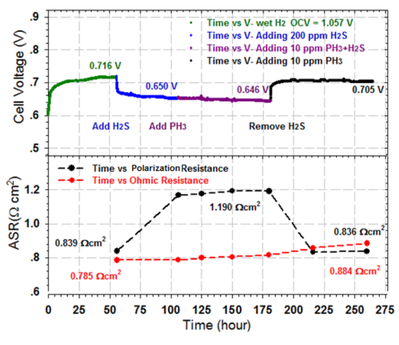
Changes to the SMM/GDC anode microstructure before and after operation in PH_3 are minimal.



SMM/GDC anode comparison to Ni/YSZ anode in 3% wet H_2 and 10 ppm PH_3



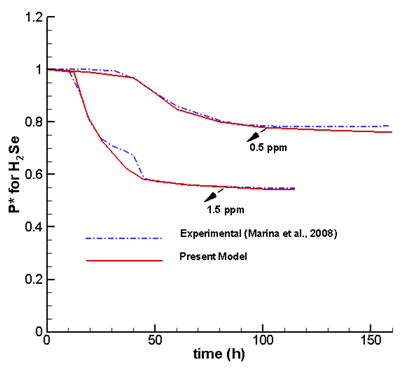
Tolerance of La_2O_3-impregnated Ni anode to H_2S in coal syngas



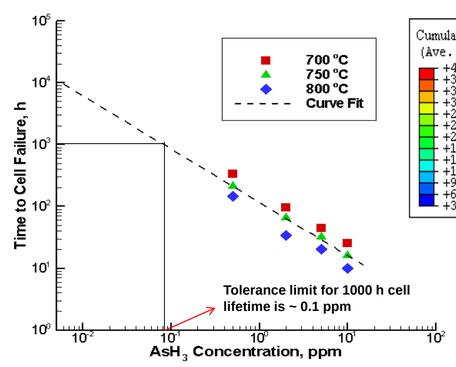
Combined H_2S (200 ppm) and PH_3 (10 ppm) in wet H_2. The filter prevented PH_3 attack and the anode resisted H_2S poisoning.

Modeling

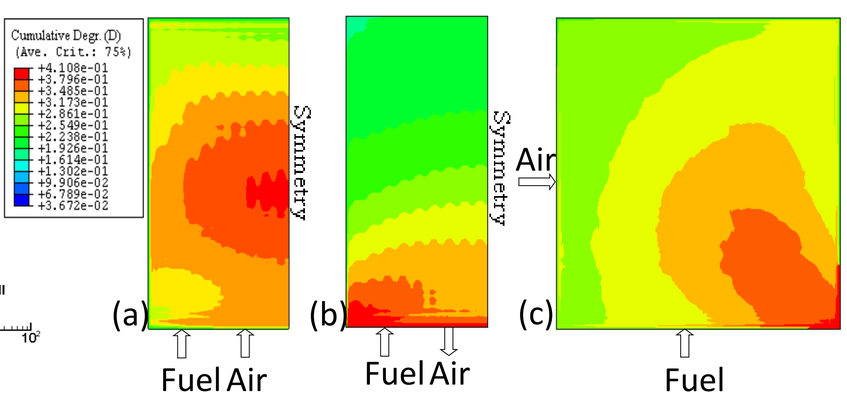
- Physics based model is developed to predict the degradation of SOFCs exposed to syngas contaminants
- Lifetime of SOFCs are predicted for various contaminants at different concentrations
- Tolerance limits are estimated for the long term operation
- Multidimensional simulations are used to reveal the underlying transport phenomena in SOFC operation
- A degradation model is developed to predict cell failure due to mechanical failure



Calibration/validation of the model against experimental results

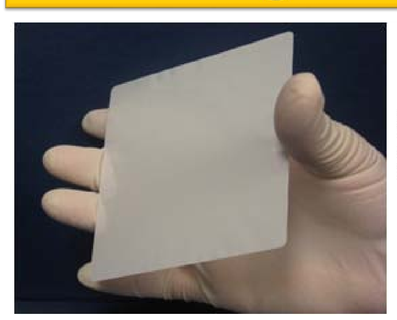


Summary of cell lifetimes predicted by the model and estimation of tolerance limits

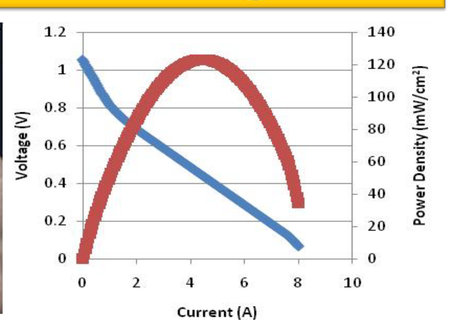


Anode structure failure locations indicated by red color for: (a) co-flow:19920h (b) counter-flow:16310h (c) cross-flow: 18450h

Large Cell Testing



100 cm^2 electrolyte-supported SOFC fabricated at WVU



Initial test in H2 fuel at 750°C of a 16 cm^2 planar electrolyte-supported SOFCS fabricated at WVU

Sponsors

DOE office of Basic energy sciences, NETL, WV State EPSCoR Office and West Virginia University

CONTACT

Dr. Ismail Celik
Department of Mechanical and Aerospace Engineering
West Virginia University, Morgantown, WV.
Ph: 304 293 3209 Fax: 304 293 6689
Email: ismail.celik@mail.wvu.edu
URL: http://nift.wvu.edu/