Brookhaven National Laboratory Advanced Electrocatalysts

Fuel Cell Seminar, Los Angeles
November 11, 2014

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BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

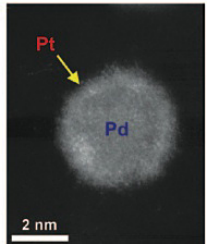
BNL Overview

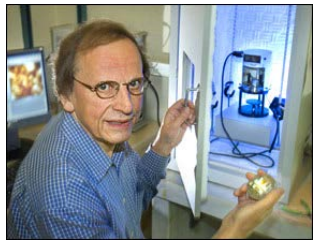
- Established 1947
- Location: Long Island, NY
- 2900 staff, 4000 annual users
- Core Capabilities
  - Primary mission in physical and energy sciences
  - And R&D in life and environmental sciences, energy technologies and national security

- Builds and operates major scientific facilities available to university, industry and government researchers
- Fuel Cell R&D: 5 PIs and co-PIs
  - Advanced electrocatalysts
  - Applications in fuel cells and electrolyzers.

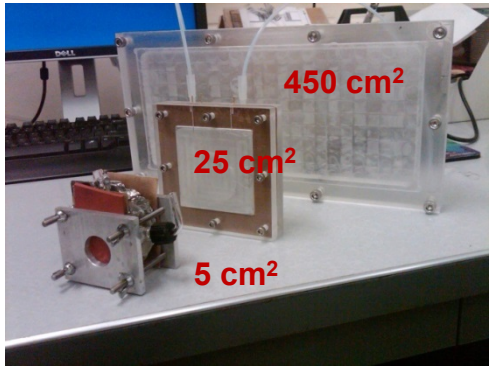
BNL Fuel Cell Capabilities

- Advanced electrocatalysts
  - Platinum monolayer core-shell electrocatalysts
  - Ultralow Pt content, high activity and durability.
  - Tech-to-Market by licensing & cooperative development





- Membrane electrode assemblies
  - Novel electrodeposition fabrication methods
  - Incorporation of core-shell electrocatalysts

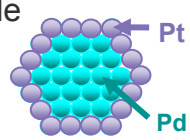


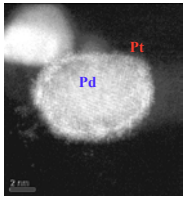
- Advanced Characterization
  - User facilities for characterization of materials and devices
  - Photon science (NSLS-II) and Nanoscience (CFN) capabilities

Core-shell electrocatalysts

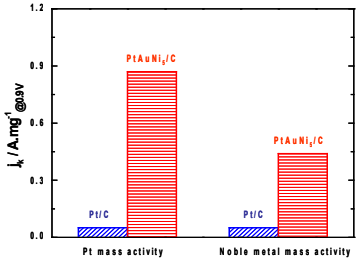
Pt monolayer shell – metal/alloy core
Core tunes activity & durability of shell

Model and TEM image of a Pt Monolayer on Pd nanoparticle

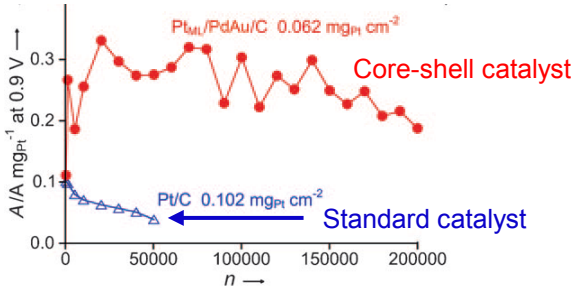




Pt-mass weighted activity enhanced 20x



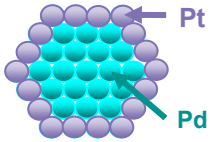
Scale-up synthesis: $Pt/Pd_9Au_1/C$
Fuel Cell durability 200,000 cycles



- Target applications
  - PEM fuel cell anode and cathode reactions
  - PEM electrolyzers for H_2 production
- Benefits – decrease platinum content and cost, improve durability
- Electrocatalysts - 14 issued US patents; >15 applications pending
- Cooperative research and development on scale-up and integration.
  - CRADA efforts with multiple partners in fuel cell applications
  - SBIR/STTR effort for electrolyzer application

Core-Shell Technology-to-Market

Electrocatalysts for oxygen reduction reaction (ORR)



Basic research 1992+ — DOE Office of Science

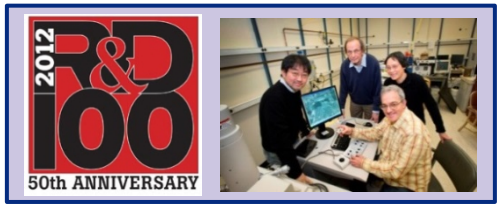
Electrocatalyst development 2002+ — DOE EERE FCTO

Fuel cell testing 2005+ — Industrial CRADA

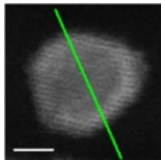
First license 2011

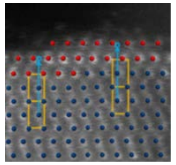
N.E. CHEMCAT
Lead The Catalyst Innovations

R&D 100 Award 2012



Electrocatalysts for hydrogen reactions (HER)

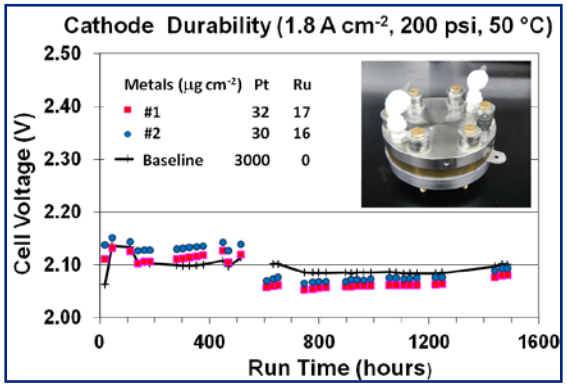




Basic research 2012+

PEM electrolyzer 2013+

DOE EERE SBIR/STTR



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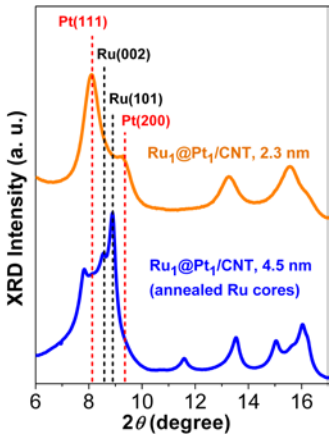
BNL Advanced Characterization User Facilities

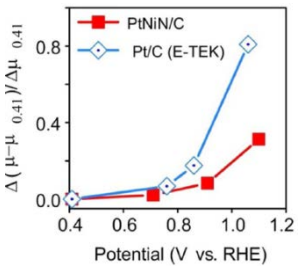
NSLS-II

CFN

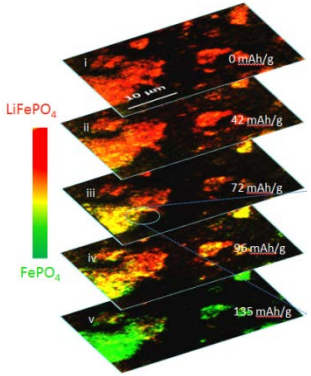
Structure, Spectroscopy & Imaging



Crystalline nanocatalyst structure

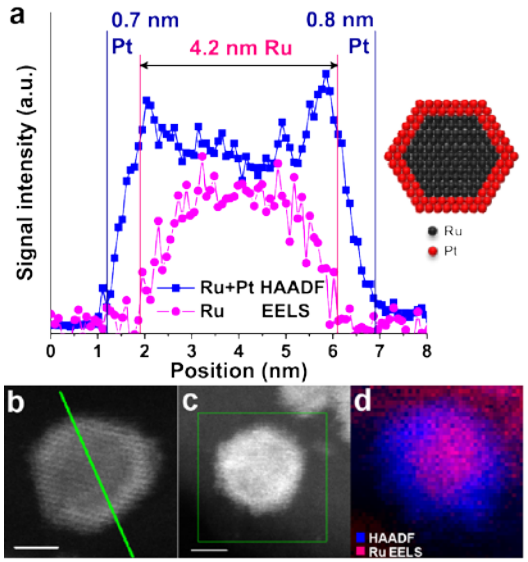


In situ – Pt shell oxidation state



Microscale chemical mapping

Nanostructure



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