INCREASE YOUR H2IQ

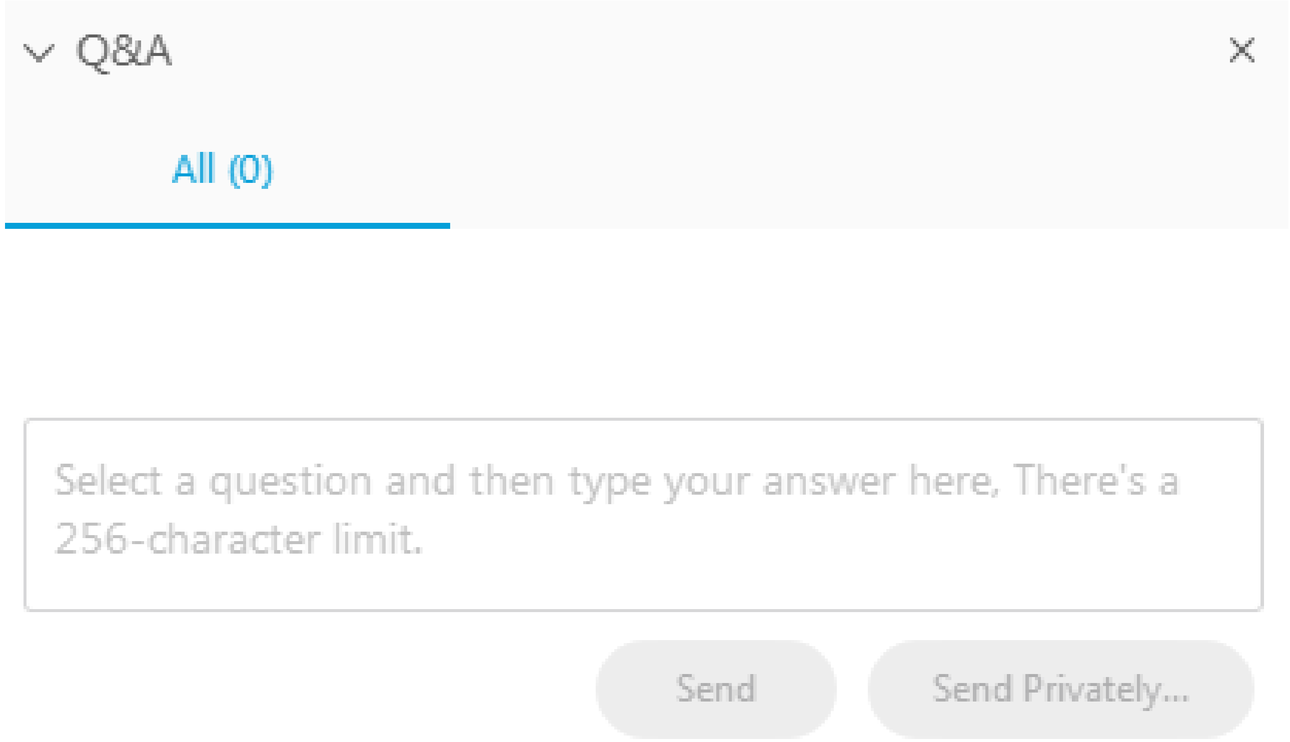
The #H2IQ Hour

Today's Topic: African American History Month – Engaging the Fuel Cell and Hydrogen Energy Community with HBCUs

This presentation is part of the monthly H2IQ hour to highlight research and development activities funded by U.S. Department of Energy's Hydrogen and Fuel Cell Technologies Office (HFTO) within the Office of Energy Efficiency and Renewable Energy (EERE).

The #H2IQ Hour Q&A

Please type your questions into the **Q&A Box**



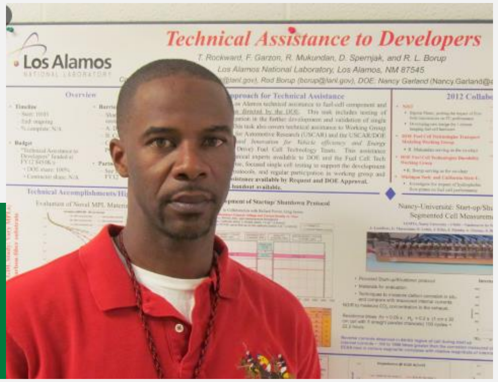
Examples of Outreach – H2IQ Hour, STEM Show and Learns

H2IQ Hours

HFTO hosts monthly public webinars to share information about hydrogen and fuel cells status, progress and needs

Upcoming H2IQ Hour:
In celebration of African American History Month:

How National Labs are engaging with HBCUs



February 25 at 12pm EST

Feb H2IQ hour will feature LANL's Tommy Rockward and efforts to engage HBCUs in H_2 and fuel cells

Register at:
energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office-webinars

H_2 and Fuel Cells Show and Learn Events For Students and in Partnership with Schools, Universities and Science Museums

HFTO has held events at the Smithsonian Air and Space Museum, Smithsonian Teachers Academy, U. of Maryland, K-12 schools, among others

Fuel Cell Car Show and Learn at Clarksburg Public High School in MD

Examples of Collaboration on H2 and Fuel Cells/STEM Awareness

Smithsonian Institution

- 2017, 2018, 2019 Smithsonian Science and Education Teachers Academy
- 2017 Smithsonian Ingenuity Festival Activities at the National Air and Space Museum
- 2017 Smithsonian's National Air and Space Museum - "Hispanic Heritage Month: Innovators in Air and Space" Festival

University of Maryland

- 2018 UMD Engineering Sustainability Day
- 2018 Maryland Day

FY21 Funding Opportunity Announcement Encourages HBCU Participation

- Covers $33M in funding to support hydrogen and fuel cells R&D
- Topics include:
  - Fuel cells for heavy-duty trucks in coordination with the M^2FCT consortium
  - Hydrogen production through high-temperature (high-T) water splitting (electrolysis) in coordination with the H2NEW consortium, as well as biological processes that use waste
  - Domestic manufacturing of high-T electrolyzers and related components.
- Important Deadlines:
  - Concept papers - January 15, 2021
  - Full applications - March 8, 2021.

FOA includes policy factor around team member diversity encouraging participants including but not limited to those from MSIs (e.g. HBCUs/OMIs) or members within Qualified Opportunity Zones, to apply.

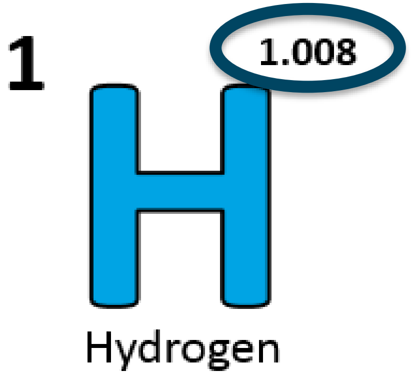
Additional Resources and Opportunities for Engagement

Save the Date

Week of June 7, 2021
Annual Merit Review and Peer Evaluation Meeting (AMR) for the DOE Hydrogen and Fuel Cells Program

Oct 8 - Hydrogen and Fuel Cells Day

(Held on its very own atomic weight-day)



Resources

INCREASE YOUR H2IQ

Join Monthly
H2IQ Hour Webinars

energy.gov/eere/fuelcells/fuel-cell-technologies-office-webinars

Download
H2IQ For Free

energy.gov/eere/fuelcells/downloads/increase-your-h2iq-training-resource

Visit H2tools.Org For Hydrogen Safety And Lessons Learned
https://h2tools.org/

Learn more: **Sign up to receive hydrogen and fuel cell updates**
www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-newsletter

Learn more at: energy.gov/eere/fuelcells AND www.hydrogen.energy.gov

Fuel Cell Research Efforts: HBCU Students at LANL

DOE HFTO H2IQ
Feb 25, 2021

Mr. Tommy Rockward, Dr. Andre Spears,
Mr. Stefan Williams, Mr. David Alexander

LA-UR-21-21836

Acknowledgement

- Hydrogen & Fuel Cell Technologies Office

- LANL's Underrepresented Minority Program (formerly African American Partnership Program)

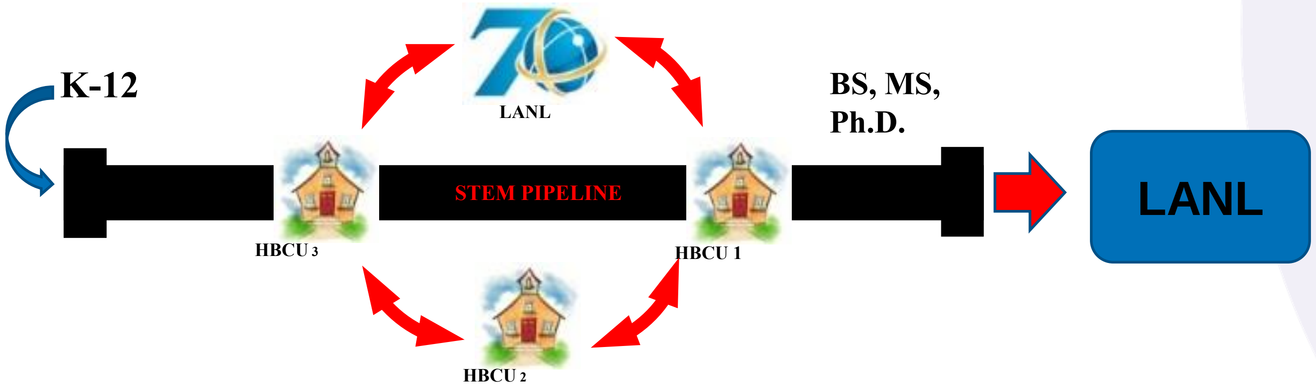
- NNSA MSIPP Program

Goal: To prepare the next generation of STEM workforce

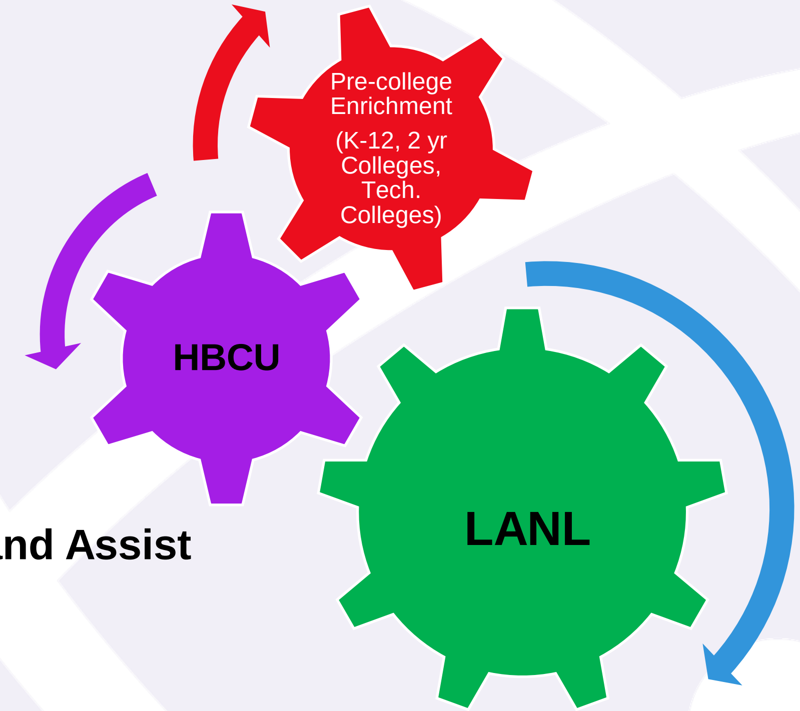
Historically Black Colleges & Universities-Consortia Schools:

****

North Carolina A & T	Fisk University
Allen University	Florida A. & M. University
Benedict College	Morehouse College
Tuskegee University	Prairie View A. & M. Univ.
Howard University	Tennessee State Univ.
	Southern University



Inspire, Encourage and Enrich STEM at early ages



Educate, Maintain, and Assist

Promote, Nurture and Sustain STEM

Opportunities available for summer, year-round appointments and graduate research

LANL Interactions:

K-12: Outreach Program

Lab set-up

Hands-on research

Short Courses/Internships

Technical Assistance to Developers: LANL Fuel Cell Short Course

Day 1

9:15 Welcome/Safety & Security Briefing/Introductions/Plan for the Day – Borup
9:30 Fuel Cell Overview – Borup
10:05 Fuel Cell Electrochemistry –Spendelow
10:50 BREAK
11:00 Durability Discussions - Borup
11:45 LUNCH (on your own)
1:00 PEM for Fuel Cells - Kim
2:00 **LANL's MEA Process –**
3:00 **Lab Session: MEA Fabrication and Assembly** – Lujan and Langlois
4:00 **Deposition**- Williamson, Romero
5:00 Adjourn

Day 2

9:00 Modeling – Holby
9:45 Fuel Cell Materials Characterization: Imaging and Tomography – Kreller and Spernjak
10:30 Break
10: 40 Fuel Cell Electrocatalysis: Zelenay
11:20 Material Characterization Techniques: SEM, XRD & XRF- Martinez
12:00 Lunch
1:00 AC Impedance –Kreller/Mukundan
1:50 BREAK
2:00 **Lab Session: Analysis of Cell Performance:**
Analytical Instrumentation/Cyclic Voltammetry/ H_2 Crossover/Polarization Curve (CC/CV)/AC Impedance – Rockward, Kreller, Mukundan
Material Characterizations Techniques:
SEM, XRF and XRD: Baker Martinez,
Electrochemistry Laboratory: Fundamentals and Corrosion Dumont
5:00 Adjourn

Day 3

8:45 Arrive at SM40; badging at Group Office
9:00 Small Fuel Cells and Fuel Cell Systems- Wilson
9:45 Hydrogen Fuel Quality and Analyzer- Brosha and Rockward
10:15 Bio Fuel Cells- Plamen
11:15 Discussion/Q&A, Course Evaluation, Wrap up and Adjourn

Every year at least 15 Scientists/staff, and **students** prepare an intensive 3 day course.
Limited to ~15 slots, REPRESENTATION FROM HBCUS EACH YEAR

Peer-to-Peer Interactions

Testimony:

The Minority Serving Institutions Partnership (MSIP) program at Allen University (AU) is key for the continued success and increased visibility for the Division of Mathematics & Natural Sciences at AU. The program currently supports six (6) students with disciplines spanning from Biology to Applied Mathematics as well as many other activities which encourage our students to contribute and excel. ***A critical component of that partnership is The African American Partnership Program (AAPP) with Los Alamos National Laboratory (LANL).*** *Many of our students, two of which will be visiting the laboratory this summer, who never considered research as a career are deciding to pursue graduate studies when they learn about this opportunity.-* ***Dr. Anthony Stewart, Allen University***

Left: Professor A. Stewart (Allen University and Andre Spears) with Dr. J. Chlistunoff.
Right : Undergraduate Andre Spears being mentored by UNM
Ph.D student, Joseph Dumont

HFTO/LANL Staff serving as Mentors


Rod Borup


Rangachary Mukundan


Cortney Kreller


Sid Komini Babu


Karen Rau


Mahlon Wilson


Troy Semelsberger


Ulises Martinez

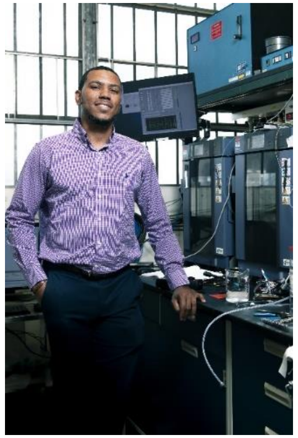

Yu Sung Kim

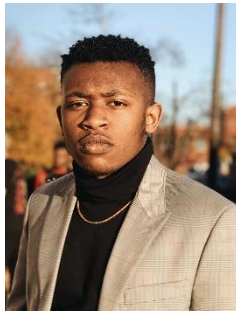

Eric Brocha


Hoon Chung

Today's Scholars, Tomorrow's Workforce









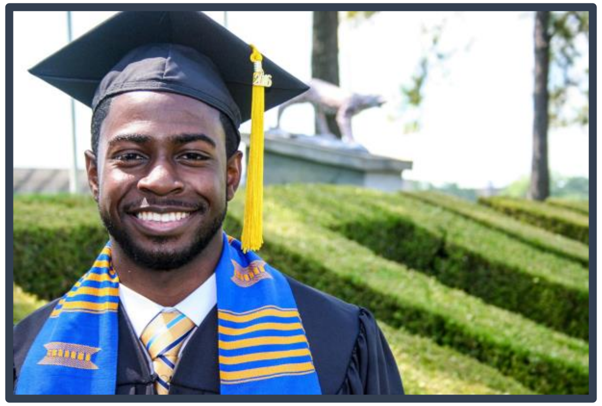




Not shown:
Ian Marts
Corey Henry
Luis Chavez
Elizabeth Martinez
Darius Smith

André Spears
LANL Timeline

Sophomore in Physics and Mathematics at Southern University and A&M College



Honors Graduate with B.S. in **Spring 2016**

2014 **2015** **2016**

Summer 2014
Began at LANL under the CMaES Consortium

Summer 2015
Returned as summer intern

Research Topics

Investigating the Interactions of Competing Adsorbates on Pt Catalysts using Electrochemical Techniques

Probing the Electrochemical Characteristics of Carbon-Supported Platinum Catalysts

Summer 2016
Returned as summer intern/mentor

André Spears
LANL Timeline


CERTIFICATE of RECOGNITION

PRESENTED TO

Andre Spears

IN RECOGNITION OF

5 Years

OF DEDICATED SERVICE

2019

2016-2017

Fall 2016
Enrolled at UNM in the Nanoscience and Microsystems Engineering Program

2018

2019

2020

Graduation
December 2020

African American Partnership Program
Providing graduate internships, creating a diverse pipeline of STEM expertise

2017
Accepted into LANL AAPP

December 2018
Received M.S.

Research at NIST 2017 & 2018

Ph.D. Candidate
Probing the Impacts of Membrane Degradation with Ultra-Low Pt Loadings

Publications

Investigation of Membrane Chemical Degradation as a Function of Catalyst Pt Loading

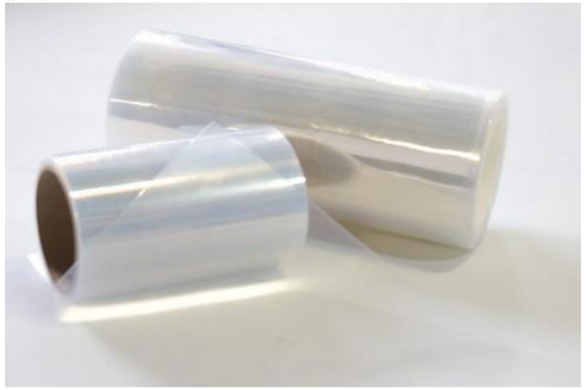
Unusually High Concentration of Alkyl Ammonium Hydroxide in the Cation-Hydroxide-Water Co-adsorbed Layer on Pt

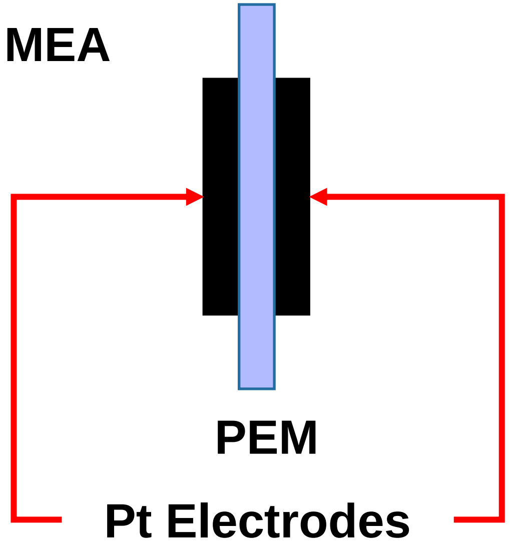
André J. Spears
Nanoscience and Microsystems Engineering
Doctoral Defense
December 9th, 2020

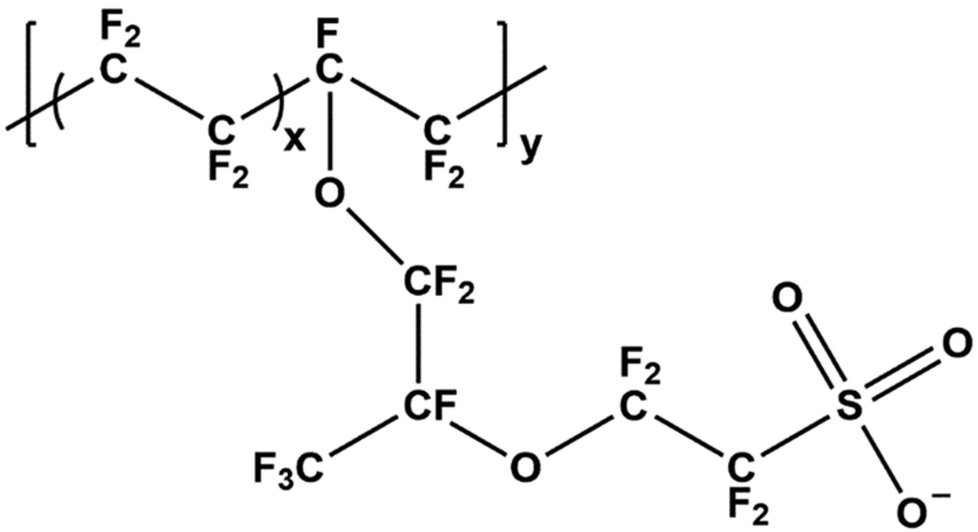
Probing the Impacts of Ultra-low Platinum Loadings on Membrane Degradation Mechanisms

Proton Exchange Membrane

- Integral component of MEA
- Electrolyte and separator of reactants
- High proton conductivity
- Proton exchange sites on sulfonic acid groups



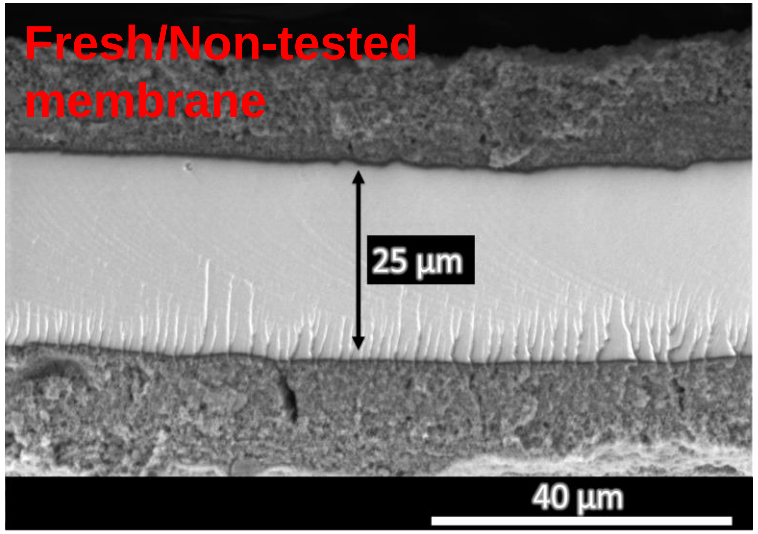


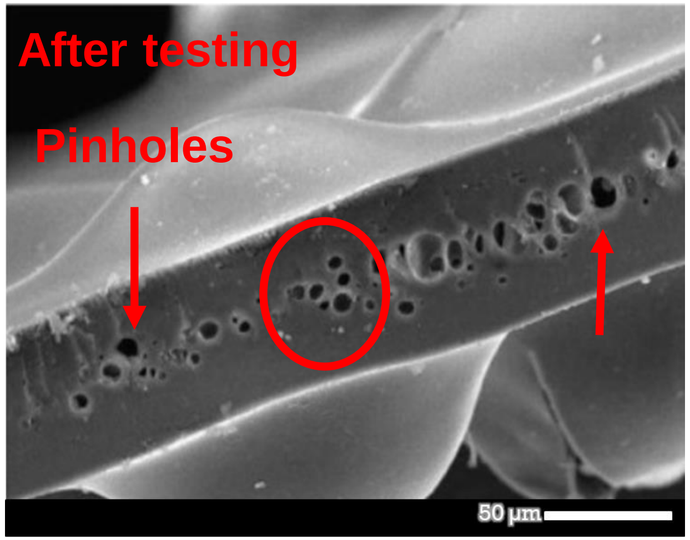


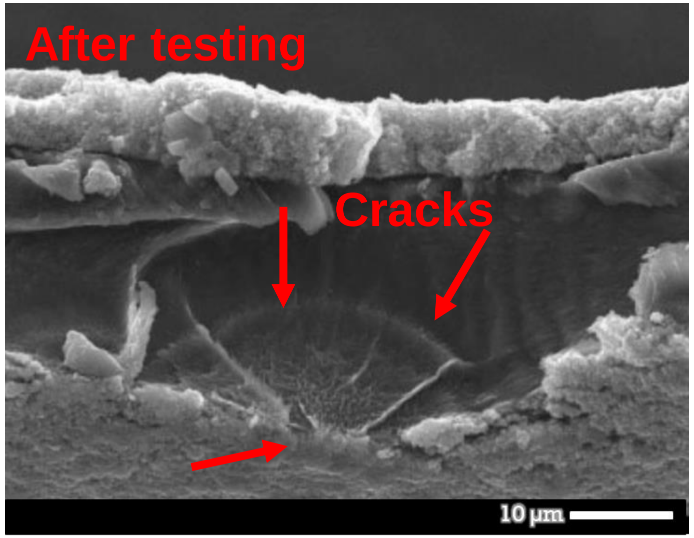
Shi, W., and L. Baker. "*RSC ADVANCES*, no. 120, 2015, p. 99284

Peroxide Formation Can Lead to Mechanical Degradation

- Mechanical failures: cracks, tears, pinholes, or punctures
- Higher gas crossover
- Lower humidity and Higher Temps causes membrane to become fragile, brittle





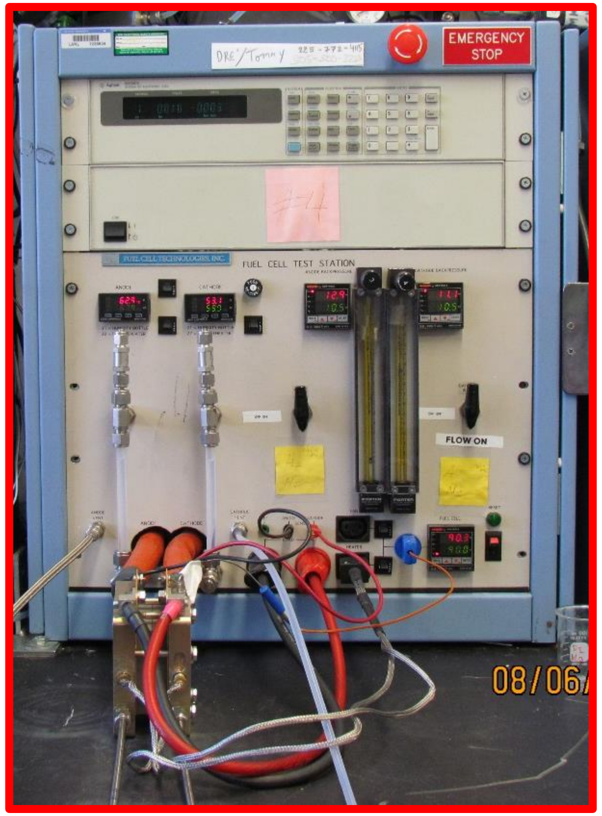


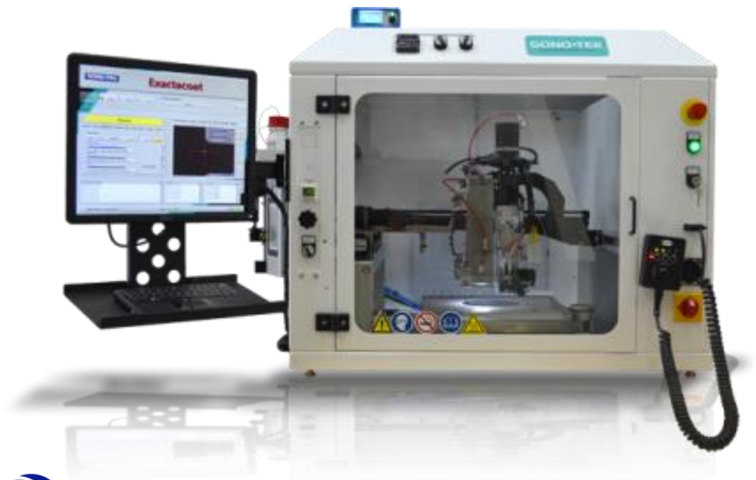
Tang, H., et. al. *J. Power Sources* **2007**. https://doi.org/10.1016/j.jpowsour.2007.03.061.

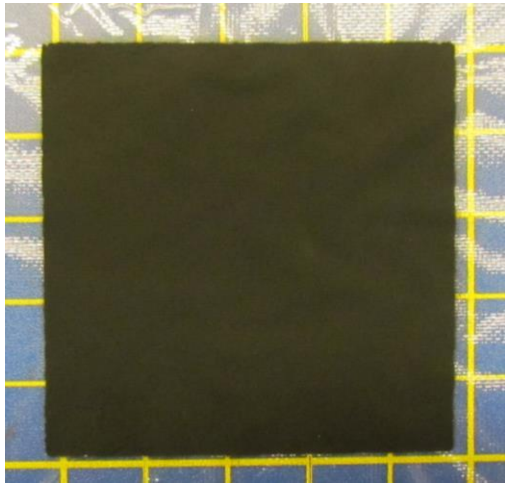
Huang, X., et. al; *J. Polym. Sci. Part B Polym. Phys.* **2006**. https://doi.org/10.1002/polb.20863.

Approach: Fuel Cell Setup

- Fuel Cell Technologies Hardware/Test Stand
  - 25 cm[2] active area, Triple Serpentine Flow, 25 BC Sigracet GDL
- Membrane Electrode Assembly (MEA)
  - Nafion® membranes (NR211, Ion Power, Inc, non-stabilized)
  - TKK Pt/C catalysts (20% and 50%)
  - 5% ionomer solution (Dupont D521)
  - Manufactured via Ultra-sonic spray coater
- XRF used to confirm Pt loading
- SEM used to measure membrane and electrode thickness







Approach: Test Protocols and Characterization Techniques

Chemical Stability Accelerated Stress Test (AST)

- Induces radical production
- **Open circuit voltage (OCV) hold**
- 90°C, 30% RH
- Back pressure: 150 kPa
- UHP H_2/ Oiless Air: 10 stoic at 0.2 A/cm^2
- Failure: 20% decrease of initial OCV

Modified Accelerated Stress Test (MA)

- Induces radical production
- **0.85 V hold**
- 90°C, 30% RH
- Back pressure: 150 kPa
- UHP H_2/ Oiless Air: 10 stoic at 0.2 A/cm^2
- Failure: less than 0.85 V

United States Department of Energy, DOE Cell Component Accelerated Stress Test Protocols for PEM Fuel Cells (Electrocatalysts, Supports, Membranes, and Membrane Electrode Assemblies), 2007.

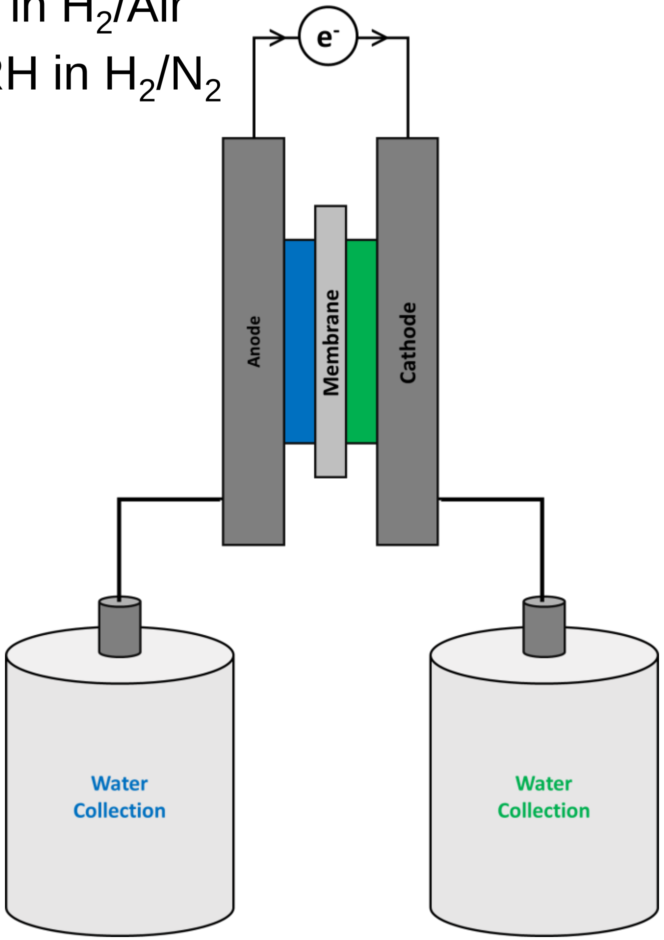
Recovery Protocol (RP)

- **Recovers reversible voltage losses**
- 0.4 V (1 hr) at 30°C, Saturated RH in H_2/Air
- 10 A (30 min) at 35°C, Saturated RH in H_2/N_2
  - Slightly negative voltage
- Repeated 3 times
- Performed every 24 hours

J. Zhang, *J. Electrochem. Soc.* **159** (7), F287 (2012)

Characterization Techniques

- Ion Chromatography (IC)
- Scanning Electron Microscopy
- Transmission Electron Microscopy
- X-ray diffraction (XRD)

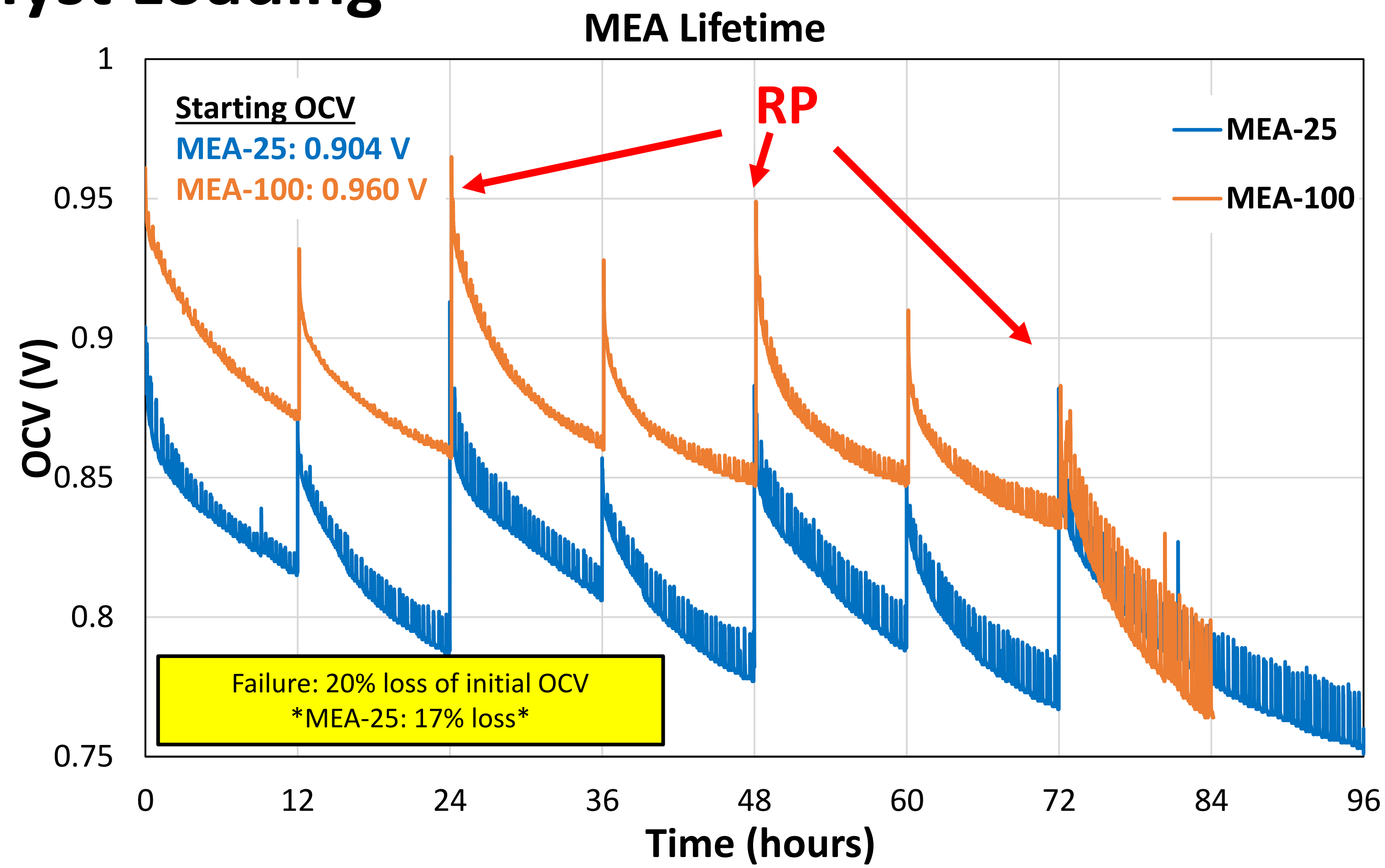


Investigation of Membrane Degradation as a Function of Pt Catalyst Loading

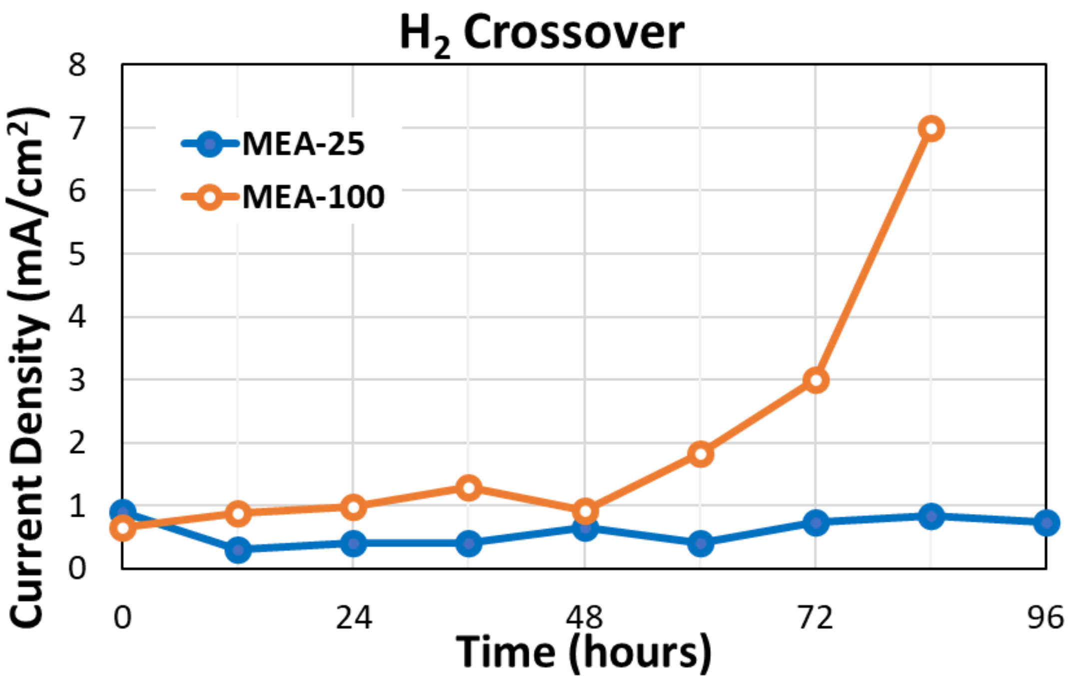
- 25 cm^2 active area
- FCT hardware
- Triple Serpentine flow plates
- Sigracet GDL 25BC
- **MEAs:**
  - **MEA-25**: 0.025 mg/cm^2 at each electrode
  - **MEA-100**: 0.1 mg/cm^2 each at electrode

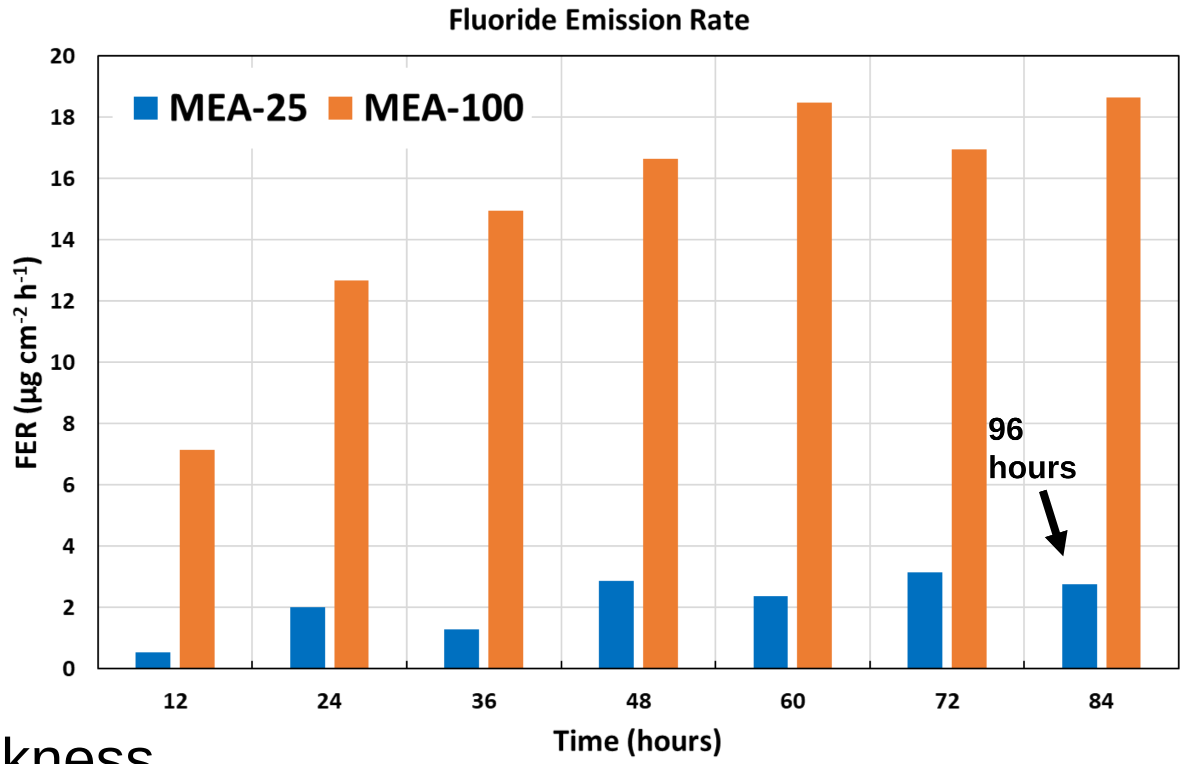
Observation:

- OCV decreases throughout the AST
- RP was applied every 24h and partially restores OCV
- MEA-25 endurance test lasted longer possibly due to initial OCV value



Characterization of Membrane Degradation





- H_2 crossover used to gauge membrane thickness
  - MEA-25 is relatively stable
  - MEA-100 increases with time due to membrane thinning
- FER: (Fluoride is a non-adsorbing anion)
  - MEA-25 had much lower amount of fluorine present
  - MEA-100 FER suggests significant membrane degradation

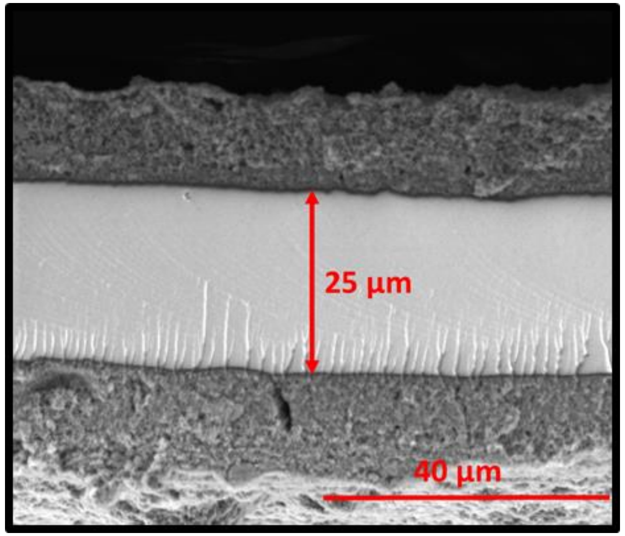
Thickness calculated from FERs

MEA-25: 23.18 µm

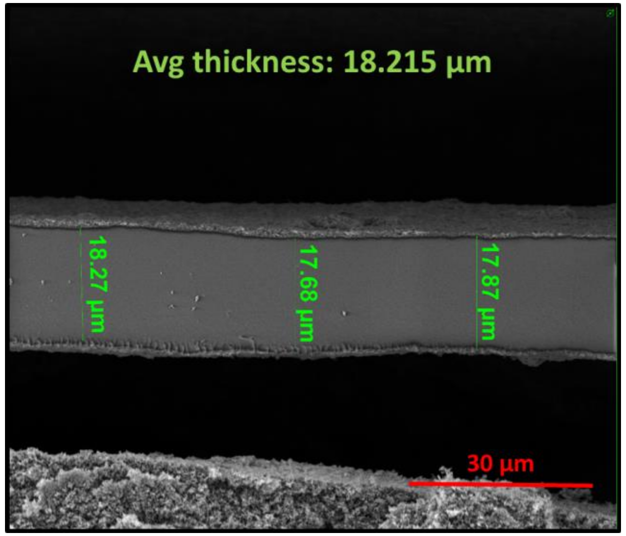
MEA-100: 14.23 µm

SEM Characterization Post-AST

Fresh Membrane (Common)

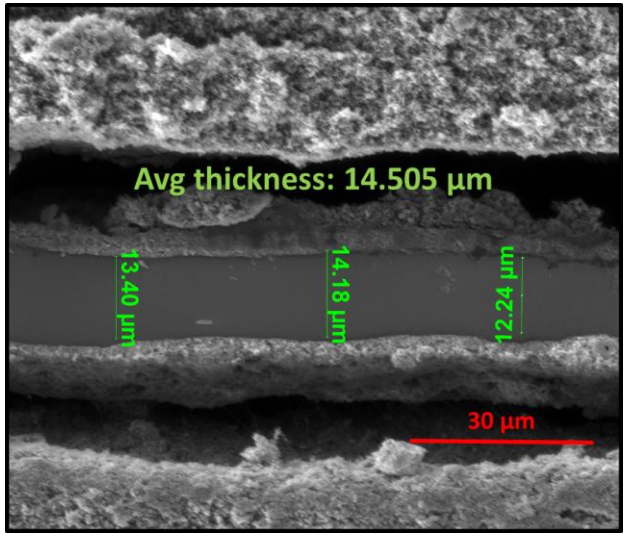


MEA-25



Length of Test: 96 hours
Thickness based on FERs: 23.18 µm
Rate of Thickness Lost 0.019 µm/h

MEA-100



Length of Test: 84 hours
Thickness based on FERs: 14.23 µm
Rate of Thickness Lost 0.13 µm/h

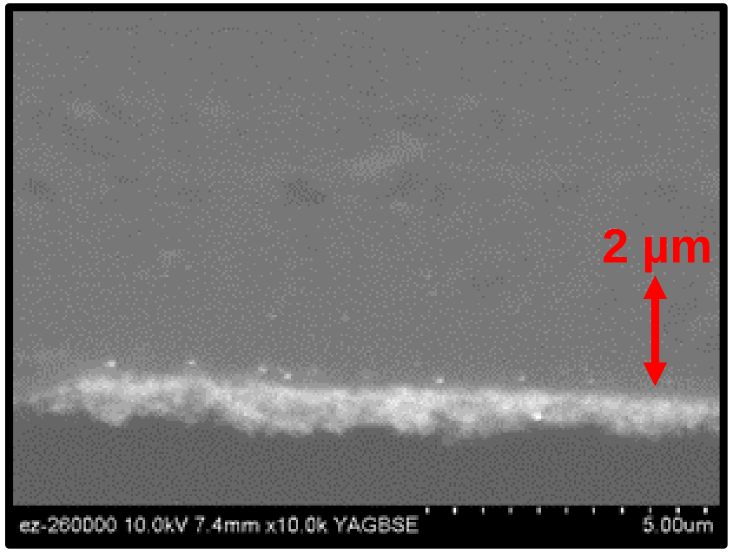
- AST caused membrane thinning in both MEAs
- MEA-25 retained more membrane thickness, but it was tested for an additional 12 hours
- MEA-100 membrane decreased by 42% (avg thickness: 14.5 µm)
- SEM images are in agreement with FERs and H_2 Xover

Pt Particle Characterization

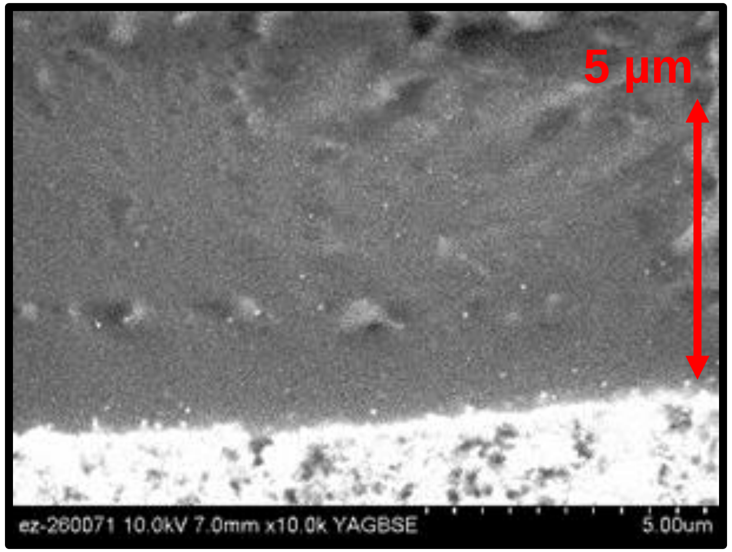
Sample	Crystallite Size (nm)
50% Pt/C Catalyst	1.53
MEA-25	1.92
MEA-100	2.14

Crystallite Size measured via XRD

MEA-25



MEA-100



- Pt particle growth after AST
- Catalyst migration more significant with MEA-100 due to higher OCV
  - Pt stability partly depends on voltage
- Pt particles in membrane are sites for radical formation
- **Higher Pt loading and higher OCVs leads to more Pt in the membrane resulting in more degradation**

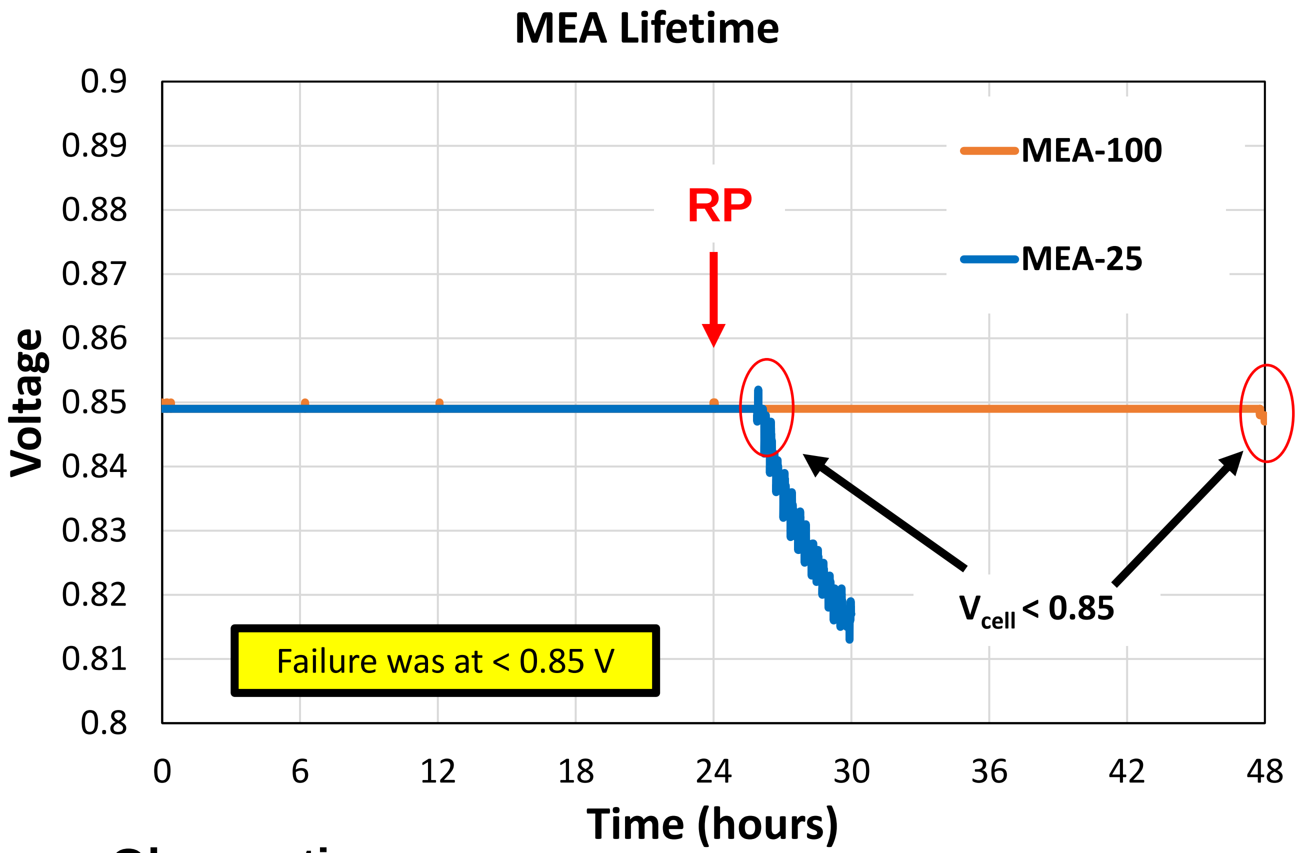
Addressing the differences in OCV!!!

AST Modified: Fixed Voltage at 0.85V

- **MEA Chemical Stability Accelerated Stress Test (AST)**
  - Eliminate the impact of OCV variations
  - **Applied Voltage (AV) hold at 0.85 V**
  - 90°C, 30% RH
  - Back pressure: 150 kPa
  - UHP H_2/ Oiless Air: 10 stoic at 0.2 A/cm^2
- Diagnostics taken in 6-hour increments
  - H_2 Crossover
  - Ion analysis in effluent water
- **Recovery Protocol (RP)**
  - 0.4 V (1 hr) at 30°C, Saturated RH (H_2/Air)
  - 2 A (30 min) at 35°C, Saturated RH (H_2/N_2)
  - Run every 24 hours

MEAs Tested

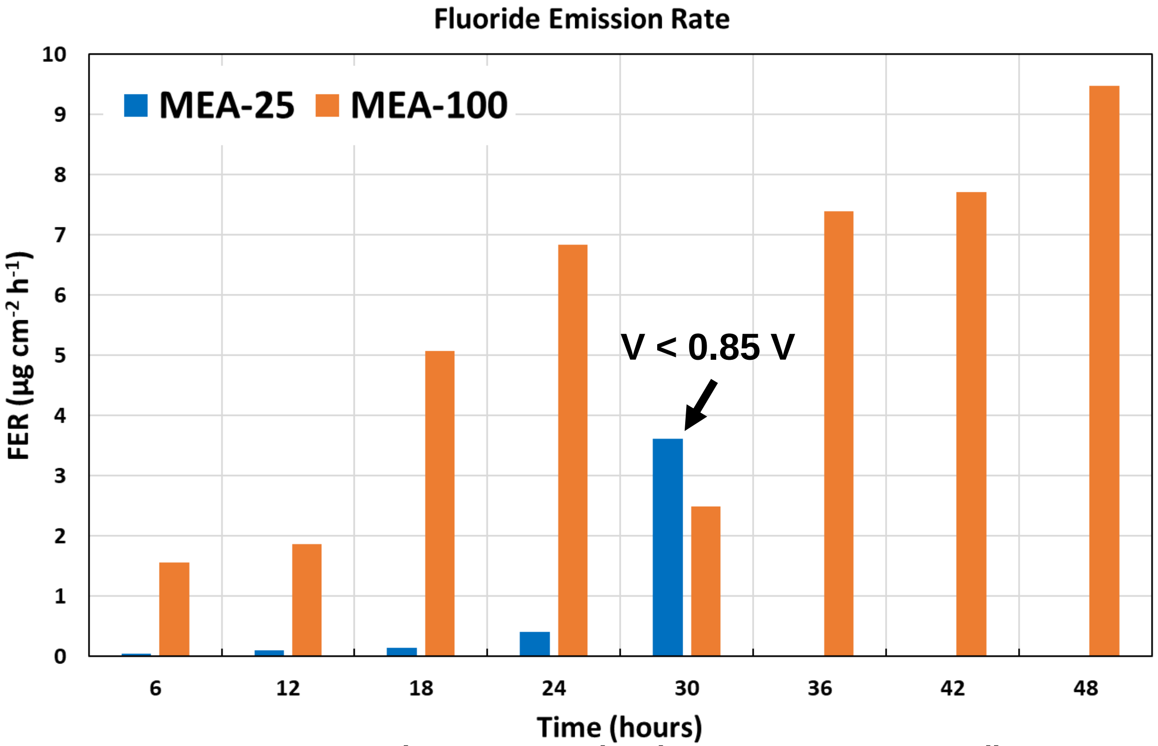
- **MEA 25**: 0.025 mg/cm^2 each electrode
- **MEA 100**: 0.1 mg/cm^2 each electrode

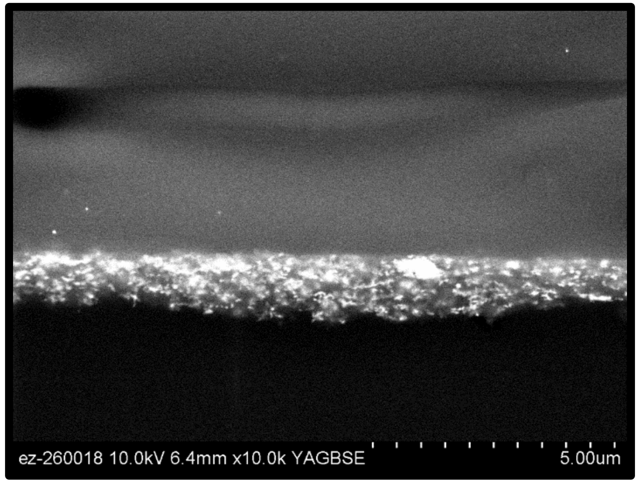


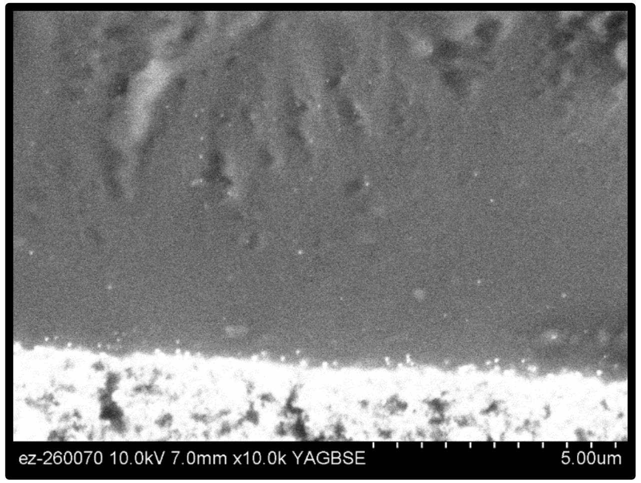
Observations

MEA-25 maintained 0.85 V for shorter time due to such low Pt loading

Membrane Characterization Post-Modified AST







- SEM was applied to examine particles in membrane
- Pt dissolution is greater with MEA-100 due to extended time and 4x the loading

- MEA-25 FER increased when V < 0.85V (began operating at OCV)
- MEA-100 has higher FERs throughout experiment
- Thickness based on FERs
  - MEA-25: 24.8 µm
  - MEA-100: 22.8 µm (23.3 µm through 30 hours)

Dionex Ion Chromatography System 2100
Standards: 1, 5, 10, 25, and 50 ppm
FER: $\frac{ppm * amount\ collected}{time * active\ area}$

Summary

- ***Investigation of Membrane Chemical Degradation as a Function of Catalyst Platinum Loading,*** ECS Trans. (2019). https://doi.org/10.1149/09208.0467ecst.
  - Increasing Pt loading increase membrane degradation
  - Higher OCVs leads to more Pt in membrane

- ***Probing Membrane Degradation with Varying Catalyst Layer Thickness and Carbon Support,*** ECS Trans. 98 (2020). https://doi.org/10.1149/09809.0407ecst.
  - Increasing catalyst layer thickness protects bulk membrane
  - Carbon support type and morphology impacts peroxide formation

- **Studying the Impact of Ce on Membrane Degradation with Bi-membranes**
  - Pt in the membrane accelerates membrane degradation
  - Ce reduces radical formation and extends membrane lifetime
  - *To be published*

Acknowledgements

Dr. Fernando Garzon
Dr. Abhaya Datye
Dr. Lok-kun Tsui

Group Members

Dr. Rangachary Mukundan (HFTO)
Mr. Tommy Rockward
Stefan Williams

LANL Colleagues

Stefan Williams: LANL Timeline

Expected Graduation Date: May ‘21

B.S. Physics	CMaES Internship	Infantry Basic Officer Leadership Course	Post Bachelors	M.S. Chem. Eng.	AAPP Graduate Research Assistant
Morehouse College	LANL	Ft. Benning, GA	LANL	University of Tennessee, Knoxville	LANL
May 2015	*Summer 2015*	*Aug-Dec 2015*	*Feb 2016-Aug 2017*	*Aug 2017-May 2019*	*June 2019-Present*

Consortium for Materials and Energy Security (CMaES)


Journal of Materials Chemistry A

ROYAL SOCIETY OF CHEMISTRY

PAPER

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Cite this: J. Mater. Chem. A, 2017, 5, 15073

Zr-doped ceria additives for enhanced PEM fuel cell durability and radical scavenger stability†

Andrew M. Baker,[ab] Stefan T. D. Williams,[a] Rangachary Mukundan,[a] Dusan Spernjak,[a] Suresh G. Advani,[b] Ajay K. Prasad[b] and Rod L. Borup[*a]

African American Partnership Program

Providing graduate internships, creating a diverse pipeline of STEM expertise

TICKLE COLLEGE OF ENGINEERING
THE UNIVERSITY OF TENNESSEE, KNOXVILLE

Generations of Continued Mentorship

Stefan T. D. Williams

Advisor: Dr. Thomas A. Zawodzinski

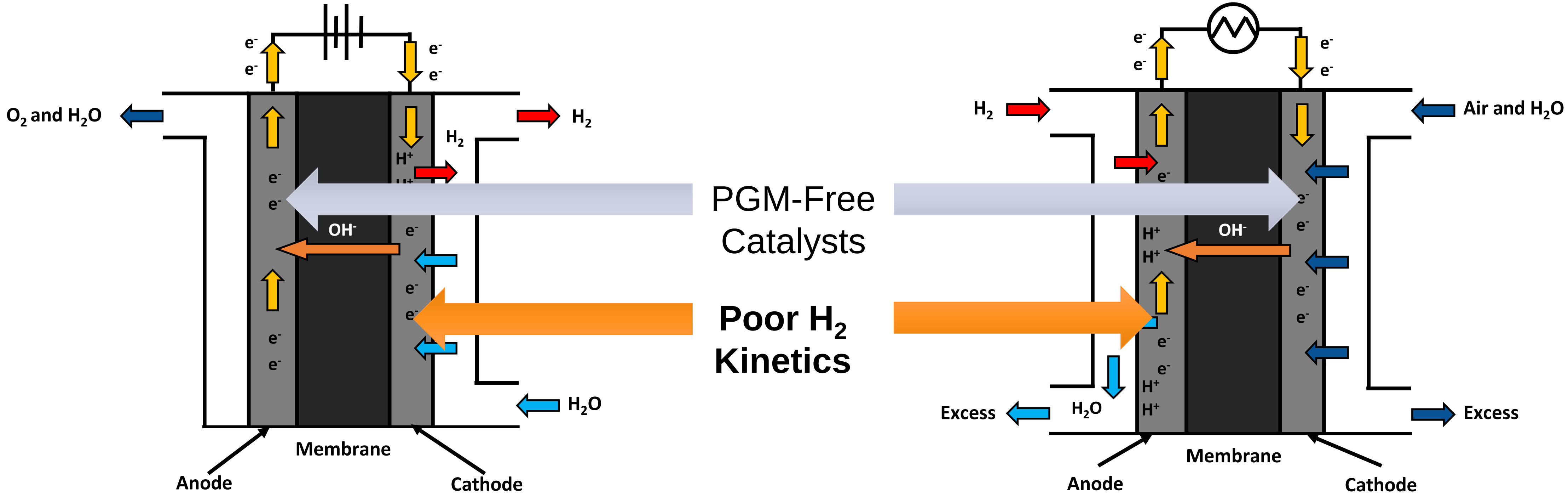
Ph.D. Candidate at The University of Tennessee, Knoxville
Graduate Research Assistant at Los Alamos National Laboratory

The Controlled Synthesis of Hydrogen Electrocatalysts for Alkaline Exchange Membrane Fuel Cell and Electrolysis Applications via Chemical Vapor Deposition

Alkaline Fuel Cell/ Electrolyzer: Issues

Fuel Cell: converts chemical energy into electrical energy via a galvanic process

Electrolyzer: converts water in to H_2 and O_2 gas via an electrolytic process



Electrolyzer Reactions

Anode: $2OH^- \longrightarrow \frac{1}{2}O_2 + H_2O + 2e^-$

Cathode: $2H_2O + 2e^- \longrightarrow H_2 + 2OH^-$

Overall Reaction: $H_2O \longrightarrow H_2 + \frac{1}{2}O_2$

Fuel Cell Reactions

Anode: $H_2 + 2OH^- \longrightarrow 2H_2O + 2e^-$

Cathode: $\frac{1}{2}O_2 + H_2O + 2e^- \longrightarrow 2OH^-$

Overall Reaction: $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

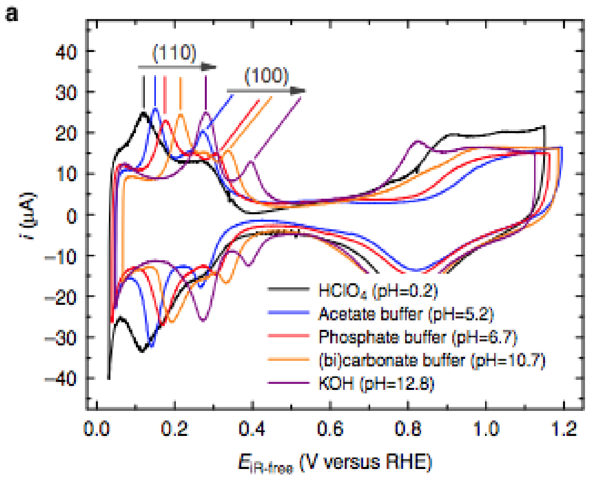
Theories Pertaining to Sluggish Kinetics of HOR/HER in Alkaline Environments

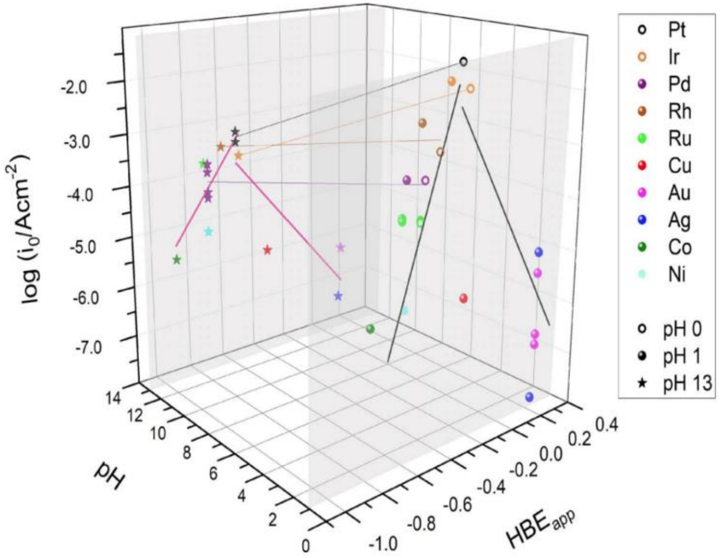
Hydrogen Binding Energy

*"The HBE is the sole descriptor for the HOR/HER activities on single metallic Pt" –**Sheng** et. al.*

HBE is measured through…

$$\Delta G_{HBE} = -E_{peak} * F$$





Bifunctional Mechanism

*"…results strongly suggest that oxophilic metal hydr(oxy)oxides lower the energy barrier of the Volmer step via the bifunctional mechanism." –**Li** et. al.*

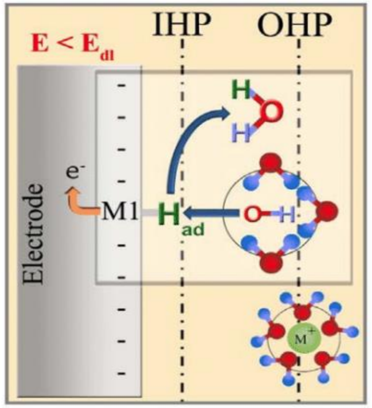
Volmer Step:

$$H -* + OH^- \leftrightarrow * + H_2O + e^-$$

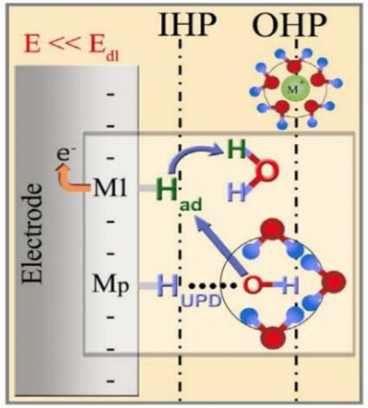
Bifunctional Catalyst promote

H^+ Desorption & Water Dissociation

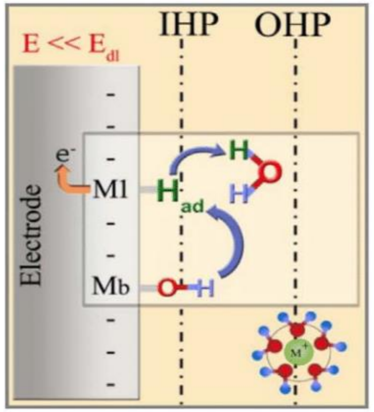
Scheme 1: Monometallic System



Scheme 2: Bimetallic System I



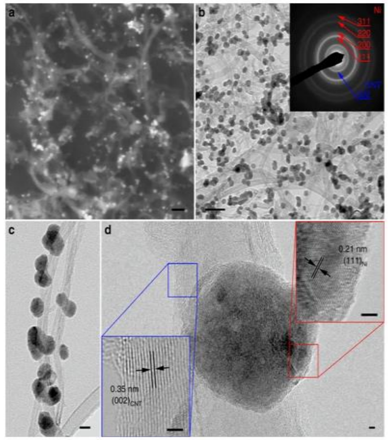
Scheme 3: Bimetallic System II



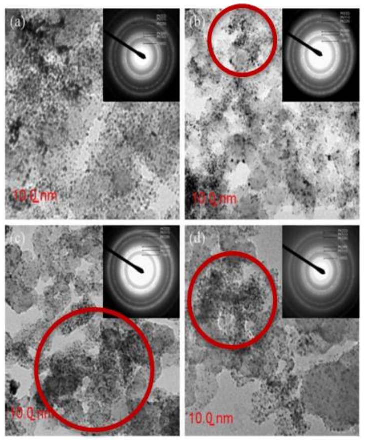
Zheng J. et. al. J Electrochem Soc 2018, 165 :H27–H29
Li, J,et. al. Chem. Int. Ed. 2017, 26, 15594-15558

Typical Catalyst Synthesis Methods

Solution-Based Methods



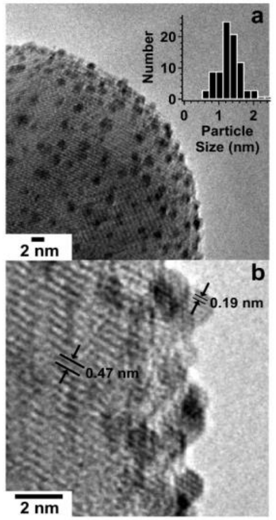
Micrographs of Ni/N-CNT[1]



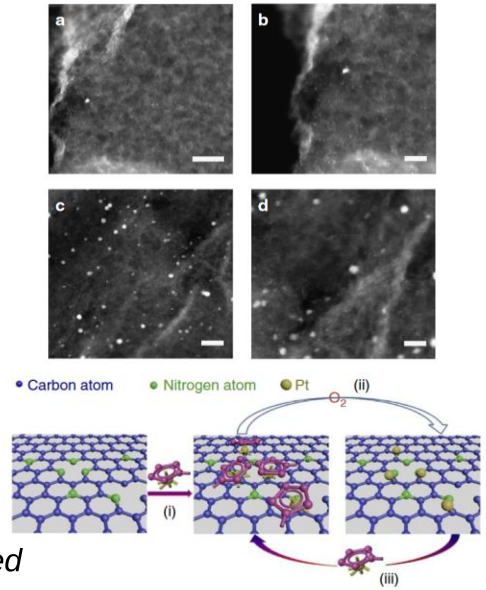
Micrographs of Pt/XC-72[2]

- Inexpensive precursors
- Moderate control of size and shape
- Moderate recovery of materials
- Low control on distribution
- Post-synthesis treatments required

Atomic Layer Deposition



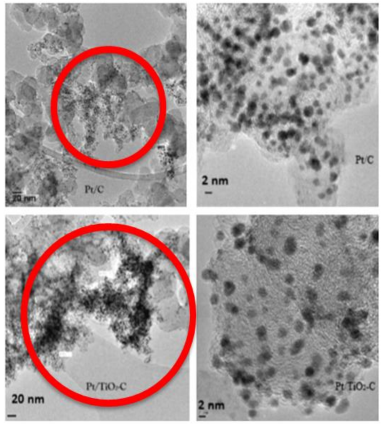
Ru-Pt bimetallic nanoparticles supported on alumina spheres[3]



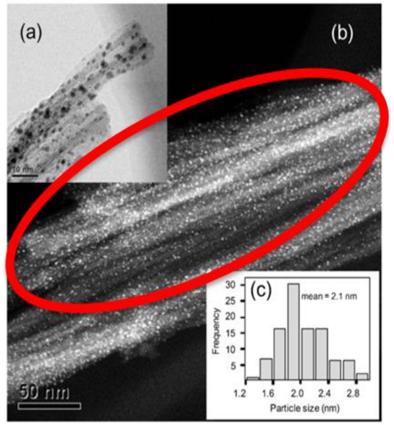
Single-atom and cluster Deposition of Pt on nitrogen rich graphene[4]

- Increased distribution of particles
- Recovery of materials
- High control of size and shape
- High cost reactor and materials

Chemical Vapor Deposition



Micrographs of 10% Pt/XC-72 and 5%TiO2-C nanoparticles[5]



Pt decorated on TiNT[6]

- Small particle size
- Expensive reactors and precursors
- Low control on shape
- Low recovery of precursor materials

[1]Zhuang, Z., et. al. *Nat Commun* 7, 10141 (2016)
[2]Huang, R., et. al. J. Power Sources, 2012, 205, 93-99
[3]*Christensen, S. et. al., Nano Lett.* 2010, 10, 8, 3047-3051
2010, 495, 458-461

Poor Man's Chemical Vapor Deposition (PMCVD)

Advantages of PMCVD

Reactions takes place in a **controlled environment**

No **post-synthesis treatment** necessary

Low reactor cost

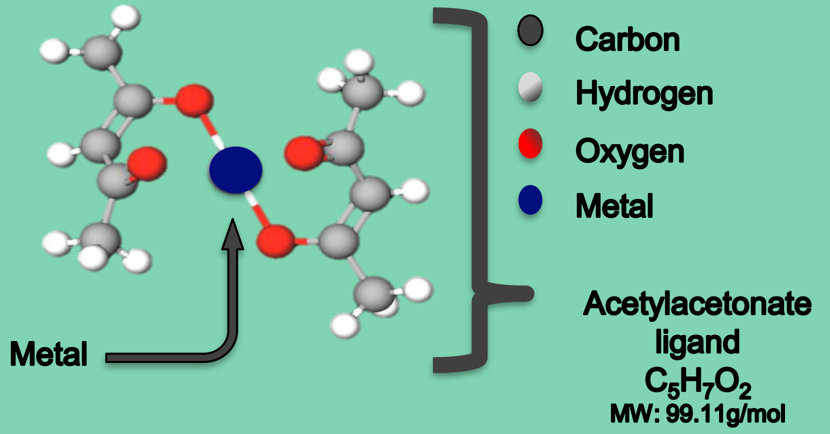
Full recovery of precursor metals

- ✓ Pt
- ✓ Ru
- ✓ Ni
- ✓ Cu
- ✓ Co
- ✓ Fe

$(acac)_n$

- ✓ Ni
- ✓ Cu

$(HFac)_n$



Typical Precursor

PMCVD Rate Laws and Deposition Mechanism

- Precursor loading where caried to probe the PMCVD deposition mechanism
- XPS elucidated the deposited Pt nanoparticles are fully reduced in a single step process.
- Particle size varies linearly with increase in Pt precursor.
- Rate laws and deposition mechanism align with materials characterization

Reaction Rates

$$Pt + * \leftrightarrow Pt - *$$

*Where * denotes a nucleation site*

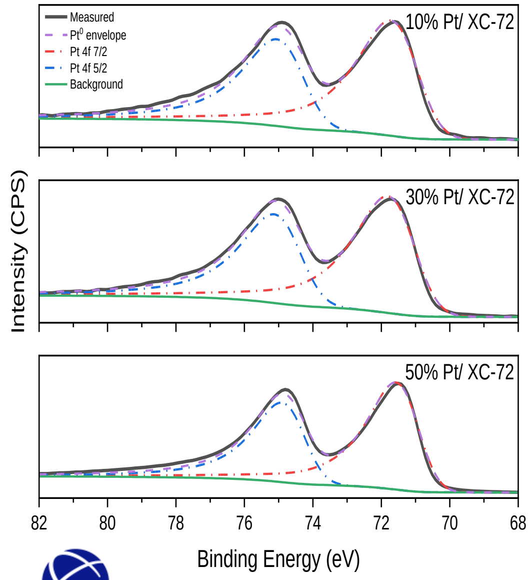
$$Rate_{Neucleation_1} = k_1^o [Pt][S_M]$$

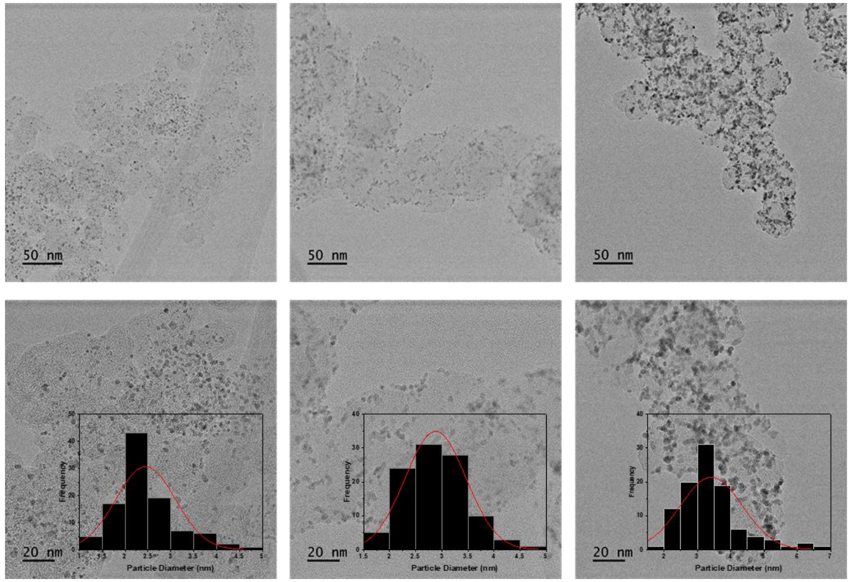
Where S_M denotes available nucleation sites for Pt

Growth: Once sites (S_M) are filled, the deposition process continues until [Pt]=0.

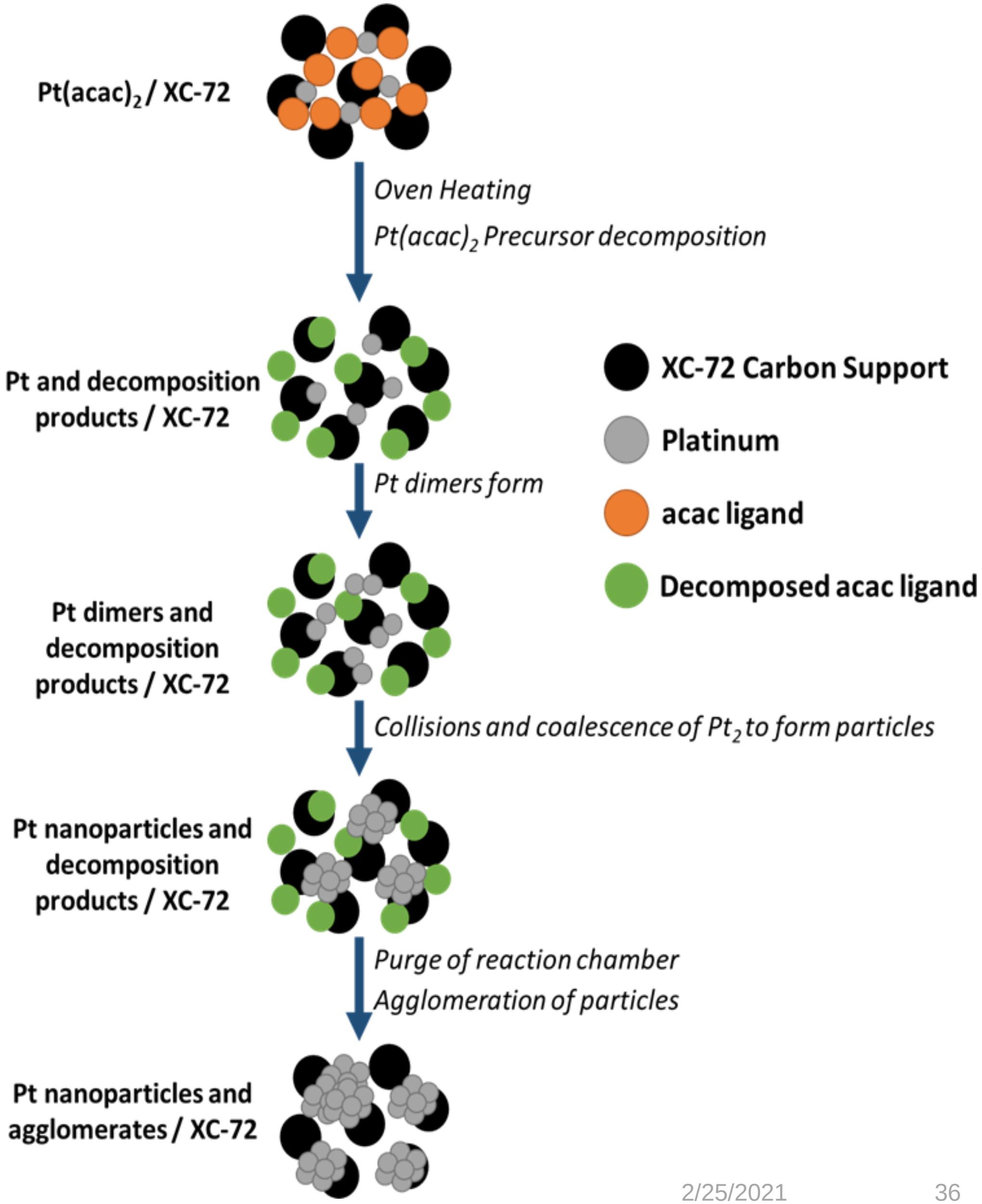
$$Rate_{Growth_2} = k_2^o [Pt]$$

Where $k_1^o \ll k_2^o$



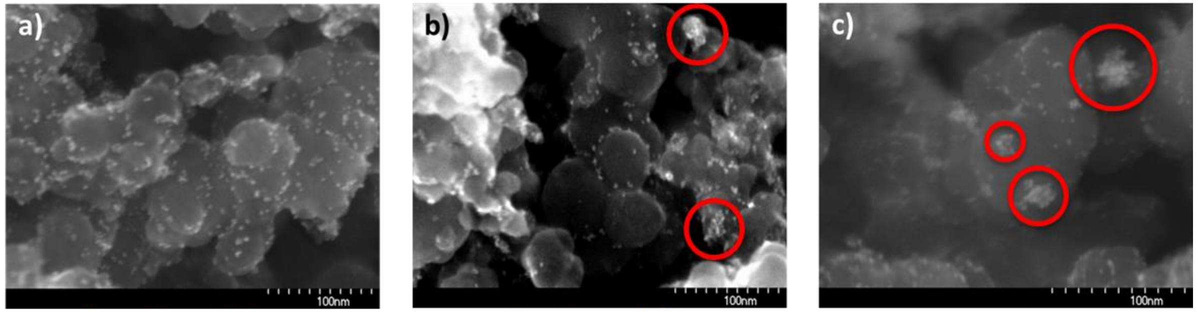


10% Pt/ XC-72 30% Pt/ XC-72 50% Pt/ XC-72

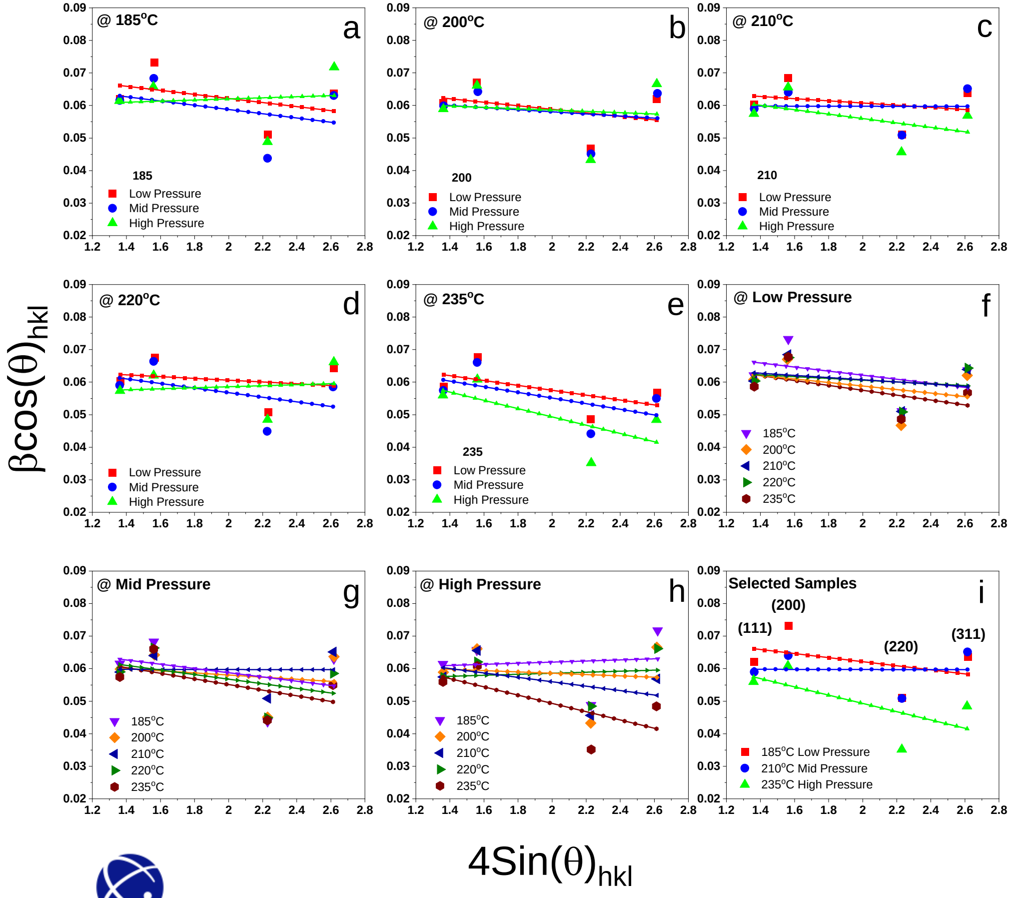


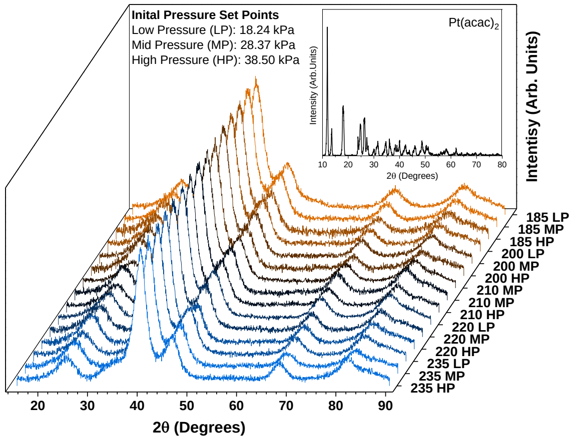
Parametric Study on PMCVD Synthesized Pt/C Catalysts

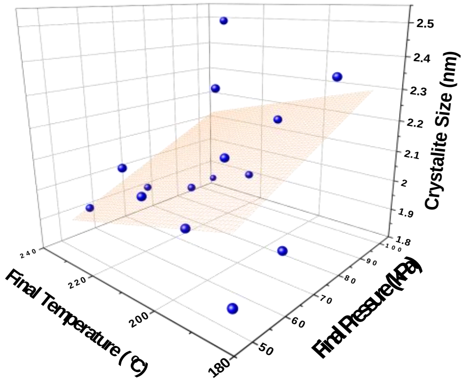
- Pressure and Temperature were varied to optimize the PMCVD process for Pt based electrocatalyts
- XRD analysis shows variations in microstrain owing to an increase in catalytic performance
- Microstrain is now a descriptor for activity in alkaline media

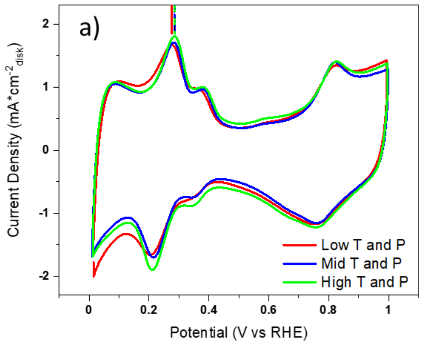


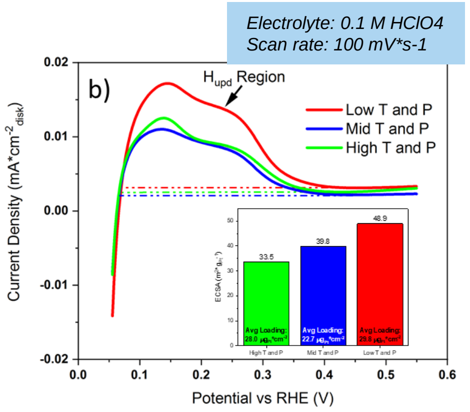
Low T and P　　Mid T and P　　High T and P

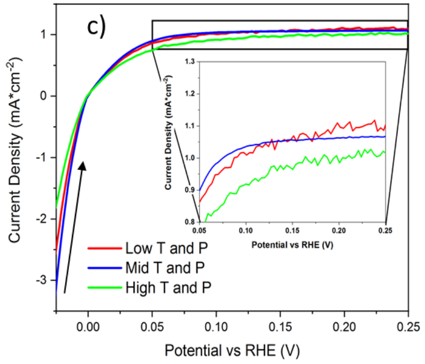


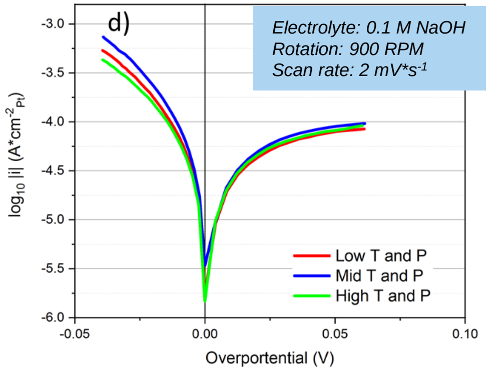








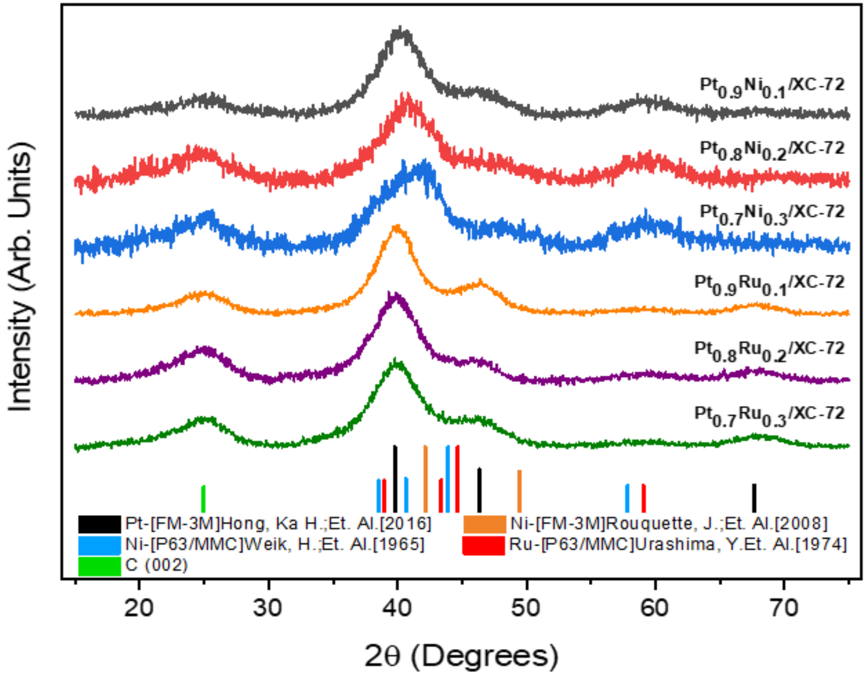


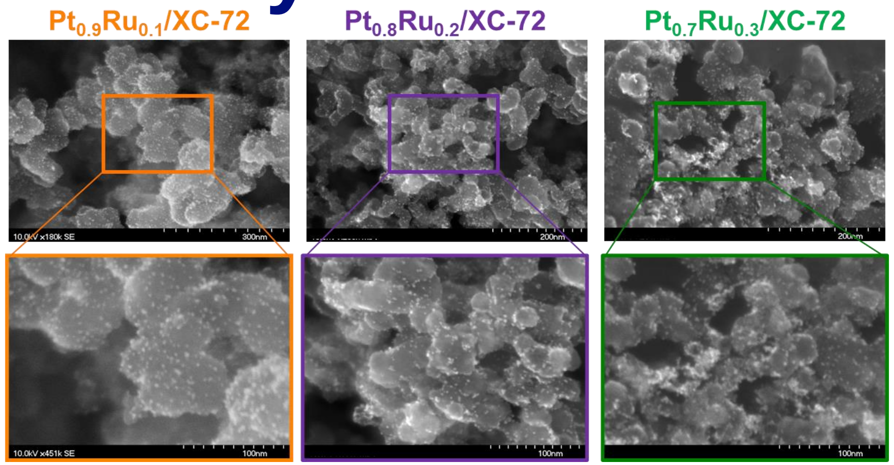


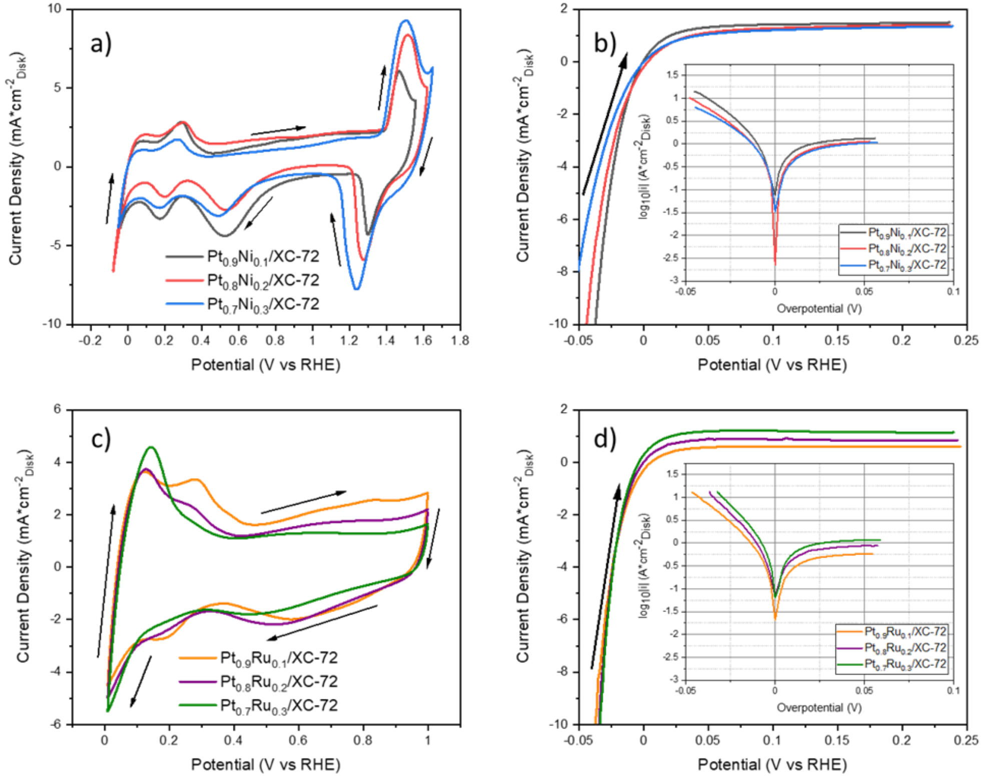
Pt_xNi_y/C and Pt_xRu_y/C Bimetallic Electrocatalyts

- Bimetallic Catalysts were prepared using CVD
- Nanoparticles are uniformly dispersed (Diameters: 2-4nm)

- Facile alloying is achieved with like space group metals (Pt and Ni)
- Minimal alloying occurs in mixed space group metals
- (Pt and Ru)
- Pefromace increases with the addition of oxyphilic metals per the bifunctional mechanism



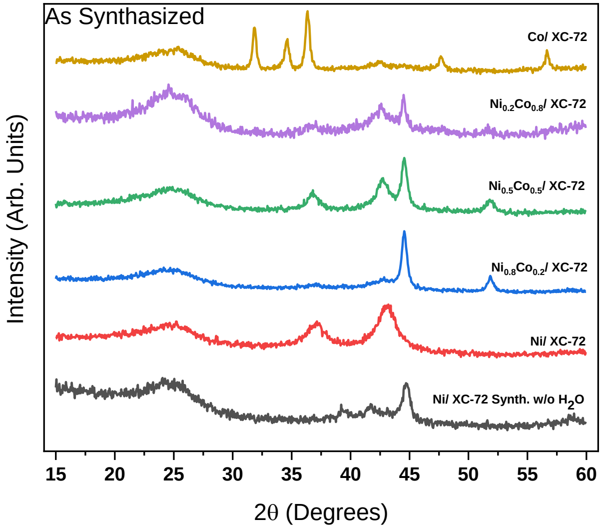




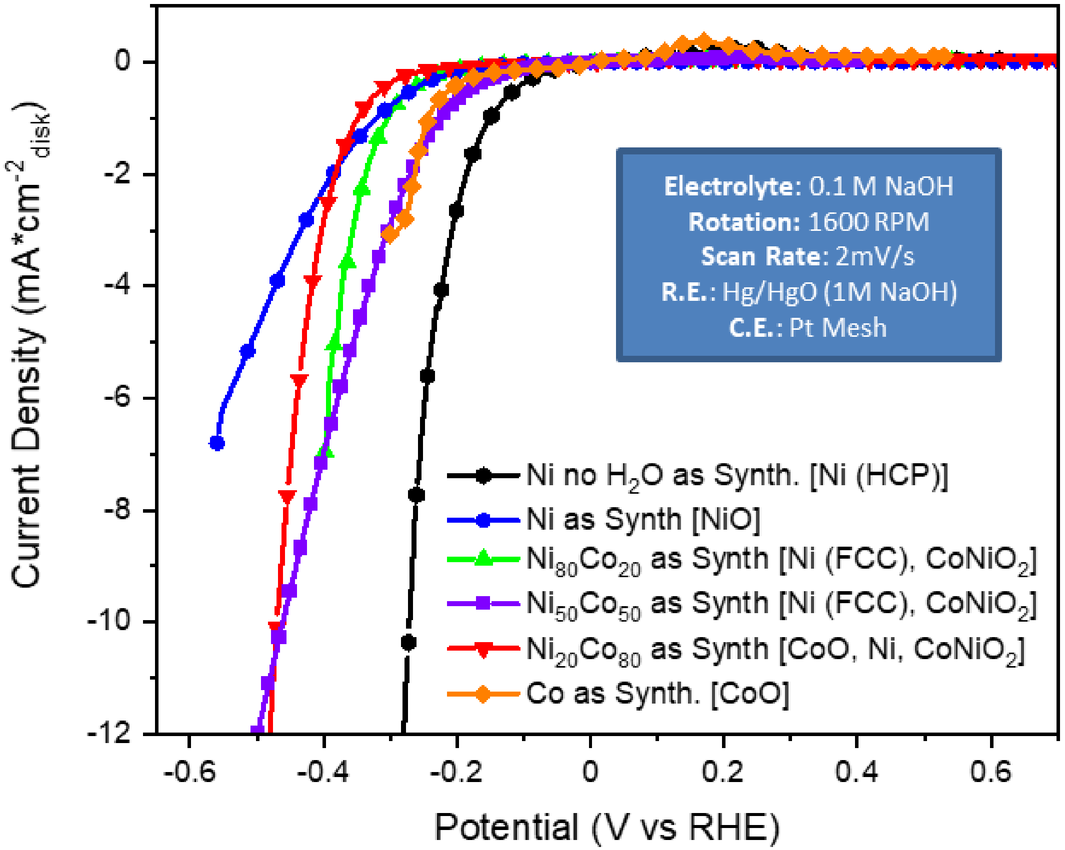
Sample	Pt (111) 2q	a	Vegard's Law	XRF		
			x	Wt.% Pt	Wt.% Ni	Wt.% Ru
$Pt_{0.9}Ni_{0.1}$/XC-72	40.204	3.88	0.083	87.66	12.34	--
$Pt_{0.8}Ni_{0.2}$/XC-72	40.771	3.83	0.211	75.02	24.98	--
$Pt_{0.7}Ni_{0.3}$/XC-72	41.050	3.81	0.263	62.82	37.18	--
$Pt_{0.9}Ru_{0.1}$/XC-72	39.901	3.911	0.057	88.60	--	11.40
$Pt_{0.8}Ru_{0.2}$/XC-72	39.853	3.916	0.016	76.97	--	23.03
$Pt_{0.7}Ru_{0.3}$/XC-72	39.887	3.913	0.040	69.63	--	30.37

PGM-Free H_2 Catalysts

- Ni, NixCoy, and Co catalysts were produced using PMCVD
- PMCVD provides a facile way to synthesis HCP Ni nanoparticles
- HCP Ni shows the highest activity for HER at minimal overpotentials



Sample	Phase(s)
Ni/ XC-72 Synth. No H_2O	Ni (HCP)
Ni/ XC-72	NiO
$Ni_{0.8}Co_{0.2}$/ XC-72	Ni, $CoNiO_2$
$Ni_{0.5}Co_{0.5}$/ XC-72	Ni, $CoNiO_2$
$Ni_{0.2}Co_{0.8}$/ XC-72	CoO, Ni, $CoNiO_2$
Co/ XC-72	CoO



Catalysts	Loading ($mg*cm^{-2}$)	Overpotentials: Current Density ($mA*cm^{-2}$)	Overpotentials: η (mV)	Mass Activity @ -0.25V ($mA*mg^{-1}$)
Ni no H_2O	0.072	1	150	-86.58
		10	272	
Ni	0.15	1	321	-2.55
		10	-	
$Ni_{80}Co_{20}$	0.061	1	305	-5.46
		10	-	
$Ni_{50}Co_{50}$	0.103	1	224	-14.54
		10	461	
$Ni_{20}Co_{80}$	0.11	1	350	-1.37
		10	470	
Co	0.15	1	243	-8.21
		10	-	

- HER Activity (based on mass activities and overpotentials):
  - Ni no H_2O>> $Ni_{50}Co_{50}$> Co>$Ni_{80}Co_{20}$>$Ni_{20}Co_{80}$>Ni
- The PGM-Free electrocatalysts exhibited poor HOR performance.
- HCP Ni crystal structure favors H_2O adsorption more than FCC Ni
  - Increasing the rate of water dissociation*

Summary

- **Williams, S. T. D**; Kilpatric, L.; Elgamall, R. A.; Benivedez, A.; Zawodzinski, T. A.; "On the Deposition Mechanism and Material Characterization of Modified Chemical Vapor Deposition Synthesized Materials.“

- **Williams, S. T. D**; Ard, B.; Rockward, T. Q.; Martinez, U.; Zawodzinski, T. A.; "A Parametric Study of Chemical Vapor Deposition Synthesized Hydrogen Electrocatalysts for Alkaline Media Devices."

- **Williams, S. T. D**; Elgamall, R. A.; Goenaga, G. A.; Rockward, T. Q.; Zawodzinski, T. A. "Synthesis and Characterization of Bimetallic Platinum-Ruthenium and Platinum-Nickel Electrocatalysts for Hydrogen Reactions in Alkaline Media.“

- **Williams, S. T. D**; Rockward, T. Q.; Martinez, U.; Zawodzinski, T. A. "Synthesis and Characterization of Chemical Vapor Synthesized Precious Group Metal-Free Electrocatalyst For Hydrogen Reaction in Alkaline Media."

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Mr. Lucas Kilpatrick

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Mr. Tommy Rockward
Dr. Ulises Martinez
Mr. André Spears

Los Alamos National Laboratory
African American Partnership Program

David Alexander IV

Advisor: Dr. Calvin Stewart

Mentors: Dr. Rod Borup (HFTO) Mr. Tommy Rockward

Ph.D. Student at The University of Texas, El Paso

Graduate Research Assistant at Los Alamos National Laboratory

David Alexander: LANL Timeline

CMaES
Tuskegee University
Spring 2017

Los Alamos Dynamics Summer School
Summer 2017

LANL
Bridge Program
Summer 2018

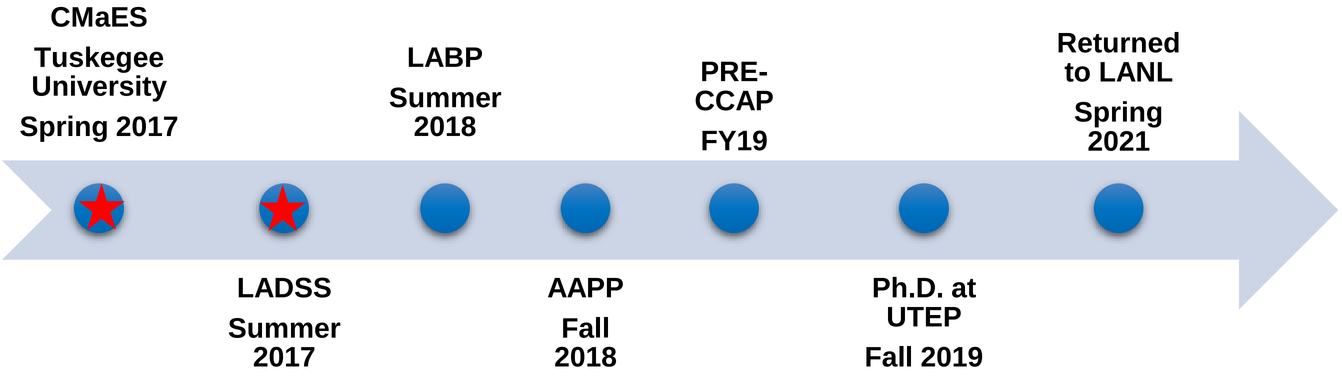
African American Partnership Program
Fall 2018

PRE-CCAP FY19

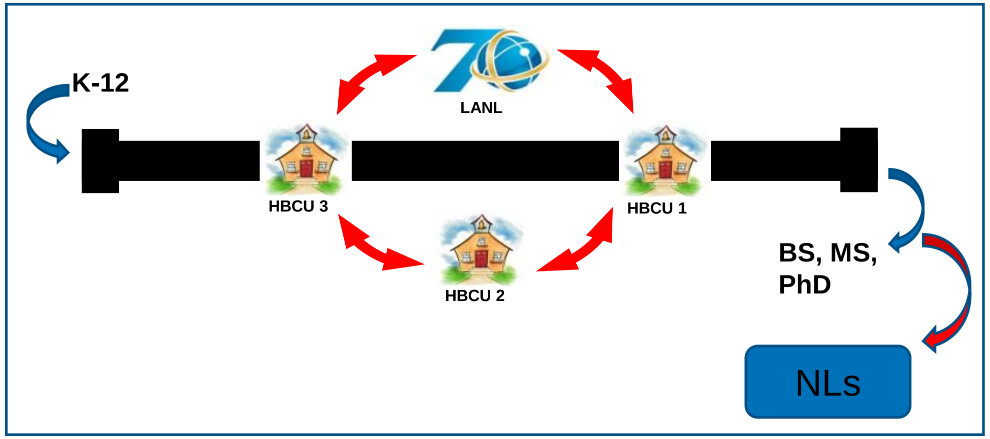
2nd year Doctoral Student
Spring 2021

I am here!

LANL Experiences…



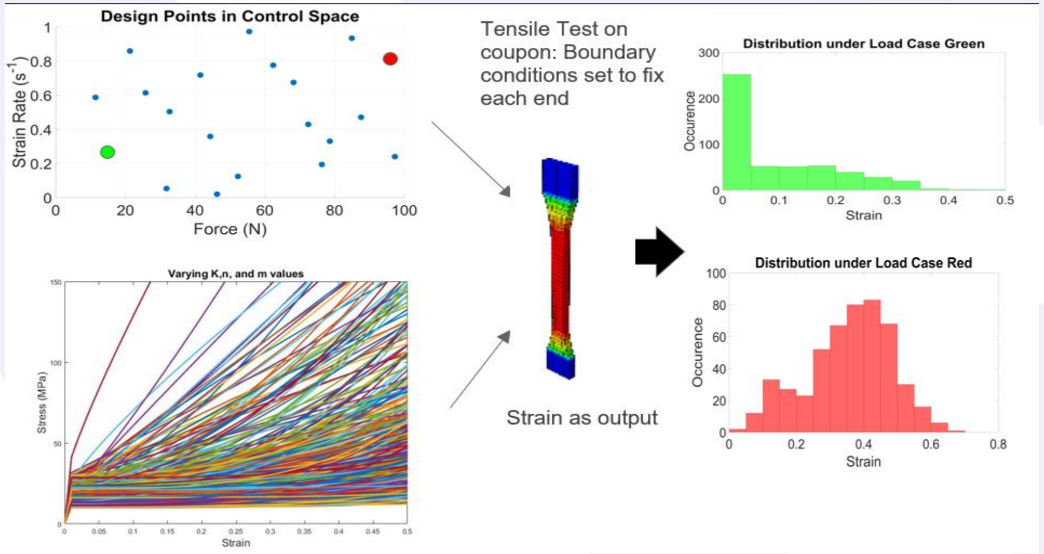
Consortium for Materials and Energy Security (CMaES)
NNSA MSIPP funding at Tuskegee



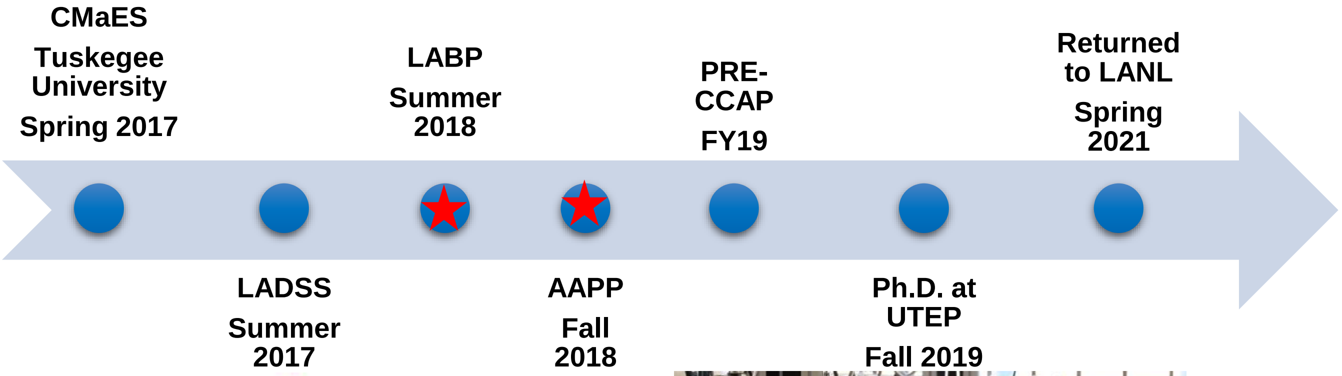
- Efforts to create STEM pipeline from K-12 to National Labs involving HBCUs
- Received COMSOL and LabVIEW software training at Tuskegee before attending LADSS

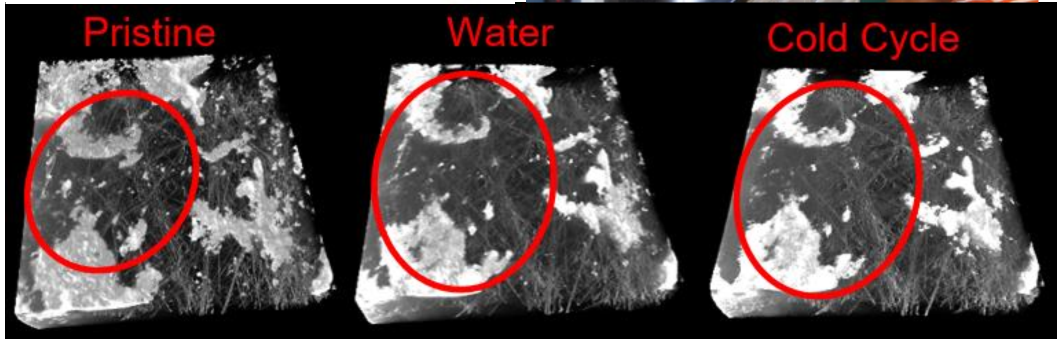
Los Alamos Dynamic Summer School (LADSS)

- 21 students selected nationwide
- Career/Technical development tutorials
- Multi-disciplinary team of 3 on single project



LANL Experiences…





- Multiple Projects: (i) Material properties in extreme conditions, (ii) mixed potential sensor development
- Hands-on experience as M. E. graduate
- Searched and applied for doctoral programs

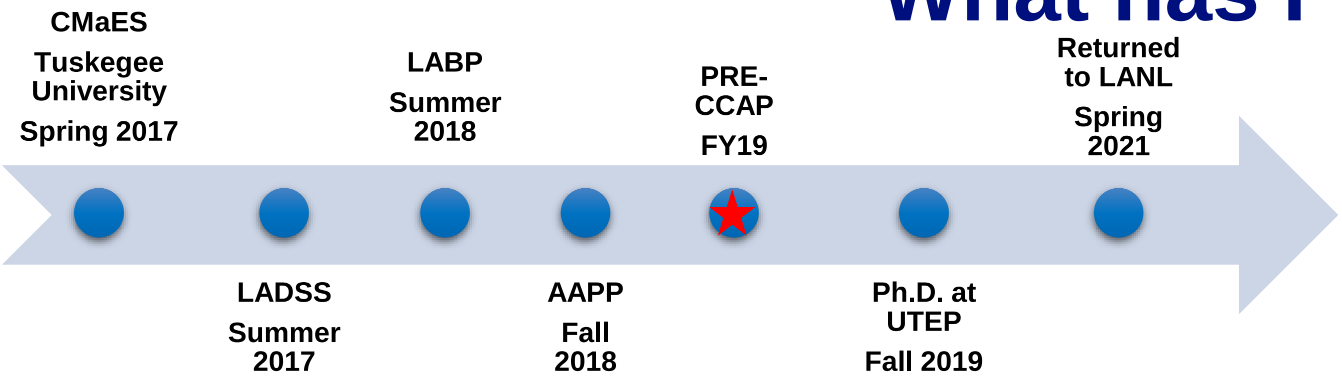
African American Partnership Program (AAPP)

African American Partnership Program

Providing graduate internships, creating a diverse pipeline of STEM expertise

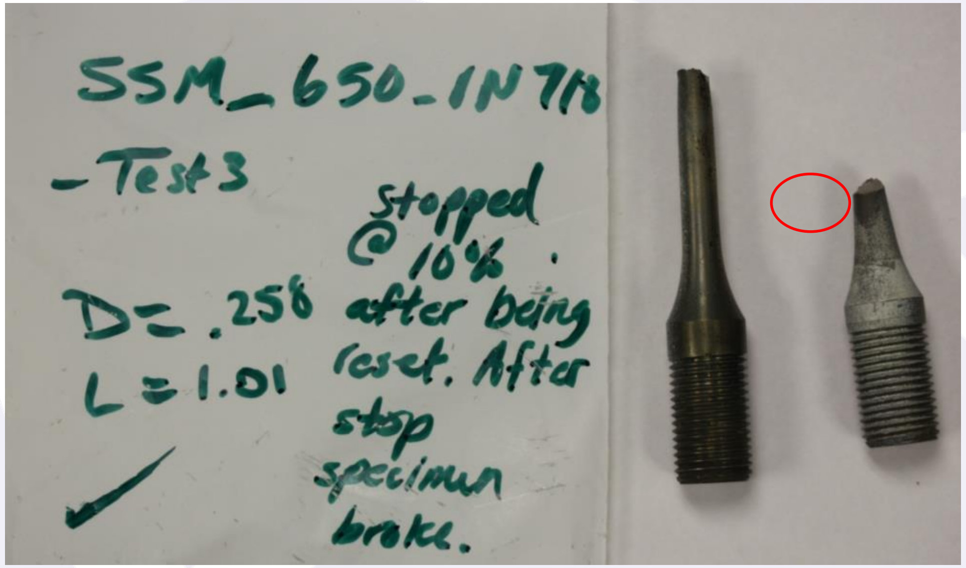
- Established in 2014
- AAPP focuses on long-term relationships between LANL, students, and universities, while assisting with the completion of graduate degrees
- **Long term goal**: Fund promising participants with organizational resources to ultimately hire deserving candidates

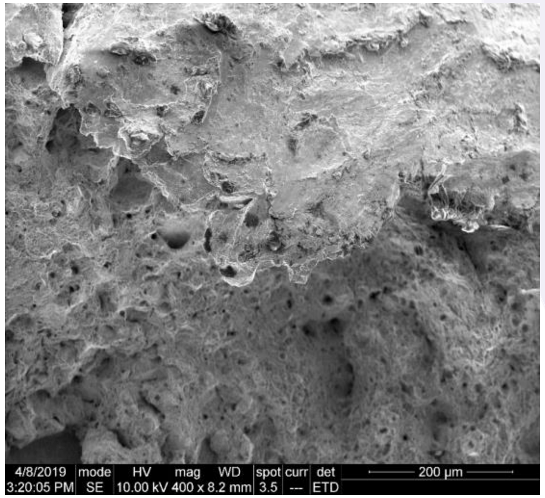
What has PRE-CCAP done for M.E.?

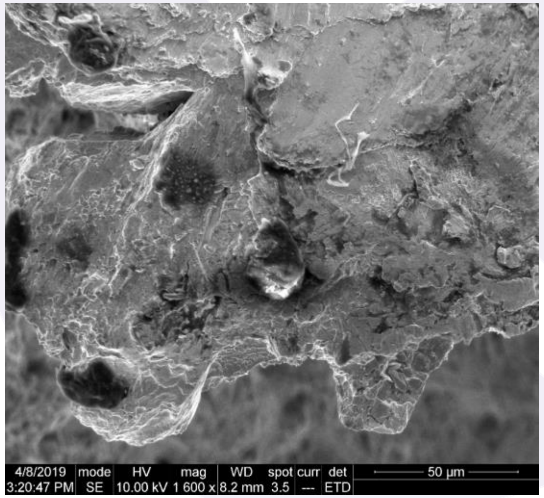


- NNSA MSIPP Scholar
- Accepted into M.E. Ph.D. Program at UTEP
- Early start on Ph.D. research
  - On-Going research on BPP via Additive manufacturing
  - FC Stach System Design
- Retuned to LANL

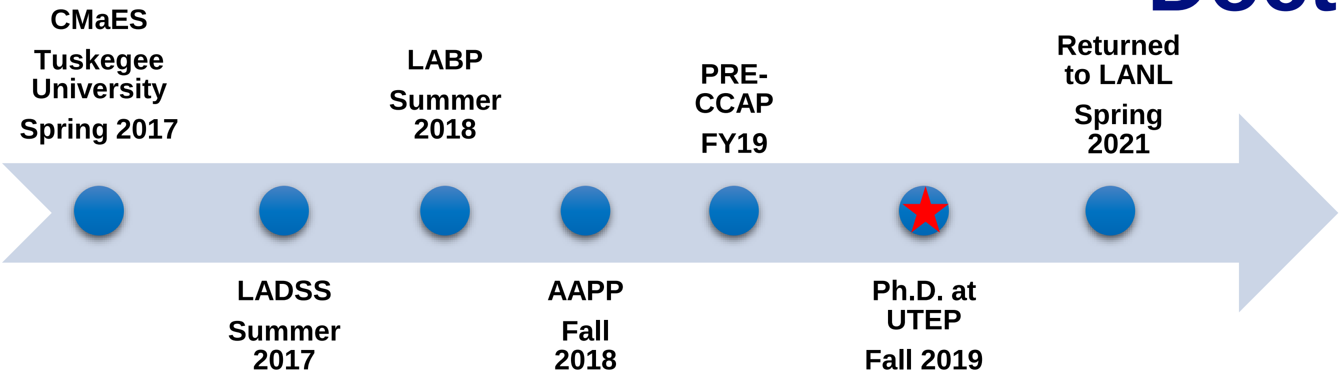
UTEP sample and SEM images of failure site







Doctoral Program at UTEP



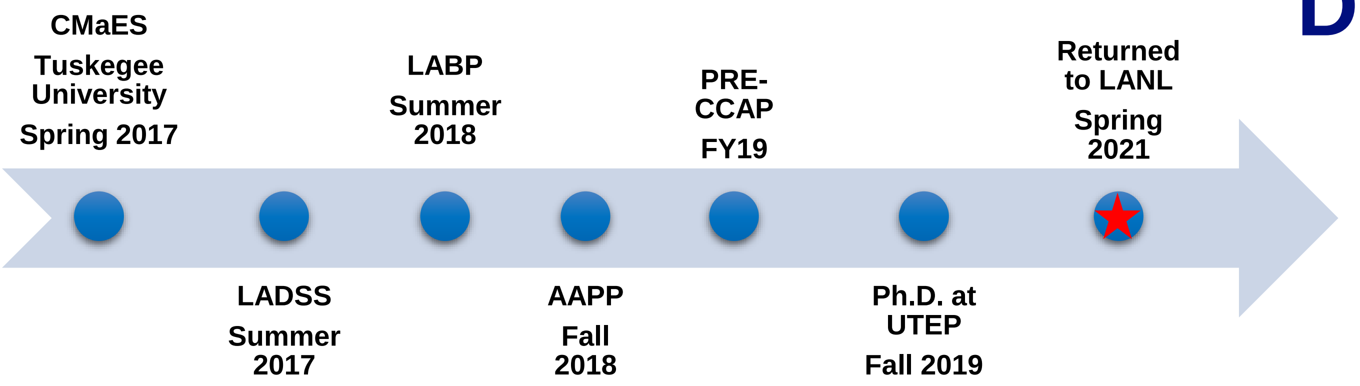
Completed 2nd year of Ph.D. Program

- Graduate certification in 3D engineering and additive manufacturing
- Professional Project manager Certification (Exam: June 2021)

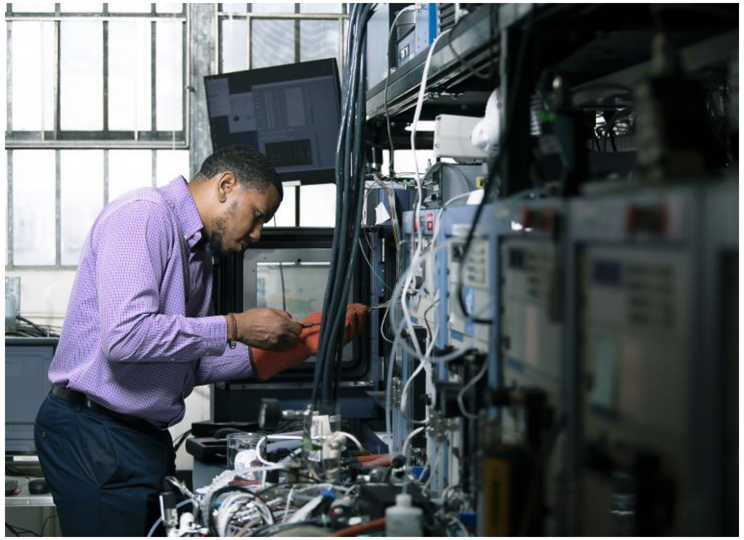
Material extrusion 3D printer for additive manufactured fuel cell hardware

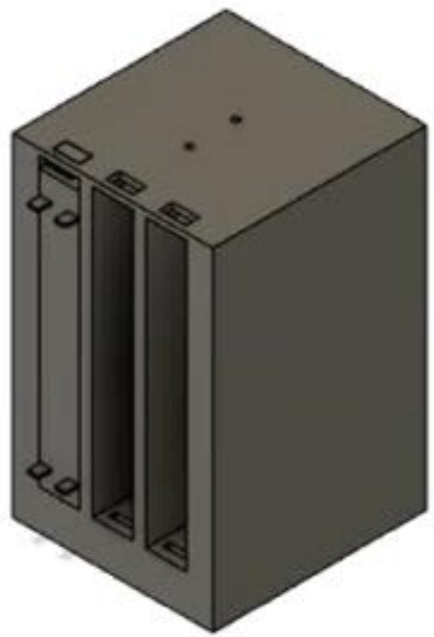
Additive manufactured fuel cell housing prototype fabricated at UTEP

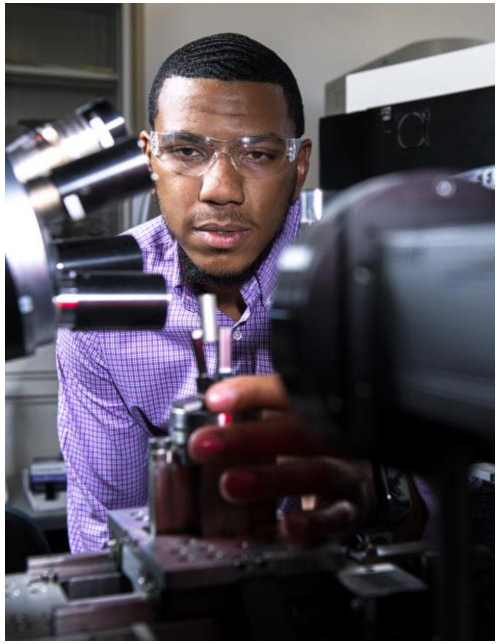
Doctoral Research at LANL

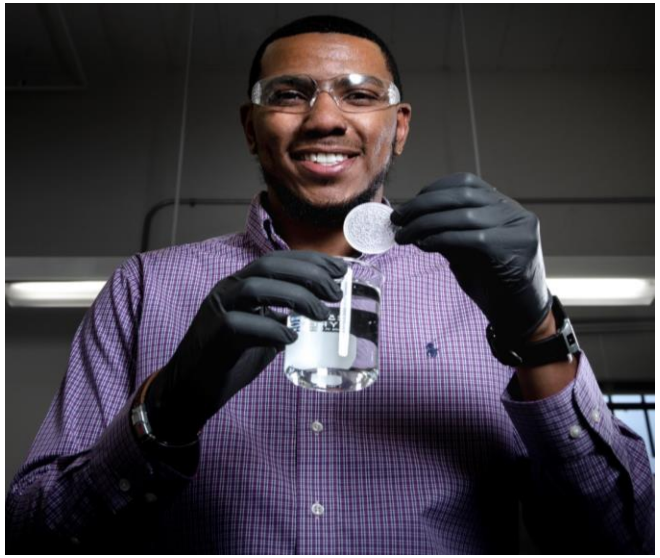


Project 1: Bipolar Plate Design	Project 2: Novel FC Stack Design
The aim is to design new bi-polar plates.	The aim is to design new fuel cell stack systems.









Thank You For Your Attention

U.S. DEPARTMENT OF ENERGY

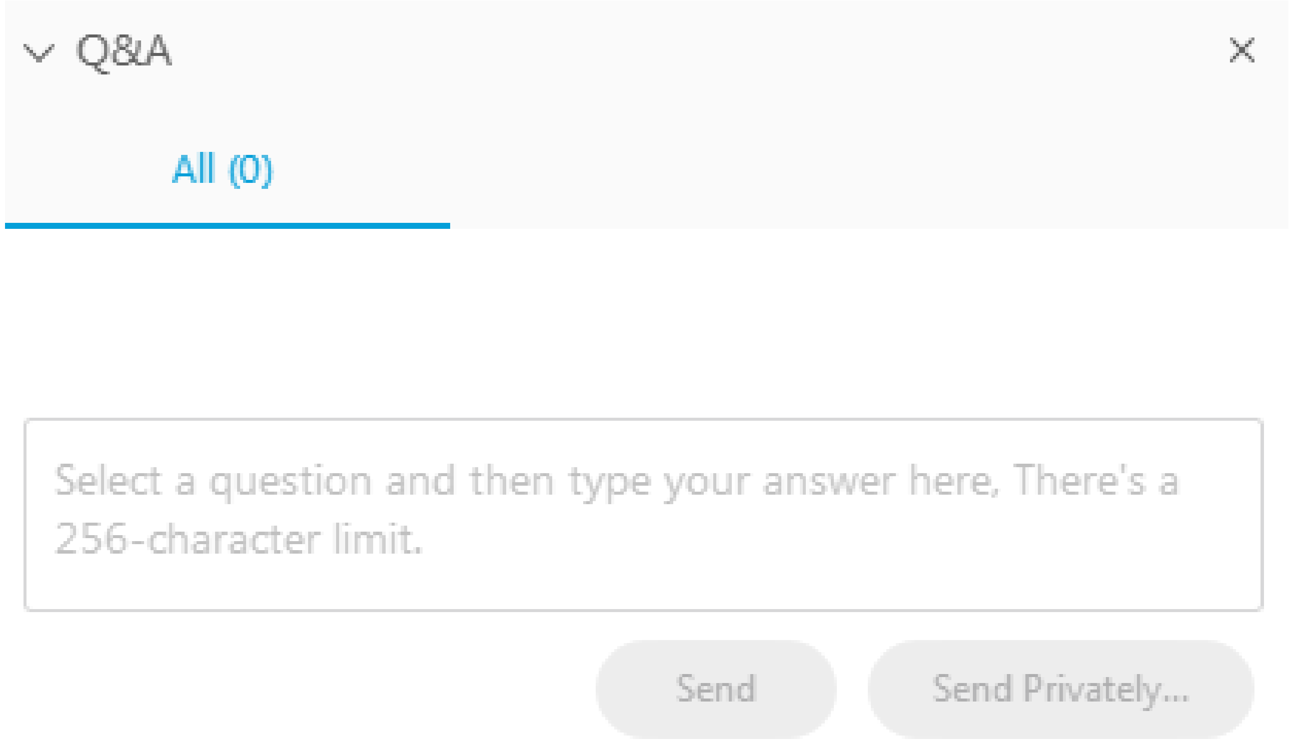
African American Partnership Program

Providing graduate internships, creating a diverse pipeline of STEM expertise

National Nuclear Security Administration

The #H2IQ Hour Q&A

Please type your questions into the **Q&A Box**



INCREASE YOUR H_2IQ

The #H2IQ Hour

Thank you for your participation!

Learn more:

energy.gov/fuelcells
hydrogen.energy.gov