PAJARITO POWDER
FUEL CELL CATALYSTS

Advanced Catalyst and Engineered Catalyst Supports for Fuel Cells, Electrolyzers, and Energy Storage

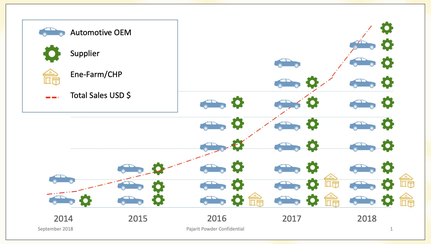
Pajarito Powder, LLC: The Team, Customer Engagement & Why We Exist

The Team

Products

- Fuel Cell and Electrolyzer catalysts
  - Catalyst is the single most expensive component in a fuel cell stack (30%+ of total stack cost)
  - Pajarito Powder products achieve 60% of needed cost reduction (~10$/kW savings)
- Current Products
  - Engineered Catalyst Support (ECS)
  - Pt/ECS Catalysts
  - Precious-Metal-Free (PMF)Catalysts
  - Electrolyzer Catalysts (In Development)

Strong Customer Engagement

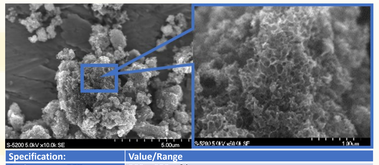


Pajarito Powder Differentiation

- Customer-focused / Customer-responsive
- "Right-scale" development and manufacturing
- Proprietary modular and flexible Varipore™ manufacturing platform
- Concentration on the lower-cost, historically under-engineered catalyst component, not the expensive precious-metal commodity
- Combination of international patents, trade-secrets and know-how

Products

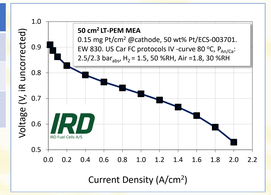
Engineered Catalyst Supports (ECS)



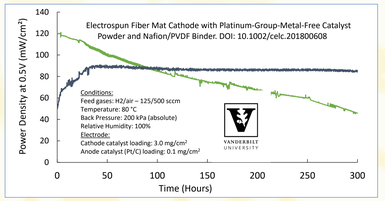
Specification:	Value/Range
Surface area, BET	300 – 950 m^2/g
Pore size	5 nm – 40 nm
Particle size, DLS	0.4 - 2.0 µm
Available dopants	Nitrogen, boron, phosphorus and others
Other properties	G/D ~0.8 - 1.2, pore volume ~0.5 – 3.0 cc/gr

Catalyzed ECS & PEM MEAs

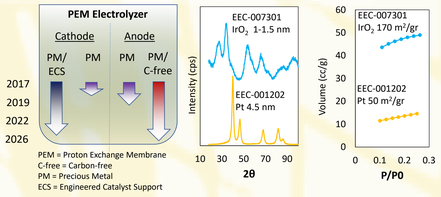
Specification	Value Range
Loading (active mat.)	10 - 85 wt%
Crystallite size, XRD	2-7 nm
PM metals/ alloys	Pt, Pd, Ir, Ru. Pt-Alloys



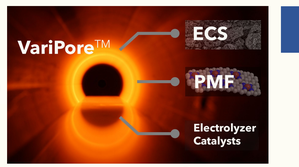
PGM-free ORR Catalysts



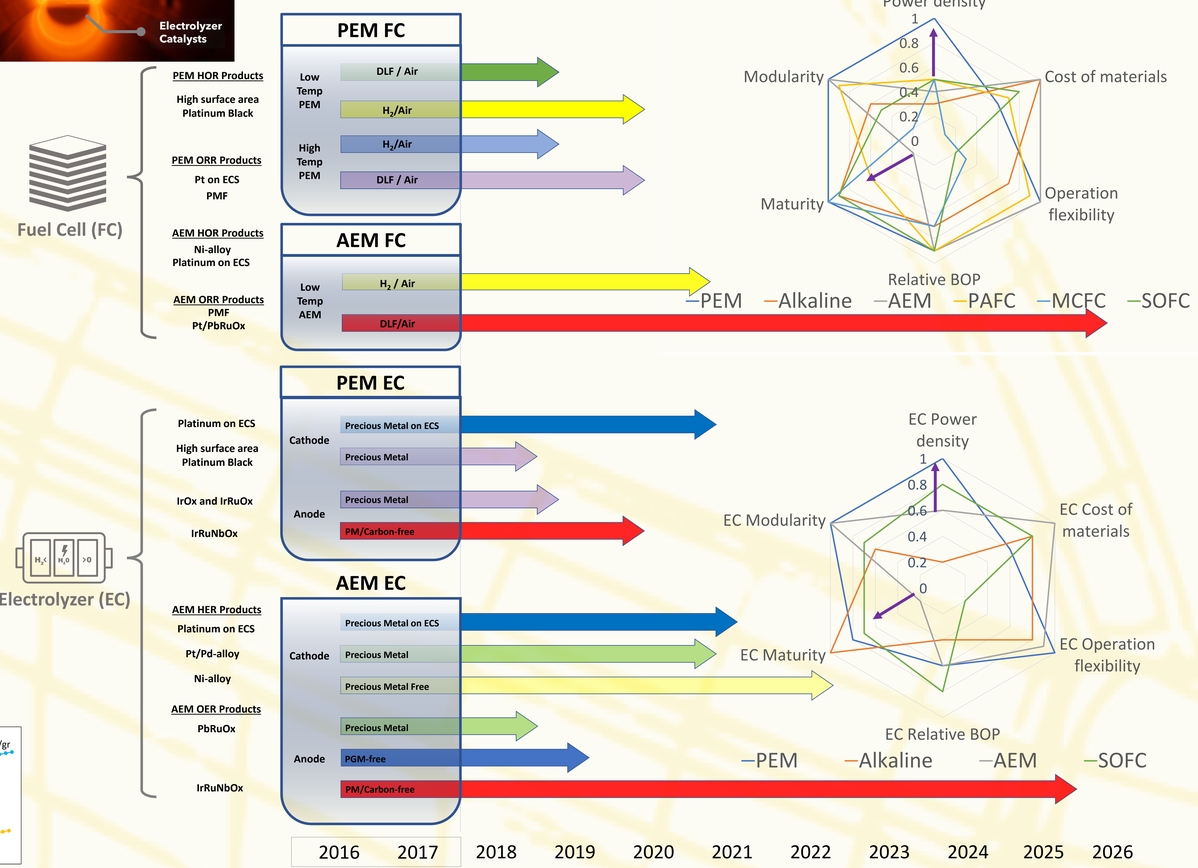
PGM-based Electrolysis Catalysts



PEM = Proton Exchange Membrane
C-free = Carbon-free
PM = Precious Metal
ECS = Engineered Catalyst Support



Product Development Roadmap



Precious Metal Free Regenerative Hydrogen Electrode ARPA-E DE-AR0000688

Lead Personnel

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Pajarito Powder
Kathy Ayers
Proton Onsite
Sanjeev Mukerjee
Northeastern University
Madeleine Odgaard
IRD

Vision

- Develop precious metal free fuel cell and electrolyzer catalysts for low cost energy storage

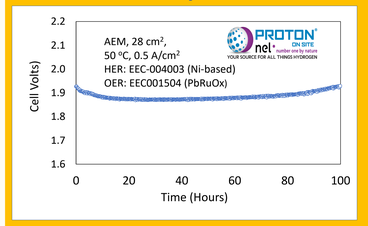
Impact

- Enable low cost precious metal free fuel cells and electrolyzers for transportation, backup-power, and renewables grid-level energy storage

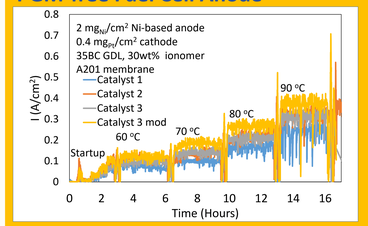
Fed. funding:	$2.8M
Length	42 mo.

AEM URFC: Key Achievements

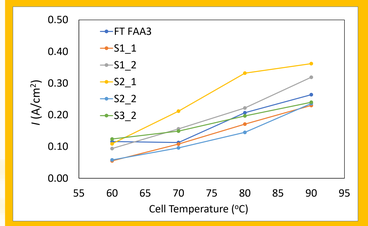
PGM-free Electrolyzer Cathode



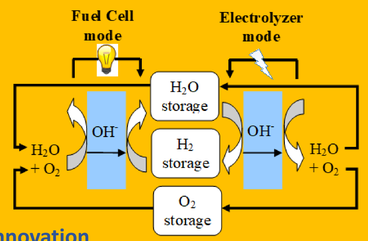
PGM-free Fuel Cell Anode



PGM-free Fuel Cell Ionomer Effects

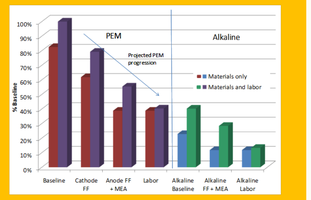


Regenerative Fuel Cell/Electrolyzer



Innovation

- Elimination of platinum group metals through use of anion exchange membrane technology for fuel cells and electrolyzer
- Focus on the bifunctional hydrogen electrode as the critical remaining enabler to low cost materials



Targets

Metric	S.o.t.A	Proposed
Voltage,0.35A/cm² (fuel cell)	0.4 V	0.65 V
Voltage, 0.5A/cm² (electrolyzer)	2.4 V	2.1 V
$/kW at stack level (AEM vs PEM)	$400 (PEM)	$50 (AEM)

Task Outline

Task and lead	Yr 1	Yr 2	Yr 3
FC catalyst: PP, UNM			
EC catalyst: NU, Proton, PP			
Electrode: Proton, EWII, PP			
T2M: PP, Proton, EWII			

Tech-to-Market Strategy

Short-term: high-value, fault tolerant electrolyzers, electrodes and catalysts for specialty markets
Long-term: reversible fuel cell and components for renewable storage

Future Work

- Increased Fuel Cell and Electrolyzer performance and stability
- Unitized Reversible Electrode testing using PGM-free Hydrogen electrodes
- Short-stack demonstration