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Metallic Bipolar Plates with Composite Coatings

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Fuel Cell Projects Kickoff Meeting

Washington DC

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Metallic Bipolar Plates with Composite Coatings Project
Objective

- Make aluminum-based bipolar plates an option for replacing machined graphite bipolar plates by applying a protective, but conductive coating
  - Improved durability over machined graphite
    - *Strong and flexible*
  - Lower cost than machined graphite
    - *Use low-cost manufacturing techniques that are already employed for other automotive parts*
  - Reduced weight as compared to machined graphite
    - *Plates can be made thinner using materials with similar densities*

Our project aims to meet or exceed all of the 2015 technical targets for bipolar plates

Characteristic	2015 Target
Cost	$3/kW
Weight	<0.4 kg/kW
H_2 Permeation Flux	$<2 \times 10^{-6}$ $cm^3/sec/cm^2$
Corrosion	<1 $\mu A/cm^2$
Electrical Conductivity	>100 S/cm
Resistivity	0.01 Ω-cm
Flexural Strength	>25 MPa
Flexibility	3 to 5% deflection at mid-span

- Technical Barriers that will be addressed: Durability, Cost, Performance, and Water Transport within the Stack

Approach

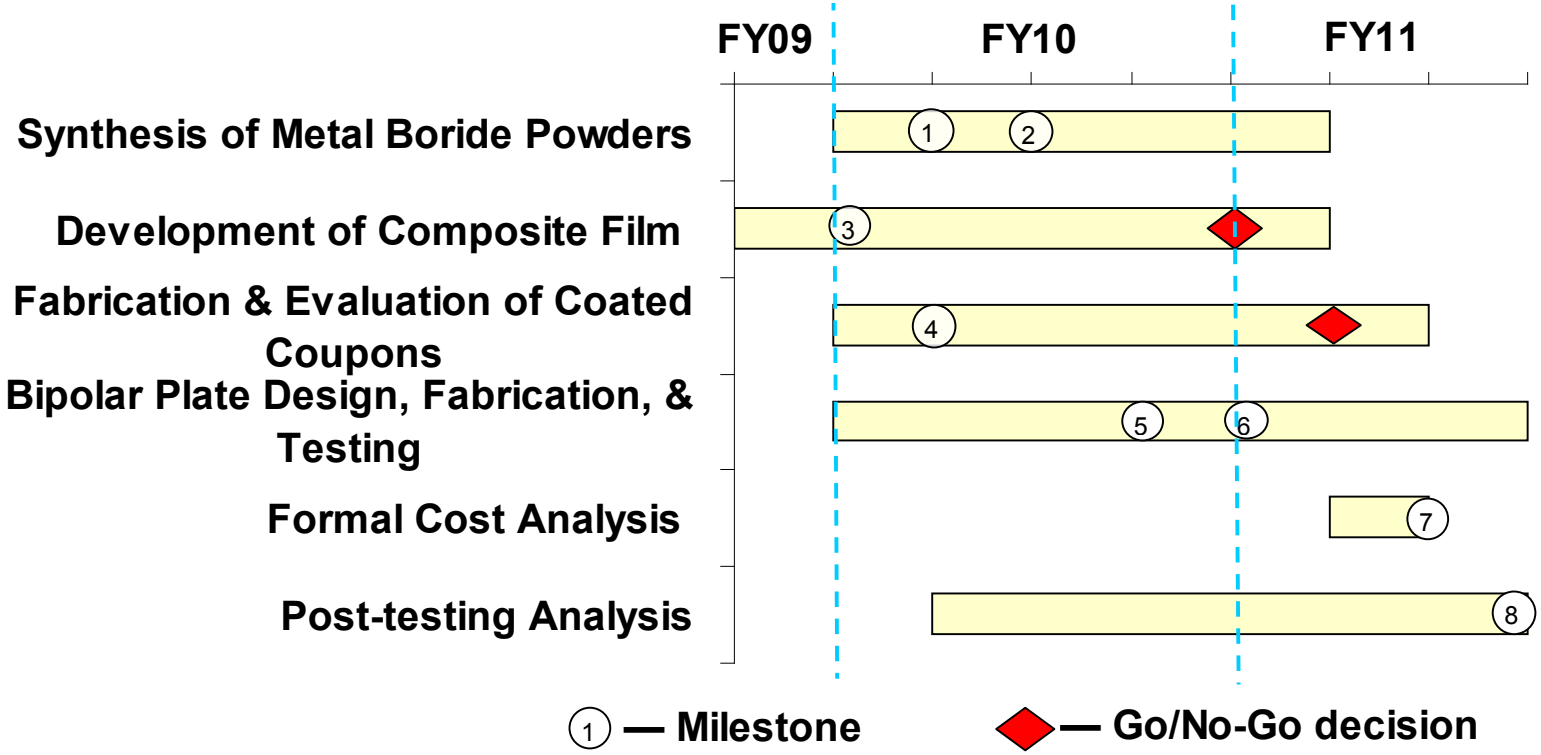
- Aluminum alone meets all of the requirements except for corrosion resistance, so we will use Al as the base metal
  - 6061 is an aerospace alloy that is available in sheet form
- For corrosion resistance, apply a coating that is a composite of two materials:
  - Filler to provide electrical conductivity
    - *Candidate Materials: graphite, carbon black, TiB_2 and CaB_6*
  - Fluoropolymer to provide corrosion resistance, sealing, and mechanical flexibility
    - *Candidate Materials:*
      ECTFE (ethylene-chlorotrifluoroethylene copolymer)
      EFTE (ethylene-tetrafluoroethylene copolymer)
      PCTFE (poly(chlorotrifluoroethylene))

Cross-sectional view

Prior Work

- Patent application filed by Argonne: "Corrosion Resistant Bipolar Plate for Polymer Electrolyte Fuel Cells"; May 28, 2008
- Mixtures of graphite and a fluoropolymer made into composite films using heat and pressure
- Volume ratios and fluoropolymer type (PVDF, PCTFE and/or ECTFE) were varied
  - Lowest resistance: 70 vol% graphite + 30 vol% PCTFE
    - *5-7 Ω*
- Laminated onto steel substrates using our own anchor material
  - Best adherence: 60 vol% graphite + 40 vol% PCTFE
    - *Survived 16 hours in boiling water*
    - *Survived 240 hrs in sulfuric acid solution (pH=1)*

Metallic Bipolar Plates with Composite Coatings Project
Timeline



- Go/No-Go decisions:
  - Sept. 30, 2010: Composite coatings that are >100 S/cm, corrosion resistant and impermeable to acid solution
  - Dec. 31, 2010: Coating that protects an aluminum plate from corrosion, while maintaining electrical and mechanical properties

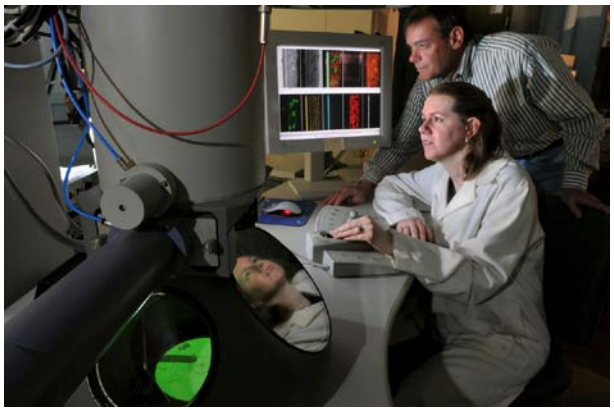
Metallic Bipolar Plates with Composite Coatings Project
Budget

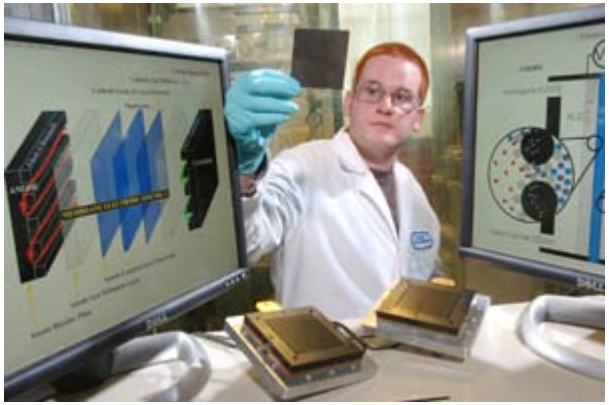
- Total project budget over 2 years: $1,679 K
  - Funding received in FY'09: $645 K
  - Anticipated funding for FY'10: $281 K
  - Anticipated funding for FY'11: $771 K

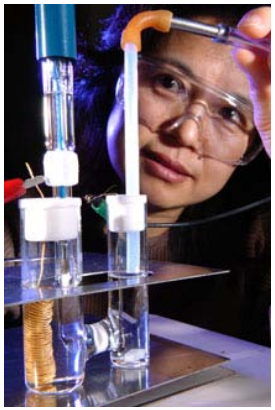
- Total budget broken down by organization:
  - Argonne National Laboratory: $956 K
  - Gas Technology Institute (Dr. Chinbay Fan): $336 K
  - Orion Industries (George Osterhout): $250 K
  - Southern Illinois University (Prof. Rasit Koc): $155 K

Project Team Members:
Argonne National Laboratory

- Argonne National Laboratory is a world class research facility with a large fuel cell program
- Ongoing research in PEM fuel cells, solid oxide fuel cells, steam electrolysis, thermochemical cycles, hydrogen storage, ethanol reforming, and hydrogen quality



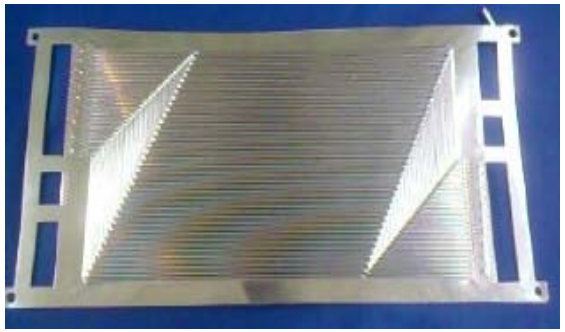




- Will determine optimal filler material volume fraction, optimal filler material particle size and geometry
- Will conduct corrosion tests, electrical properties measurements, and mechanical testing

Project Team Members:
Gas Technology Institute

- Extensive experience designing, making, and testing bipolar plates and PEMFC stacks
  - Vertically integrated in-house stack prototyping
- Comprehensive testing facilities
  - Wide variety of test cells and stands



- Responsible for designing, stamping, and welding aluminum substrates
- Will conduct H_2 permeability tests
- Will conduct a 2000 h test of our bipolar plates in a short stack

Project Team Members:
Orion Industries

- Orion is a leader in the application of functional coatings
  - Primary business is the application of fluoropolymer coatings to manufactured parts
  - Customers include Honda, Chrysler, Nissan, Caterpillar, Calphalon, and Baxter Healthcare
  - Holds 13 coating application patents
  - >70 employees



- Will develop the application process for the composite coatings
- Will apply test coatings and coatings to finished bipolar plates for stack tests and final deliverables

Project Team Members:
Southern Illinois University Carbondale

- Prof. Rasit Koc holds 2 patents on a novel process for producing high-purity metal carbide, nitride, and boride powders
  - R&D 100 award winner
- Powders can be synthesized at lower temperatures resulting in great cost savings as compared to the current state-of-the-art processes
- SIUC will demonstrate that their process can be used to make TiB_2 and CaB_6 with controlled aspect ratios
  - Will supply filler materials for test coupons and the final bipolar plates

Thank You