Metallic Bipolar Plates with Composite Coatings

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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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2015 Target</th>
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<tbody>
<tr>
<td>Cost</td>
<td>$3/kW</td>
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<tr>
<td>Weight</td>
<td>&lt;0.4 kg/kW</td>
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<tr>
<td>H₂ Permeation Flux</td>
<td>&lt;2 x 10⁻⁶ cm³/sec/cm²</td>
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<tr>
<td>Corrosion</td>
<td>&lt;1 µA/cm²</td>
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<tr>
<td>Electrical Conductivity</td>
<td>&gt;100 S/cm</td>
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<tr>
<td>Resistivity</td>
<td>0.01 Ω-cm</td>
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<tr>
<td>Flexural Strength</td>
<td>&gt;25 MPa</td>
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<tr>
<td>Flexibility</td>
<td>3 to 5% deflection at mid-span</td>
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- Technical Barriers that will be addressed: Durability, Cost, Performance, and Water Transport within the Stack
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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\textsubscript{2} and CaB\textsubscript{6}
  - Fluoropolymer to provide corrosion resistance, sealing, and mechanical flexibility
    - Candidate Materials:
      - ECTFE (ethylene-chlorotrifluoroethylene copolymer)
      - EFTE (ethylene-tetrafluoroethylene copolymer)
      - PCTFE (poly(chlorotrifluoroethylene))
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Prior Work

- 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
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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 TiB₂ and CaB₆ with controlled aspect ratios
  - Will supply filler materials for test coupons and the final bipolar plates
Thank You