Bipolar Plate-Supported Solid Oxide Fuel Cell: "TuffCell"

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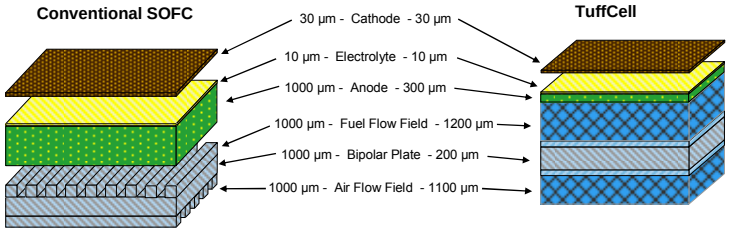
Objective

Develop an improved solid oxide fuel cell (SOFC) for portable power applications (e.g., auxiliary power units)
- SOFC advantages
  - High power density and efficiency
  - Fuel versatility/simplified fuel processing
  - Well-suited to duty cycle of APU
- SOFC issues
  - Sealing – glass or mica seals prone to leak
  - Startup time, temperature cycling, and durability
    - Status: 2-3 hours, 50 cycles, 1000 hours lifetime
    - Goal: 15-30 min, 500 cycles, 5,000 hours
  - Vibration and shock resistance
  - Cost
    - Status: >$2,000/kWe, goal: $400

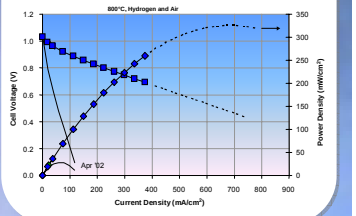
Metallic Bipolar-Plate-Supported Design Addresses SOFC Shortcomings for Portable Power



- Large wt% of expensive materials
- Multiple high-temp processing steps
- Brittle ceramic failure
- Contact resistance between plates
- Bipolar plate corrosion issues

- Thin layers of expensive materials
- Single HT processing step
- High strength due to metallic layers
- Single contact plane between cathode and flow field
- Functionally graded bipolar plate

Current Status of TuffCell's Power Density

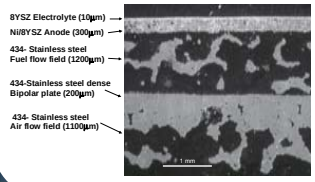


Future Plans

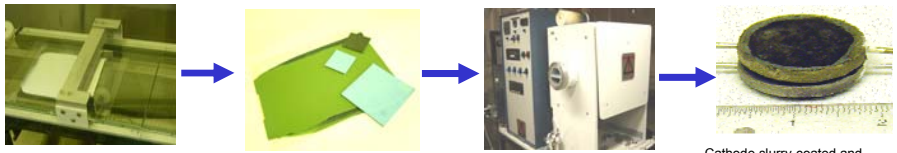
- **Continue to improve single cell and stack power densities to decrease size, weight, and cost**
  - Improve design and fabrication procedure
  - Investigate improved materials for metallic support, anode, and cathode
- **Demonstrate that TuffCell stacks can meet DOE Performance Technical Targets for APU application**
  - Test start-up time (goal: < 30 min.)
  - Temperature cycling tests (goal: > 500 cycles)
  - Investigate durability (goal: > 5,000 operating hours)

Bulk of TuffCell is Inexpensive Metal

Anode-supported SOFC Stack Materials: $139/kWe
TuffCell Stack Materials: $85/kWe



TuffCell Fabrication Approach: *Powder Metallurgy Processing*

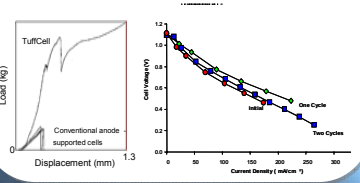


Tape cast films of SOFC layers → Laminate bipolar plate, anode, and electrolyte films → Co-sinter laminate in hydrogen → Cathode slurry-coated and sintered *in situ*

TuffCell's Superior Mechanical Properties, Cyclability Demonstrated

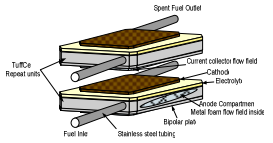
Physical tests:
- Impact test
- 4-point bend test

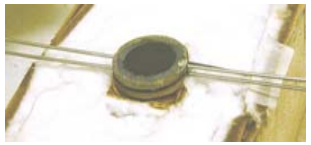
Cycle tests:
- Room temp. to 800°C at ~10°C/min



New seal concept simplifies stack building and solves high temperature gas-sealing issue

- Edges of anode chamber sealed with metal
- Feed and exit tubes brazed into edge of stack unit
- Cells stack like batteries





Conclusions

- Developed a rugged solid oxide fuel cell with improved mechanical & electrical properties
- Reduced materials and manufacturing costs
- Simplified cell stacking
- Solved the high temperature sealing issue

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