2nd Annual Solid State Energy Conversion Alliance (SECA) Workshop

Low Cost Multi-layer Fabrication Method for Solid Oxide Fuel Cells

DE-AC26-00NT40707

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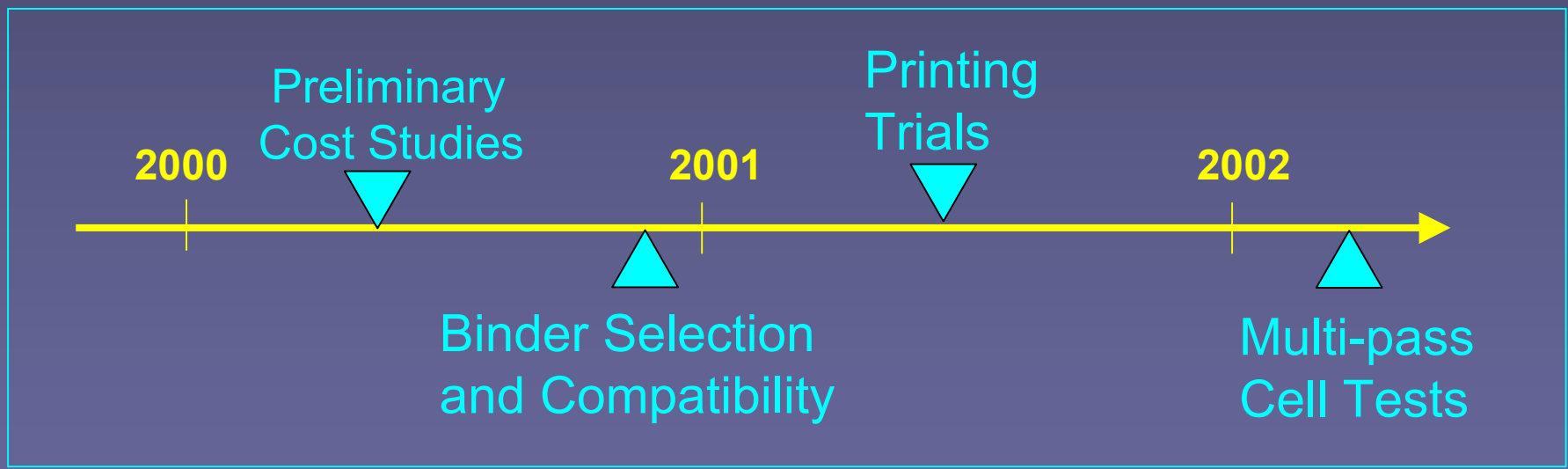
Background of TMI

- Organized in 1990 to commercialize low cost planar SOFC technology
- Engineered compact, integrated, systems.
- Designed for multi-use applications and simplified field service.

- Operated on common fuels- multiple 100 Cell stacks on CH_4 /JP-8

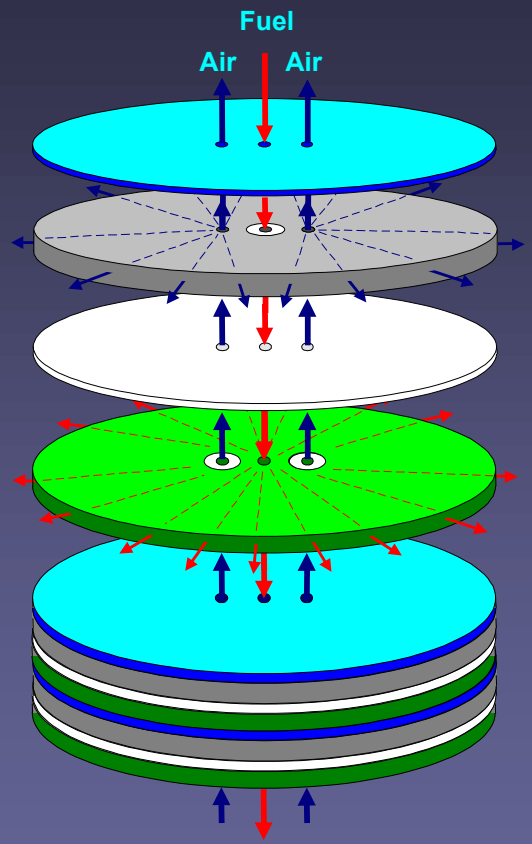
Overall Program Objectives

- *Large demand for low cost SOFC systems.*
- *Multi-Pass Screen Printing* -mature, low cost fabrication technique adapted to the TMI SOFC radial-flow design



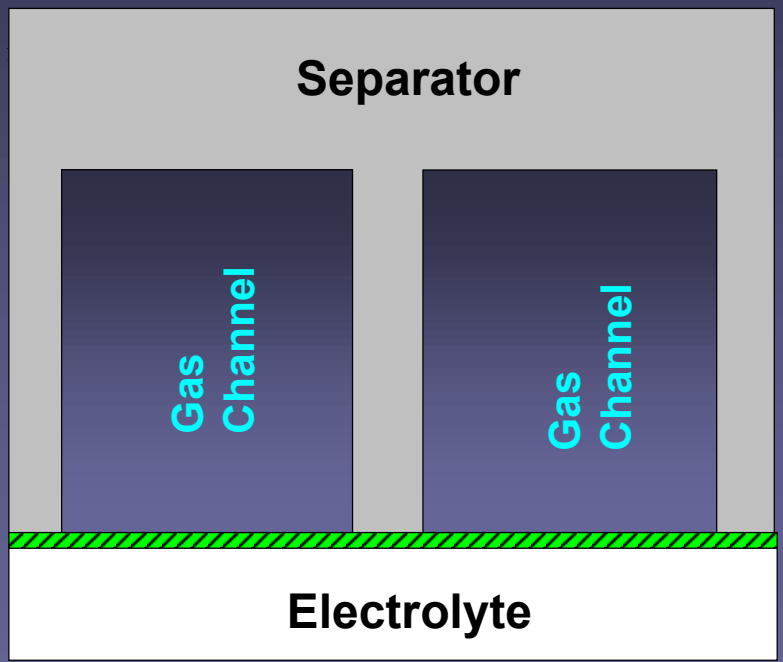
TMI Cell Design

- Simple Geometry
- Small, central seals
- Radial Co-flow
- Low Cost (vs. Performance)

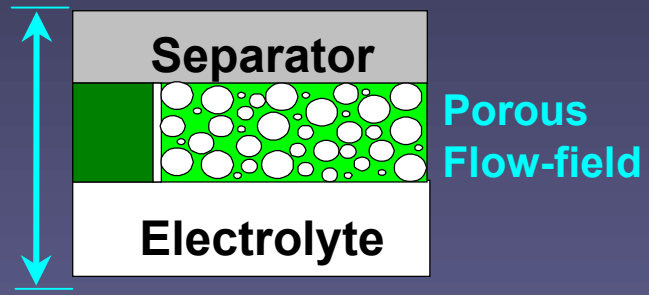


Compatible Flow Strategy

A Common Planar Design

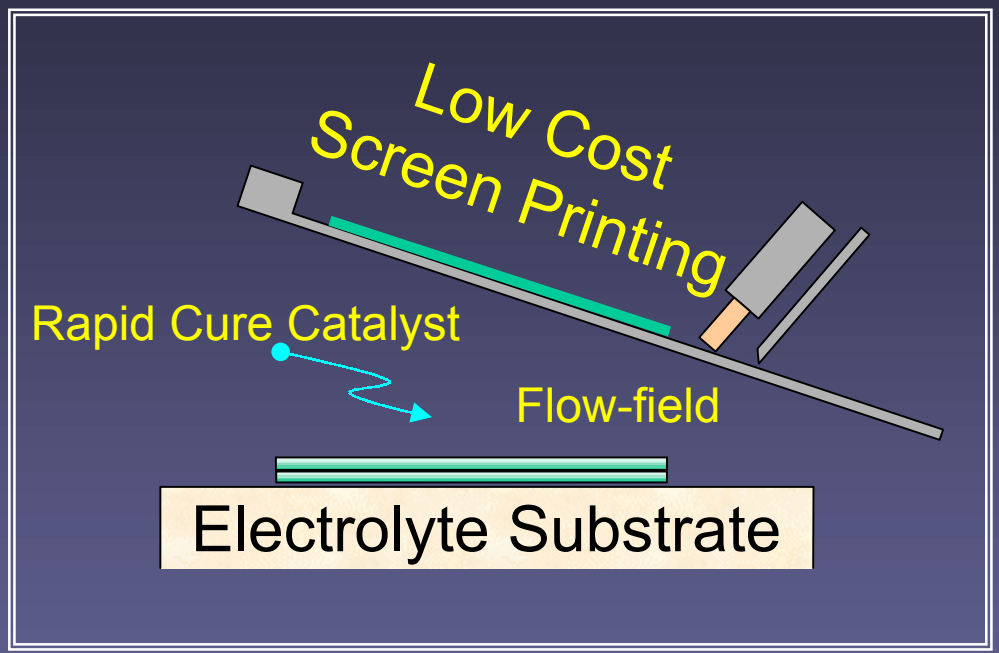


TMI Design



1.0 - 1.5 mm
(0.040-0.060")

Low Cost Manufacturing Strategy

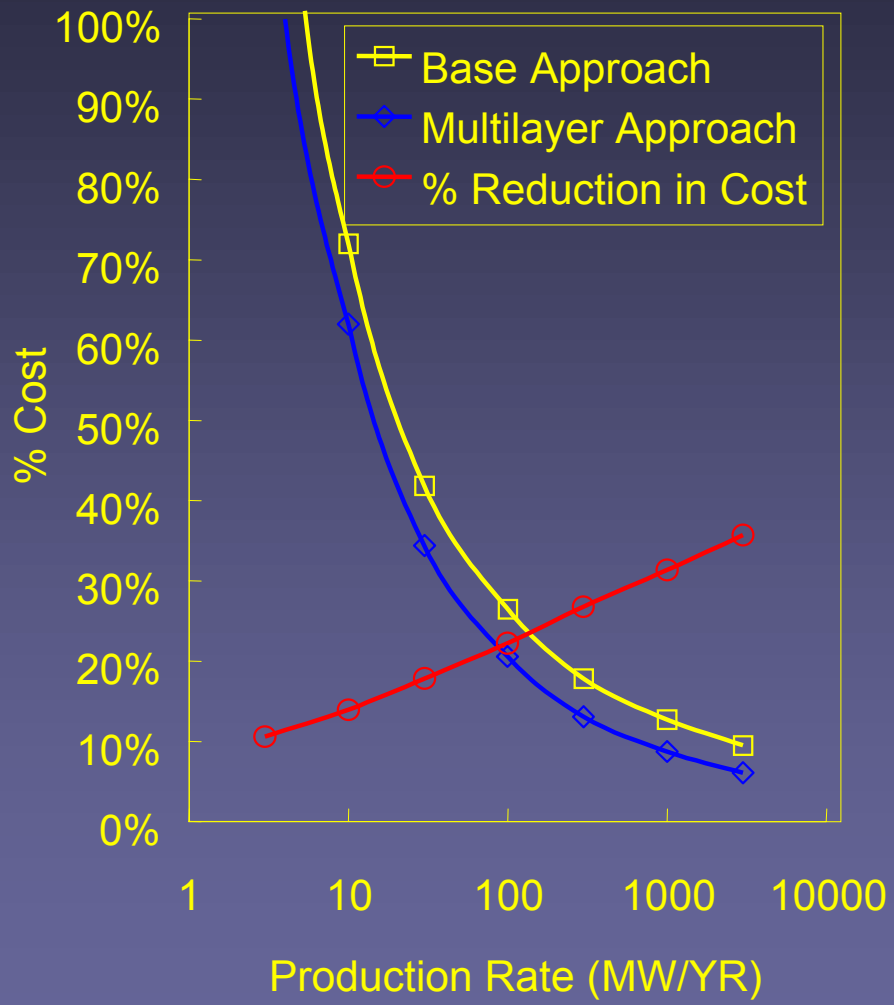


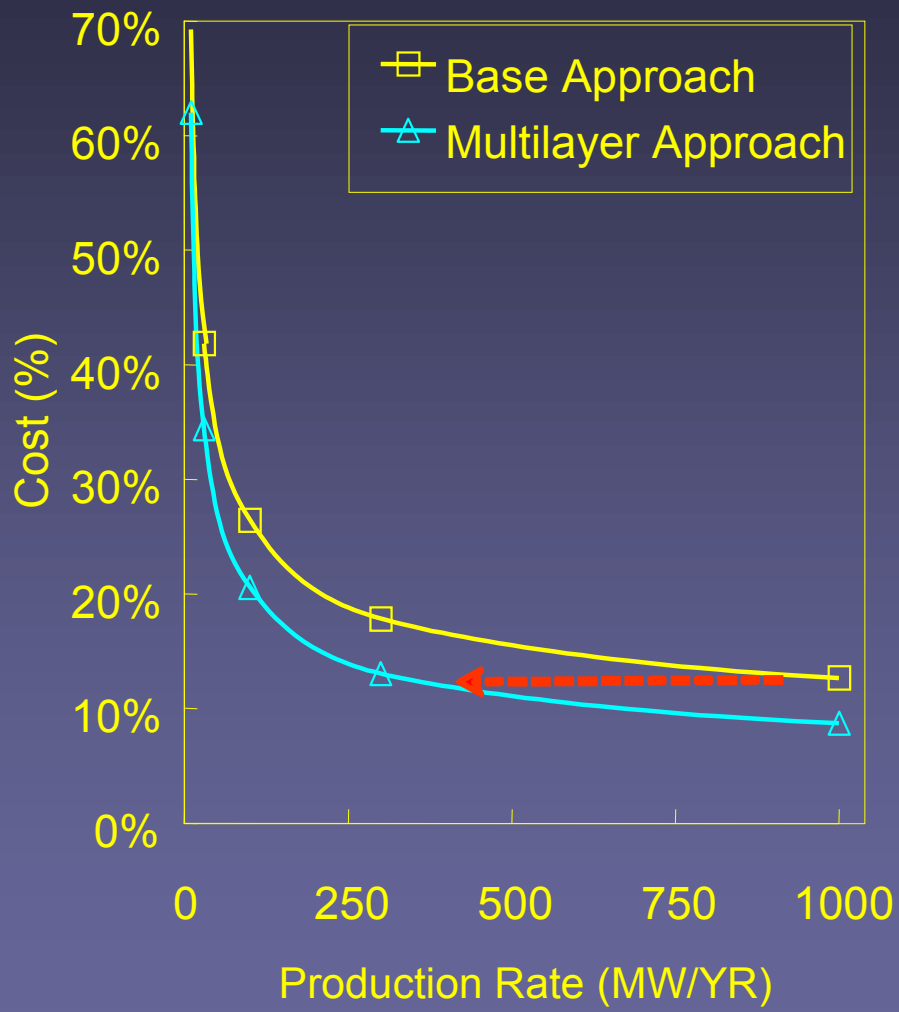
Automated Commercial Screen Printer

Task 1. Cost/Benefit Estimate

- Cost Build-up:
  - Direct Materials, Labor and Overhead
  - Indirect
  - Amortization of Capital Costs
- Benefits
  - Reduced Stack Cost
  - Increased Power Density (volume and weight)

Lower Per-Unit Costs





Task 2. Binder Systems

- Identified Candidate Binders
- Characterized Seven different systems
  - Reactivity/Contamination
  - Sensitivity/Hardness
- Four systems ranked by Compatibility.

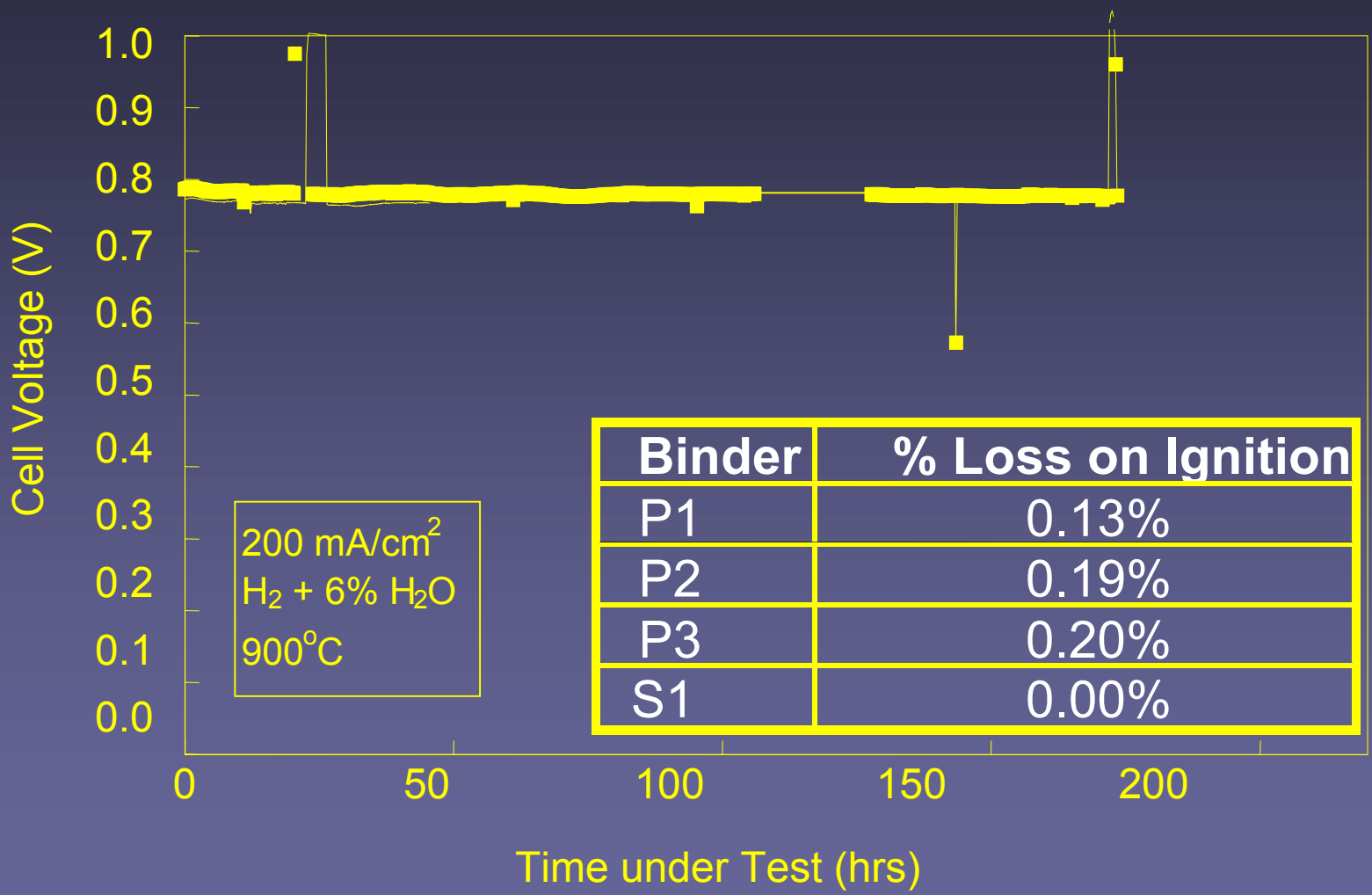
Reactivity Analysis

Binder	Cathode Powder	Seal Glass	Anode Powder
*Sample S1**	None	None	None
Sample C1**	None	None	None
Sample C2	None	None	None
Sample P1	None	None	None
Sample P2	None	None	None
Sample P3	None	None	None
Sample P4	Slight	Slight	Slight

* Reacted > 24 hrs with Cathode

** Reacts in ambient conditions

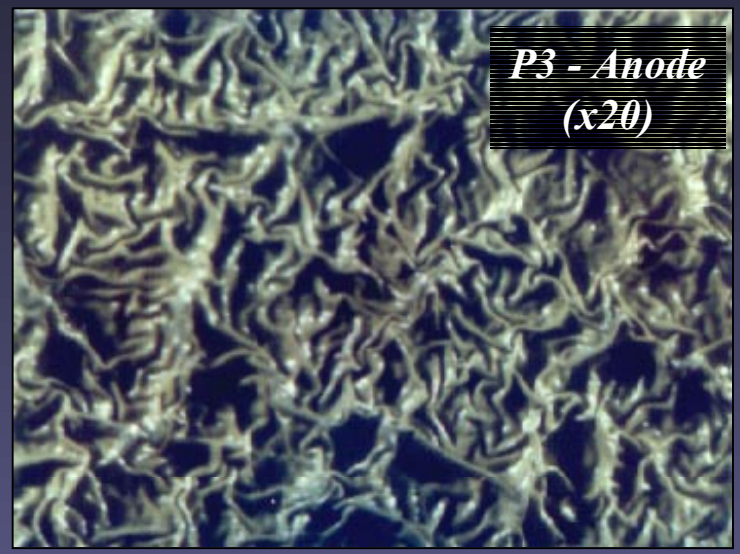
Cell Performance (a Contamination Indicator)

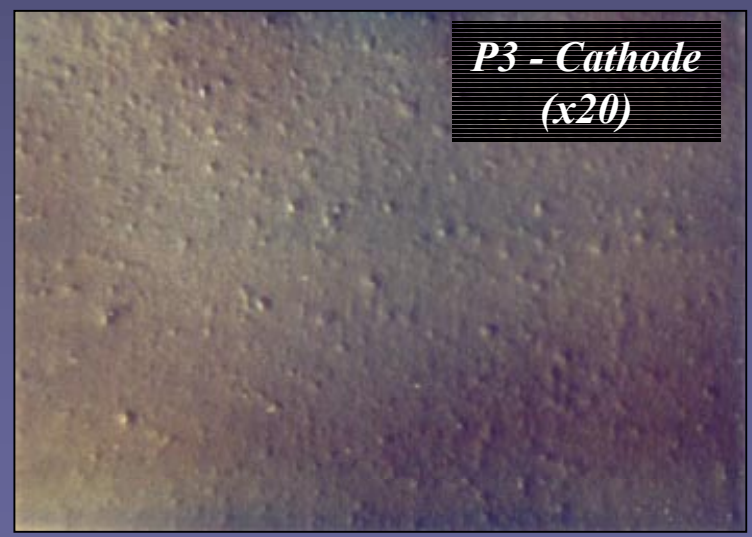


Binder	% Loss on Ignition
P1	0.13%
P2	0.19%
P3	0.20%
S1	0.00%

Task 3. Ink Curing Quality

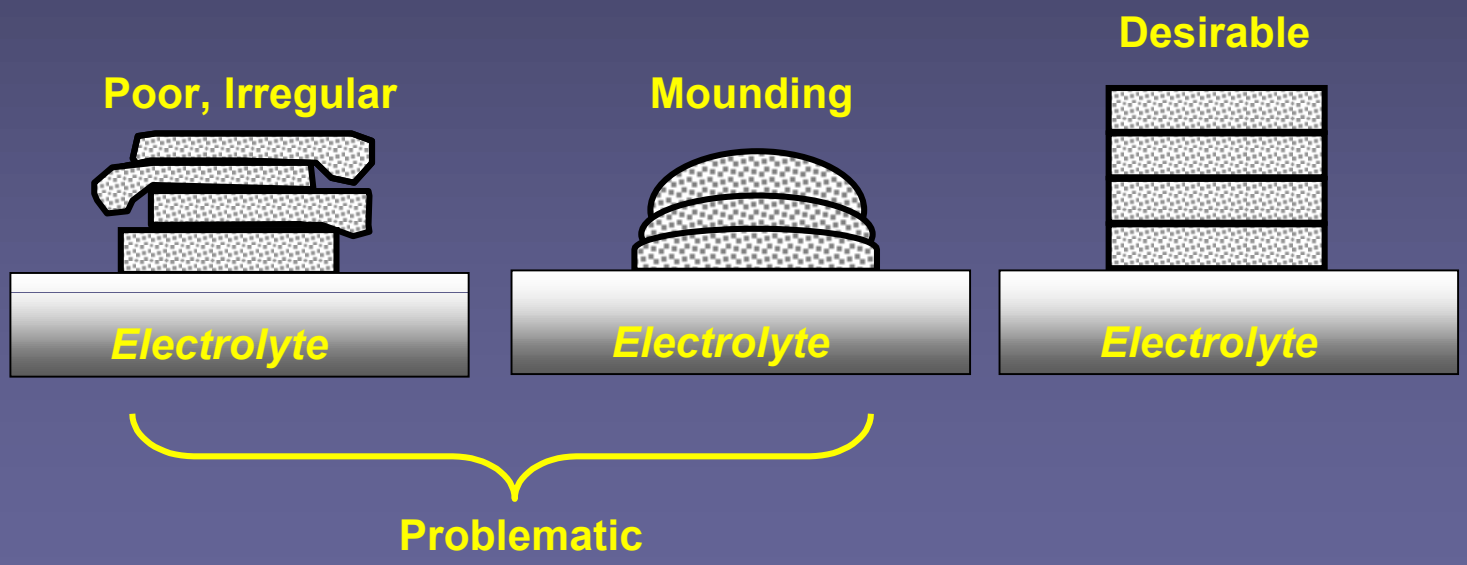
- Curing quality & rate depends on powder, thickness, and catalyst
- Challenges
  - Voids / Pockets
  - Incomplete curing





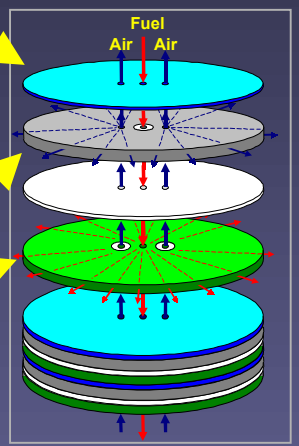
Current Challenges

- Trade-offs among rate of cure, thickness, and catalyst.
- Multi-pass Printing



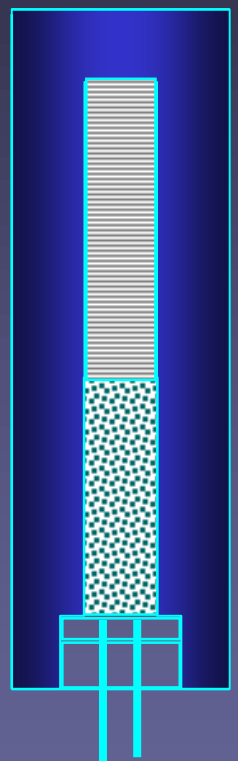
Low Cost Strategies

Adv. Separators
DE-FG02-00ER83109

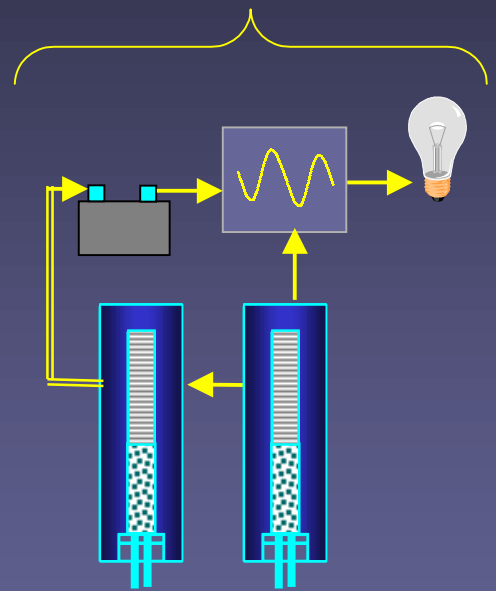


Multilayer Printing "Manufacturing"
DE-AC26-00NT40707

Integrated Hot Assembly
(Internal)



Multi-Module Operation
DE-FC26-00NT41009



Summary

- Completed Cost Estimate.
- Identified Binders
  - Reactivity and Contamination Studies Initiated.
  - Trade-offs among rate of cure, thickness, and catalyst.
- Multi-pass tests (Phase III).