# A05-0947: Solid-state battery designed for electric aviation

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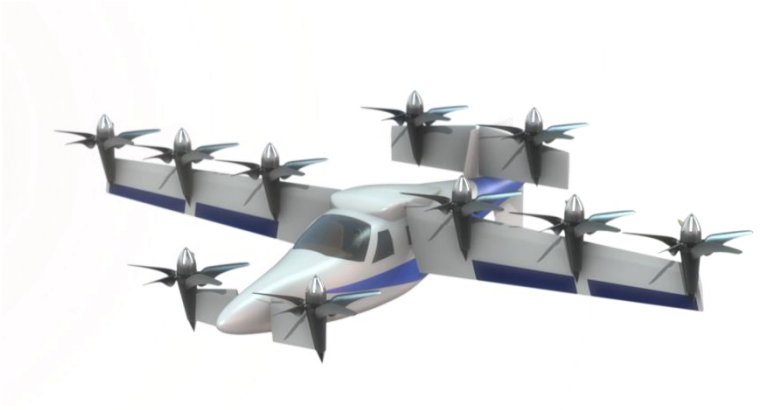
# Introduction – Electrified Aviation



- Electric and hybrid electric aircraft systems can lead to higher efficiencies, safer designs, and quieter operation
- Current battery technology is insufficient to achieve the requirements for electric aviation:
  - Energy, Power, and Safety
- Higher energy density batteries and current flammable liquid electrolytes lead to safety concerns

# Solid-State Electrolytes

Advantages:

- Solid-state electrolytes = low volatility/low flammability
- Wide temperature tolerance

Disadvantages:

- Difficult to manufacture
- Interface issues
  - Solid-Solid contact vs Liquid-solid
- High density vs liquid (g/cm3)

# Material Selection

- Lithium-Sulfur
  - Lithium metal is an ideal anode material
    - Lightweight (3860mAh/g), low potential, metallic
  - Sulfur has high capacity (1675mAh/g)
    - Reasonable potential above lithium (~2V)
    - Dissolution prevented in a solid-electrolyte

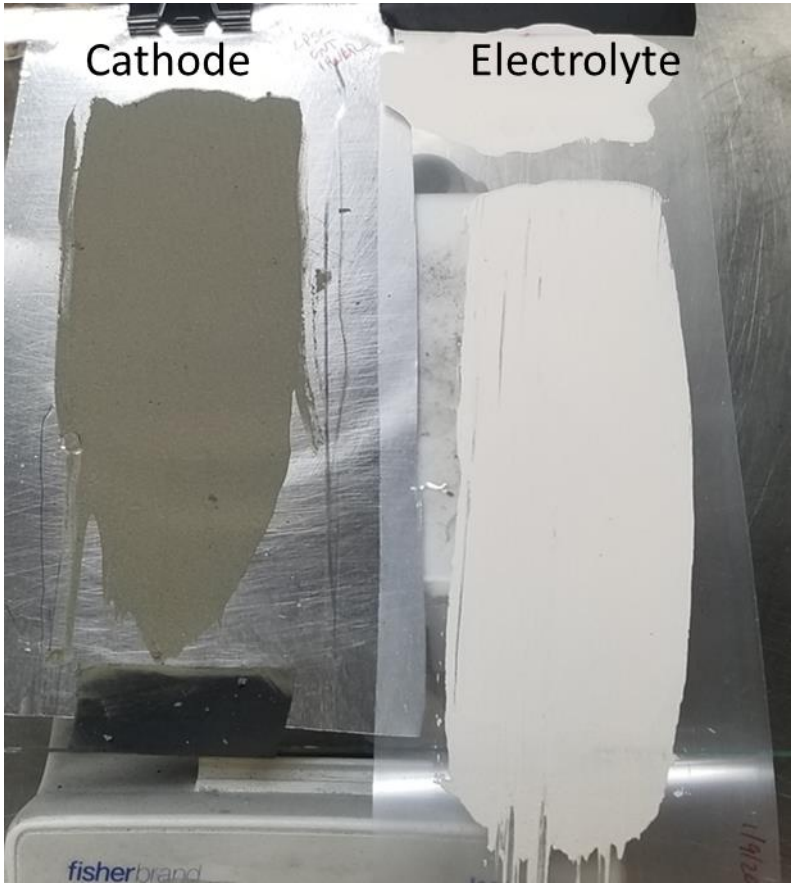
- Solid-Electrolyte — 25 micron separator:
  - Polymer ~1.2g/mL → 3 mg/cm2
  - Sulfide ~1.7 g/mL → 4.25 mg/cm2
  - Oxide ~5.6 g/mL → 14 mg/cm2

Oxides, such as LLZO, must be x3.3 times thinner than corresponding sulfide to achieve same weight penalty

# Manufacturing Thin Electrolytes

## Sulfide-Polymer Composites

- Tape-casting produces thin electrolytes
- Traditional lithium-ion manufacturing technique
- Utilizing inert binder (3-5wt%) to achieve well adhered films
- Capable of producing multi-phase cathodes
  - (Active-Carbon-Electrolyte-Binder)

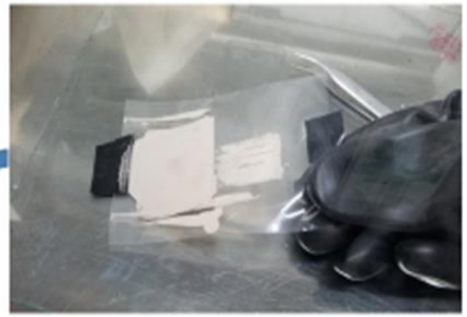


# Improved mechanical properties

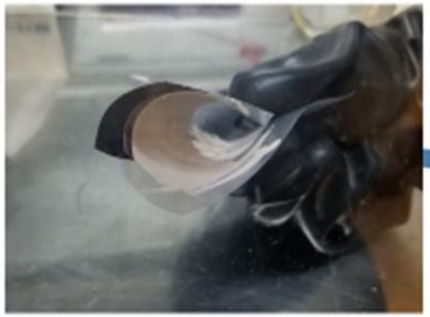
## Mylar Supported

Flexibility test: ~2"x2" tape-cast electrolytes

Dried SSE film

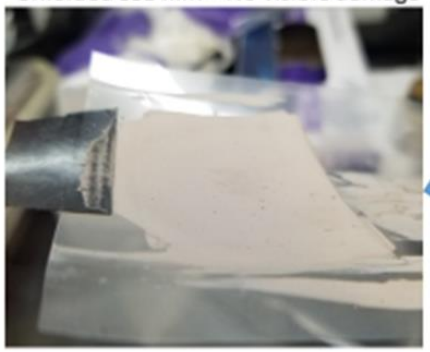


Folded SSE film – Side View



Folded SSE film – Top View

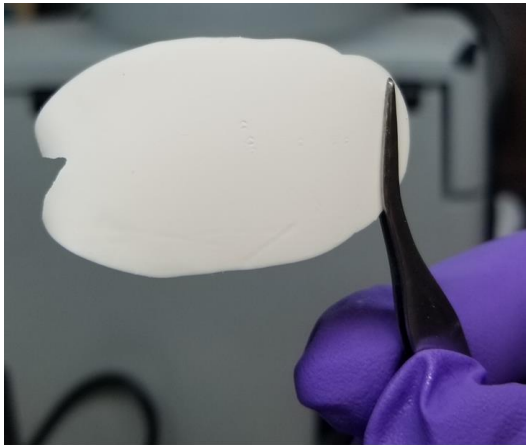
Unfolded SSE film – No visible damage

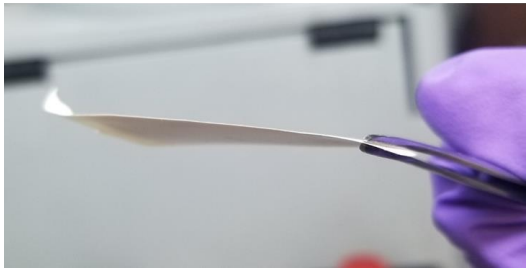


Bent or rolled over

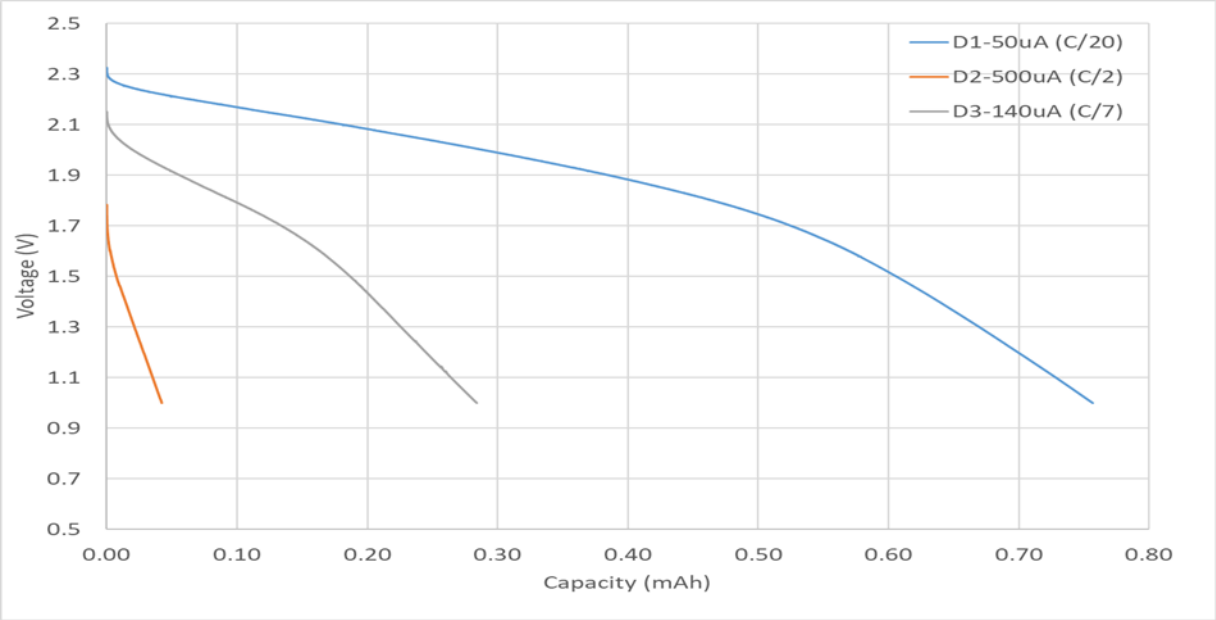
Shape rebounds undamaged

## Free-standing





# Full Cell Demonstration $TiS_2$/Sulfide SSE/Lithium




- TiS2 test candidate cathode (1mAh)
  - Similar potential window to sulfur
  - Lower volume change
  - High electrical conductivity
- ~25 micron thick solid-state electrolyte achievable
- Ionic Conductivity Retention of Sulfide-Polymer Composite: ~40% (3E-4 S/cm)
- Rate capability/mixing requires further improvements

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