ATB
THERMAL BATTERIES

THE POWER OF RELIABILITY

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Advances in Thin-Film Thermal Battery Processes: Performance and Cost Benefits

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Thin-Film Technology Development
Overview

Objective: Develop a technology which can capture the following characteristics over traditional Thermal Battery technology

Manufacturing Benefits

- Easier to Handle Thin Components
- Reduced Production Time/Cost

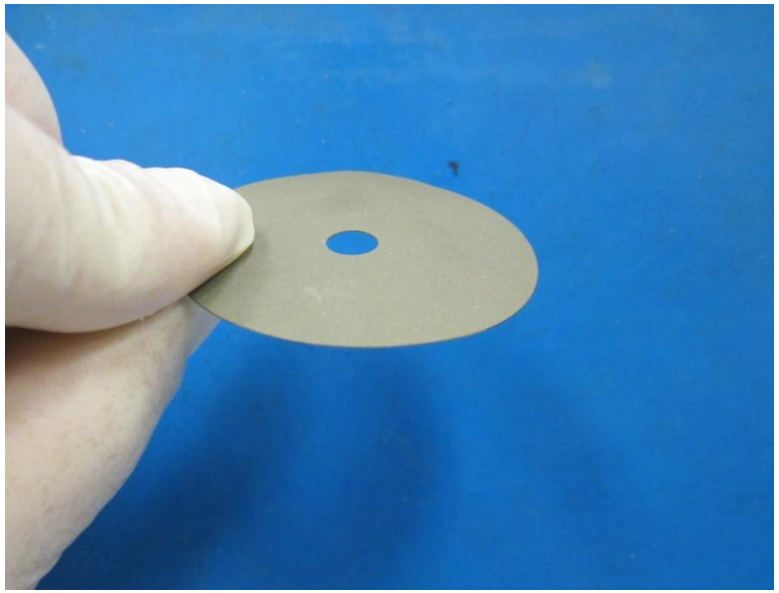
Performance Benefits

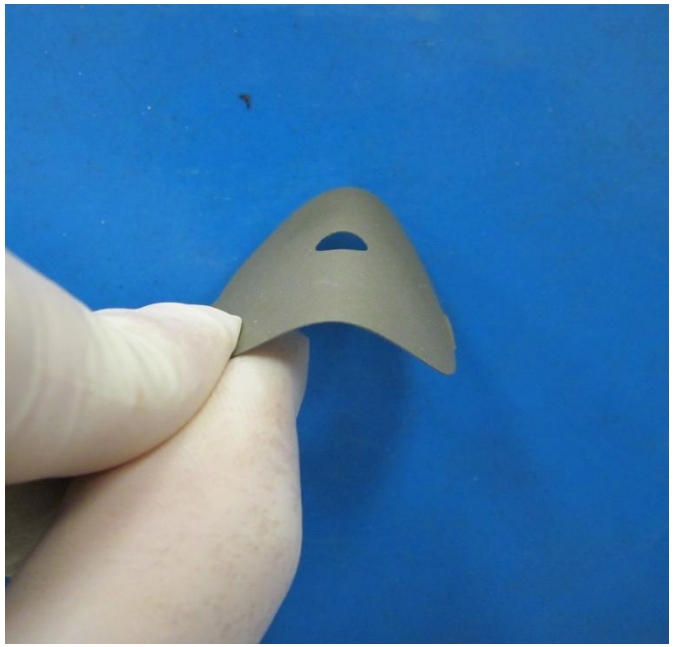
- Shorter Rise Time
- Increased Battery Power Capability
- Reduced Battery Weight/Volume

Thin–Film Technology Development
Ease of Handling

Ease of handling is increased with the addition of the binder

- Easier Storage Solutions
- Reduced Stacking Time
- Reduction in FOD





Thin–Film Technology Development
Reduced Production Time

High-Speed processing techniques reduce production/cost.

- Thin-Film component production is a magnitude higher than pellet production.
  - Increased surge capability
- Automation can more easily be integrated.
  - SPC and storage

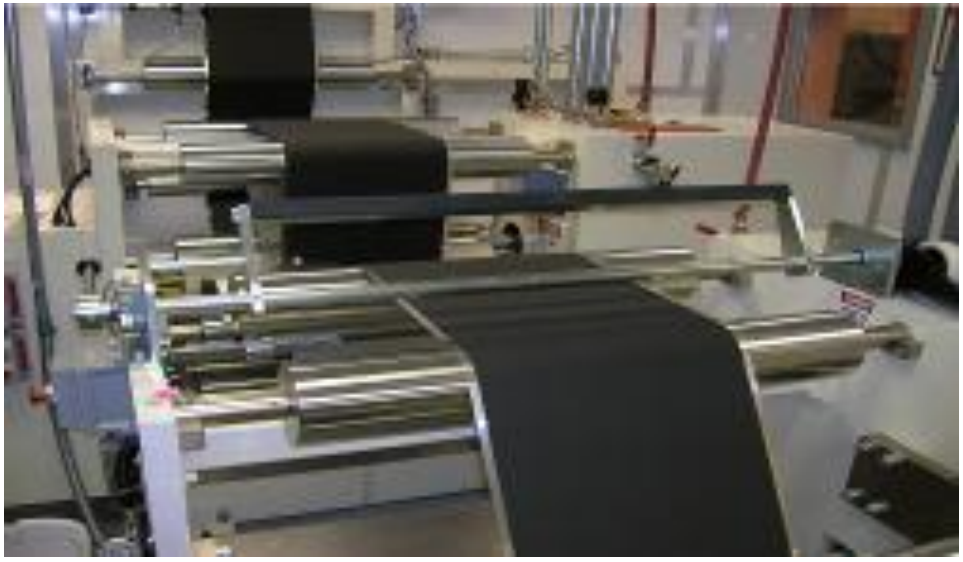
Thin–Film Technology Development
Improved Production Rate

Coating rate of thin-film parts is a magnitude higher than pressing pellets

- Lower Production Cost
- Better Surge Capability

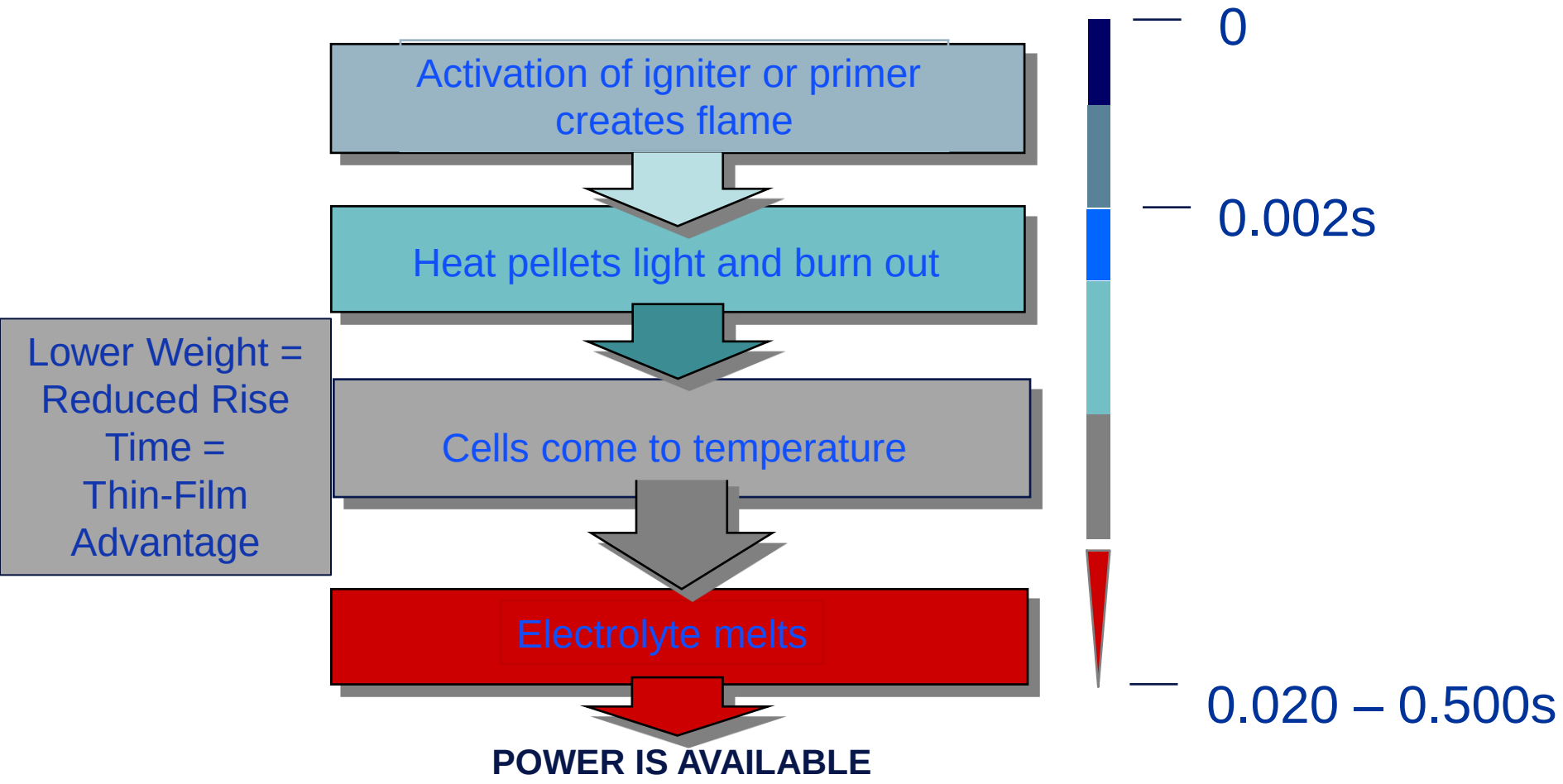
Pellet Presses

Small Roll-to-Roll
Coating Equipment

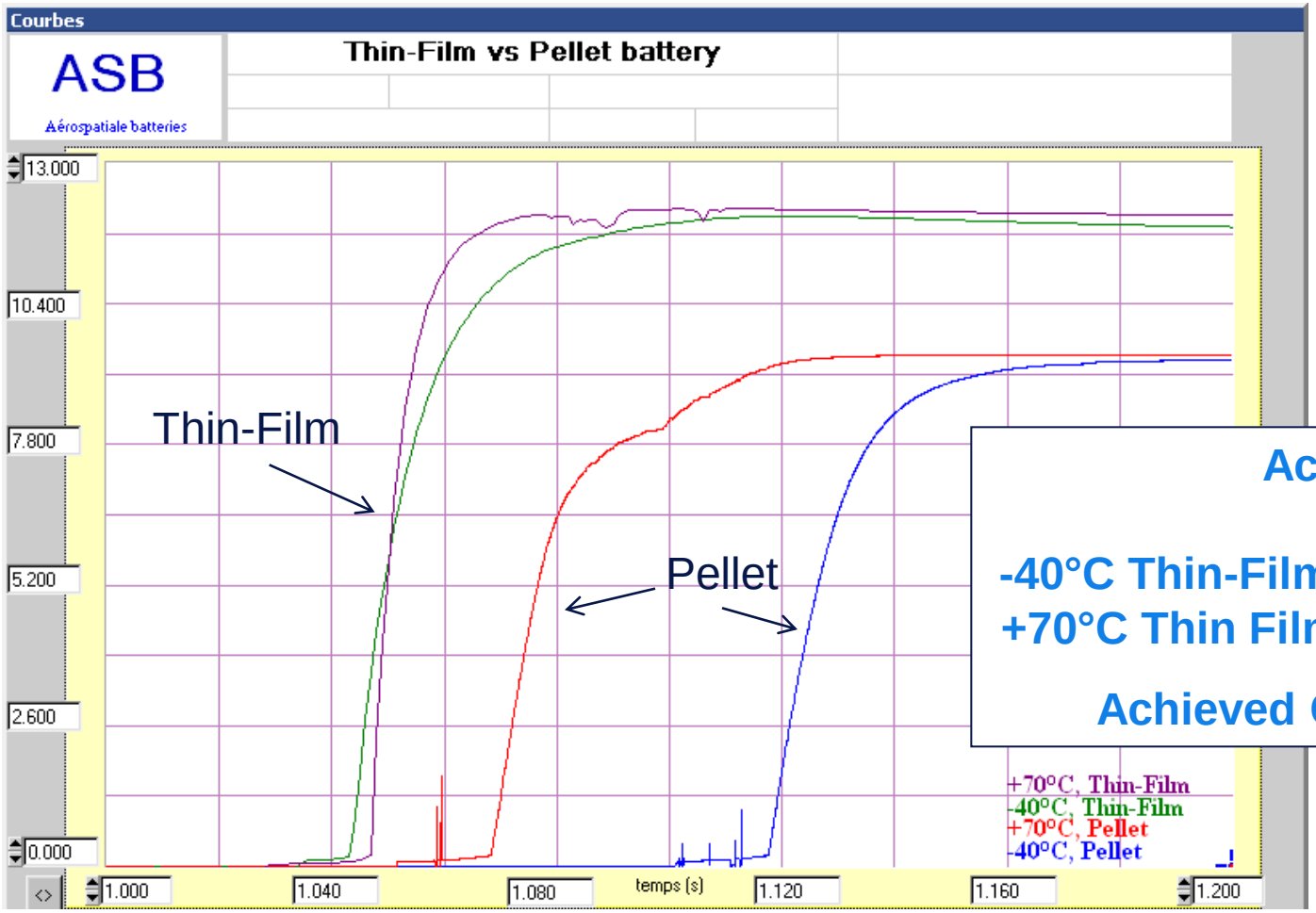


Thin–Film Technology Development
Improved Rise Time

Activation time determined by a multi-step process



Thin–Film Technology Development
Improved Rise Time



Activation

-40°C Thin-Film: 23ms (18% faster)
+70°C Thin Film:18ms (33% faster)

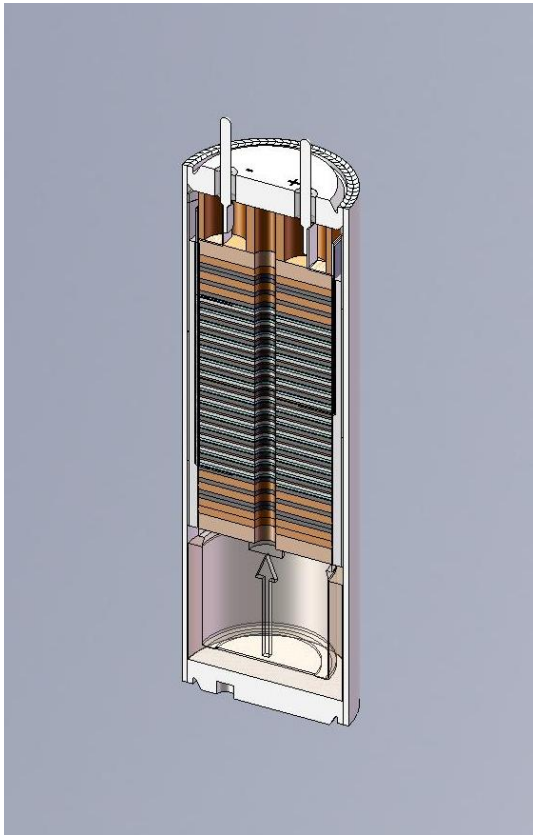
Achieved Goal of < 50ms

Note: Time=0 differs from test to test and is accounted for in activation time calculation

Thin–Film Technology Development
Fast Rise Time Battery Development

Battery Characteristics

Design	**Two Stacks of 5 Cells in Parallel**
Size	**0.625” Dia. X 2.0”Length**
	(Achieved 0.625” Dia X 1.4” Length)
Load	**0.75A**
Start Time	**50 ms**
	(Achieved 23ms tested @ -40°C)
Temp. Range	**-40°C to +70°C**



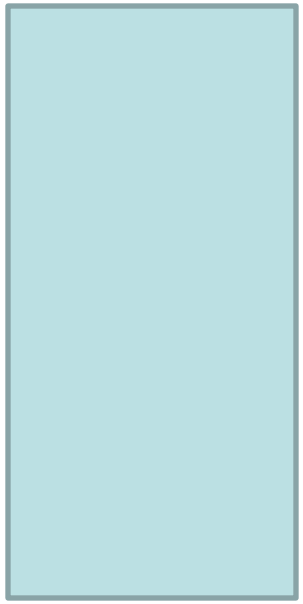
NOTE:

- **Battery is primer fired for lab testing**
- **Battery if inertially fired for Air Gun Testing at ARDEC**
- **Inertial starter effort done by Omnitek**

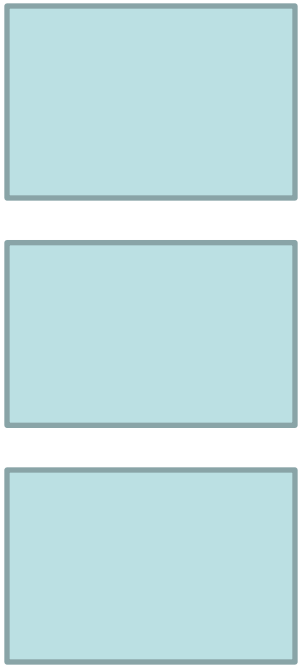
Thin–Film Technology Development
Increased Battery Power Capability

Battery Power Can be Increased/Optimized by introducing parallel stacks

Single Stack



Multiple Stacks in Parallel



- **Reduction in battery impedance by introducing more equivalent cell area which helps voltage regulation in high current applications**
- **Length/weight increased only slightly for additional thin-film stacks**
- **Length/weight increased dramatically for traditional pressed powder pellet stack because of pellet manufacturability**

Thin–Film Technology Development

Reduced battery weight and volume is beneficial for tight-tolerance / high-performance applications

- Traditional pellet battery designs are sometimes limited by manufacturability of pellets
  - Pellets are delicate if made too thin
  - Critical thickness based on pellet diameter
  - Result is batteries designed with excess capacity

- Thin-Film battery designs can use optimized cell thicknesses/weights because thinner cells can be easily manufactured
  - Critical thickness is based on the thin-film processing
  - Critical thickness is approached for thicker coatings
  - Lowered cell thickness/weight = lower battery height/weight
  - Reduction in materials used in batteries = lower material cost

Thin–Film Technology Development

Current Minimum Cell Thickness Comparison

Small Cell Diameter

	Pellet Th. (in.)	Thin Film Th. (in.)
SS Foil	0.001 (x 2)	0.001 (x 2)
Anode	0.007	0.003
Electrolyte	0.008	0.006
Cathode	0.004	0.003
Heat	0.010	0.009
Total Cell	0.031	0.023

← 25% →

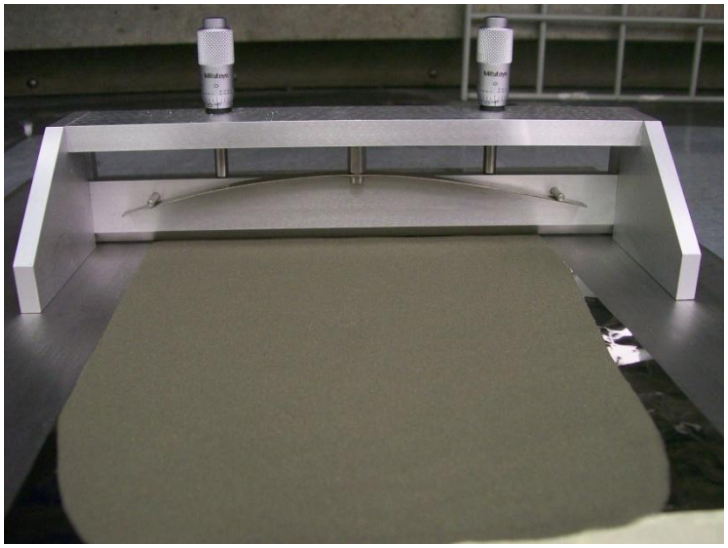
Thickness Savings

Medium Cell Diameter

	Pellet Th. (in.)	Thin Film Th. (in.)
SS Foil	0.003	0.002 (x 2)
Anode	0.014	0.003
Electrolyte	0.014	0.006
Cathode	0.014	0.003
Heat	0.016	0.011
Total Cell	0.061	0.027

← 55% →

Thin–Film Technology Development



Doctor Blade With Micrometer Setting for Hand Coating

Anode

Separator

Cathode

Heat

Conclusion

Goals Met – Fast Start, Smaller, Robust Battery

- Start Time (Preconditioned at -40°C)
  - Achieved 28ms for Pressed Pellet Battery (SN009)
  - 23ms for Thin Film Battery With Pellet Heat (SN022)
- Layer Thickness Reduced compared to Pellet by ~25%
- Battery height reduced from 2.0” to 1.4”
- Air Gun Testing (15,000g) with Thin-Film Battery at ARDEC – Successful

Path Forward

- Longer-Life Applications
- Process Industrialization
  - Transition to higher speed coaters, calendars and punching
- Thin-Film Heat Source
  - Investigations are underway to choose a heat source which is safe, performs well and is cost-effective

Acknowledgement

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Questions/Comments

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