Advances in Thin-Film Thermal Battery Processes: Performance and Cost Benefits
J. Reinig
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
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Ease of Handling

Ease of handling is increased with the addition of the binder
- Easier Storage Solutions
- Reduced Stacking Time
- Reduction in FOD
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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
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Improved Production Rate

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

- Lower Production Cost
- Better Surge Capability

Small Roll-to-Roll
Coating Equipment

Pellet Presses
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Improved Rise Time

Activation time determined by a multi-step process

- Activation of igniter or primer creates flame
- Heat pellets light and burn out
- Cells come to temperature
- Electrolyte melts

Lower Weight = Reduced Rise Time = Thin-Film Advantage

POWER IS AVAILABLE

0

0.002s

0.020 – 0.500s

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Improved Rise Time

Thin-Film vs Pellet battery

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.
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
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Increased Battery Power Capability

Battery Power Can be Increased/Optimized by introducing parallel stacks

- 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
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

<table>
<thead>
<tr>
<th></th>
<th>Small Cell Diameter</th>
<th>Medium Cell Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pellet Th. (in.)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS Foil</td>
<td>0.001 (x 2)</td>
<td>0.003</td>
</tr>
<tr>
<td>Anode</td>
<td>0.007</td>
<td>0.014</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>0.008</td>
<td>0.014</td>
</tr>
<tr>
<td>Cathode</td>
<td>0.004</td>
<td>0.014</td>
</tr>
<tr>
<td>Heat</td>
<td>0.010</td>
<td>0.016</td>
</tr>
<tr>
<td><strong>Total Cell</strong></td>
<td>0.031</td>
<td>0.061</td>
</tr>
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<td>0.003</td>
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<tr>
<td>Heat</td>
<td>0.009</td>
</tr>
<tr>
<td><strong>Total Cell</strong></td>
<td>0.023</td>
</tr>
</tbody>
</table>

**Thickness Savings**

- 25% (Small Cell Diameter)
- 55% (Medium Cell Diameter)
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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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Dr. Jahangir Rastegar, Rich Murray

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Emmanuel Durliat
Author Information

Jeffrey Reinig
Advanced Thermal Batteries
410-568-2217
Jeffrey.Reinig@atb-inc.com