Material Sector
Business Briefing
Separators SBU

September 8, 2016
Asahi Kasei Corp.
Separators SBU

Asahi Kasei Corporation

Separators SBU

- Planning & Coordination: Strategic business planning & analysis for separator
- Battery Materials Division: Hipore LIB separator
- Polypore International, LP: U.S. headquarters function
  - Celgard, LLC: Celgard LIB separator
  - Daramic, LLC: Daramic lead-acid battery separator
Overview of Polypore

**Acquisition of Polypore announced in February 2015 and closed in August 2015**

Pursuing growth strategy of battery separator business with high growth potential

- R&D and manufacturing technology
- Marketing
- Human resources and corporate culture

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**Polypore**

**Battery Separator Business***

<table>
<thead>
<tr>
<th>Segment</th>
<th>Net Sales (Million)</th>
<th>Operating Income (Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium-ion battery separator</td>
<td>$127</td>
<td>$87</td>
</tr>
<tr>
<td>Lead-acid battery separator</td>
<td>$323</td>
<td></td>
</tr>
</tbody>
</table>

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* Polypore’s Energy Storage Segment results in 2014.
**Integrate technology and marketing, accelerate delivery of value to customers**

- Shift from organizational integration to new value proposals for customers
- Utilize Asahi Kasei Group technology for materials, analysis, and manufacturing
- Optimize global manufacturing, marketing, and development configuration to meet customer needs

**HIPORE**
Wet-process Li-ion battery separator

- Presence and development strength in CE (consumer electronics)
- Continuing growth of IT-related markets

**CELGARD**
Dry-process Li-ion battery separator

- Strength in EDV (Electric Drive Vehicle) applications
- Rapid market expansion from stricter environmental regulation

**DARAMIC**
Lead-acid battery separator

- World-leading presence
- Stable market growth centering in emerging countries
- Market inflection with spread of ISS* vehicles

Solidify world-leading position through unique solution proposal ability having both wet and dry processes, with global manufacturing, marketing, and development configuration, meeting various customer needs

Strengthen customer support, capture demand in emerging markets, develop new products with group technology

**Pursue synergy between lead-acid and Li-ion battery separators**

*ISS = Idling stop and start*
## Technology innovation

<table>
<thead>
<tr>
<th>Technology</th>
<th>Innovation</th>
<th>Polypore</th>
<th>Asahi Kasei</th>
<th>Separators SBU</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithium-ion battery</td>
<td>Mono-PP and tri-layer separator</td>
<td>✓</td>
<td>—</td>
<td>✓</td>
<td>Utilization Rate</td>
</tr>
<tr>
<td></td>
<td>Dry-process coated separator</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet-process coated separator</td>
<td>—</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet-process PE separator</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Lead-acid battery</td>
<td>Current product (PE + silica)</td>
<td>✓</td>
<td>—</td>
<td>✓</td>
<td>Production Capacity</td>
</tr>
<tr>
<td></td>
<td>New product development</td>
<td></td>
<td>✓</td>
<td></td>
<td>New Product Sales Rate</td>
</tr>
<tr>
<td></td>
<td>Adjacency area</td>
<td></td>
<td>✓</td>
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* Analytical capability, material technology, electrochemistry.
1. Celgard

**EDV**\(^{*1}\): Dry-process coated separator
- Product development
  Commercial sample (sample products manufactured on mass production line) developed
  → ready for mass production
- Early start-up of Celgard commercial coating line
  Applied Hipore coating technology and know-how
  → commercial line in operation

**CE**\(^{*2}\): Technology and process innovation at Celgard Korea, Ltd.
- New products developed with sequential stretch process (wet)
  → ready for mass production
- Improved quality, productivity, and yield
  Applied Hipore production technology and know-how

\(^{*1}\) Electric Drive Vehicle
\(^{*2}\) Consumer Electronics
Technology innovation and business transformation (2)

2. Daramic

- Analysis by Asahi Kasei’s Analysis & Simulation Center
  - Analysis of quality flaws and mechanism of functional expression
    → opened path to new product development

- Process improvement by Asahi Kasei’s Corporate Production Technology
  - Improved quality, productivity, and yield
    → customer complaints resolved, sales increased

- New product development through procurement of high-quality, high-performance materials
  - Studying adoption of Asahi Kasei’s Sunfine ultrahigh molecular weight polyethylene
    → opened path to new product development

- Marketing and technical service in Japan by Asahi Kasei
  - Swiftly handling the Japanese market
    → ripple effect in Asian markets
3. Business transformation

- Cost reduction by revising Polypore’s corporate function
  - Administrative overhead
    → reduced by approximately half
  - Utilizing global infrastructure & professional functions
    → synergy within Asahi Kasei Group

- Leveraging Asahi Kasei’s purchasing power for global procurement and sourcing, Raw materials, logistics, etc.
  → cost reduction
  - Jointly accessing Japanese leading-edge equipment & machine manufacturers
    → high quality, state-of-the-art equipment and tooling
Our lead-acid battery separator business and lithium-ion battery separator business are both:

- The world’s **market pioneer**
- The world’s **technology leader**
- The world’s **top supplier**
The world’s market pioneer

- The world’s first mass production of the present battery separator
- Establishment of the *de facto* standard
  → technology and know-how accumulated over many years

**Lead-acid battery separator** (lead-acid battery invented by Gaston Planté in 1859)
  ▫ Daramic business founded in 1930
  ▫ Commercialized world’s first polyethylene separator in 1972

**Lithium-ion battery separator** (lithium-ion battery invented by Dr. Akira Yoshino in 1985)
  ▫ Celgard and Hipore each developed from late 1960s to early 1970s for various applications
  ▫ Celgard (polypropylene) and Hipore (polyethylene) were commercialized as lithium-ion battery separator in early 1990s
Characteristics of our separator business: Both lead-acid and lithium-ion (3)

The world’s **technology leader**

- **Product technology**
  
  Product design capabilities and processing know-how that contribute to improved battery performance

- **Production technology**
  
  High volume and reliable supply capability

- **Evaluation technology**
  
  Separator development backed by battery evaluation technology
Characteristics of our separator business: Both lead-acid and lithium-ion (4)

The world’s top supplier

Global manufacturing and R&D in proximity to local markets

- Lead-acid battery separator
  - Manufacturing: Europe (Germany, France), the US (Kentucky, Indiana), Asia (India, Thailand, China)
  - R&D: Europe (France), the US (Kentucky), Asia (India)

- Lithium-ion battery separator
  - Manufacturing: Asia (Japan, Korea, China), the US (North Carolina)
  - R&D: Asia (Japan, Korea), the US (North Carolina)
Characteristics of our separator business:
Both lead-acid and lithium-ion (5)

Our lead-acid battery separator business and lithium-ion battery separator business are both:

✓ The world’s market pioneer
✓ The world’s technology leader
✓ The world’s top supplier

Marketing: Quickly discerning market trends and technical requirements
R&D: Technology and know-how to meet requirements
Manufacturing: Providing stable supply at high quality and high volume
History of Hipore

1970s  Development and pilot line in Moriyama, Shiga, Japan
1980s  Commercialization and adoption for lithium primary batteries
1990s  Adoption for lithium-ion batteries
2000s  Rapid growth in lithium-ion batteries for laptop computers, expansion of capacity in Moriyama
2010s  Start-up of plants in Hyuga, Miyazaki, Japan and Pyeongtaek, Korea

- Invention of lithium-ion battery by Dr. Akira Yoshino
- Start of R&D
- Pilot line in Moriyama
- Start of sale for lithium primary batteries
- Start of sale for lithium-ion batteries
- 2012 China Plant (processing)
- 2011 Korea Plant (processing)
- 2010 Hyuga Plant

Sales volume

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<tr>
<td>Sales volume</td>
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History of Celgard

With more than 40 years of market-leading research, development, and manufacturing, Celgard delivers highly-engineered products with proven quality and performance.

- **1970s**: Development and production of Celgard film for lithium primary batteries begins. Charlotte, North Carolina facility is built. First microporous film patents granted in the late 1960s, leading to commercial sales of Celgard film. Film sold as key component in blood oxygenation devices.
- **1990s**: Entry into Lithium-ion battery market. Polypropylene/polyethylene trilayer is developed. First expansion of the Charlotte facility.
- **2000s**: Opportunities in EDV market allow Celgard to expand USA manufacturing. Concord, North Carolina facility is built; includes a new state-of-the-art battery testing lab.
- **2010s**:
For 86 years, Daramic has led the way in developing innovative technology for the lead-acid battery market.
Characteristics of our lithium-ion battery separator business

World’s leading capacity and track record of supply for both wet-process and dry-process

- Able to provide optimum separator for various battery designs and performance requirements
- Supply capability backed by product technology and manufacturing technology → producing and evaluating samples on commercial line (especially important for EDV applications)

Established capability from R&D to high-volume supply for both membrane manufacturing and coating

- Both wet-process and dry-process manufacturing technology with coating technology and high-volume track record for coating both wet-process and dry-process membrane → supplying higher added value products through collaboration with coating partners

Schematic illustration of coated separator supply chain
Lithium-ion battery separator manufacturing processes

**Features of wet-process separator**
Various control factors, e.g., plasticizer, polymer and stretching conditions, enable diverse design and control of pore structure. Thinner membrane formation is possible.

- Extrude the mixture of molten polymer and plasticizer and obtain the precursor film.
- Stretch and control the film structure. Bi-axial stretching in both machine and traverse directions is conventional.
- Extract the plasticizer and form the porous morphology.

**Features of dry-process separator**
No plasticizer extracting and treatment is necessary. Solvent free, simple process contributes to lower manufacturing cost.

- Heat up and melt the crystalline polymer and obtain the extruded film.
- Stretch the film to tear the crystalline interfaces, and form the porous structure.
Lithium-ion battery separators

**HIPORE** (wet process)
- N-series
- S-series
- Layered membrane
- Ceramic layer: Base film, Ceramic (Heat resistance)

**CELGARD** (dry process)
- Monolayer PP
- Trilayer PP/PE/PP
- Ceramic layer: Base film
- Polymer: Base film, Polymer (Adhesiveness)
- Combined: Base film, Ceramic layer (Heat resistance + adhesiveness)
Lithium-ion battery separator for EDV applications

<table>
<thead>
<tr>
<th>Cylindrical cells</th>
<th>Prismatic cells</th>
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<tbody>
<tr>
<td>Battery packs containing cylindrical cells are used by some vehicle manufacturers. (ex: Tesla, some Chinese electric bus manufacturers)</td>
<td>Electric vehicles typically contain a single battery pack containing several large-format prismatic cells which are configured into module packs.</td>
</tr>
</tbody>
</table>
LIB separator demand growth and capacity expansion

Demand forecast for LIB separator (Asahi Kasei estimate)

- Demand increase: CAGR approx. 20%
- CAGR approx. 30%
- CAGR approx. 3%

Asahi Kasei production capacity for LIB separator (planned as of May 2016)

<table>
<thead>
<tr>
<th>Location</th>
<th>Process</th>
<th>Capacity increase</th>
<th>Investment</th>
<th>Start-up</th>
</tr>
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<tbody>
<tr>
<td>Hyuga, Miyazaki, Japan</td>
<td>Wet</td>
<td>60 million m²/year</td>
<td>≈¥5 billion</td>
<td>Spring 2016</td>
</tr>
<tr>
<td>Moriyama, Shiga, Japan</td>
<td>Wet</td>
<td>60 million m²/year</td>
<td>≈¥6 billion</td>
<td>1H 2018</td>
</tr>
<tr>
<td>T.B.D.</td>
<td>Wet and Dry</td>
<td>500 million m²/year</td>
<td>¥15–20 billion</td>
<td>By 2020</td>
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Asahi Kasei’s LIB separator strengths and strategy

**Dry-process separator**

**Cost competitiveness:** Simple process (solvent-free), efficient investment for expansion

→ Expanding sales in fast-growing EDV market by leveraging capability for low cost and stable supply. Accelerating performance improvements by applying Asahi Kasei membrane design technology.

**Wet-process separator**

**Discerning and responding to leading-edge customer requirements:** Providing new products to leading-edge customers with accumulated technology

→ Landing big programs through investments to expand capacity and product enhancements.

**Synergy between dry-process and wet-process separators**

**Integrated marketing and R&D:** Gaining a comprehensive view of LIB separator requirements

→ Providing leading value to customers by having both dry-process and wet-process products.
Lead-acid battery structure

cell reaction:
\[ \text{Pb}(s) + \text{PbO}_2(s) + 2\text{HSO}_4^-(aq) + 2\text{H}^+(aq) \rightarrow 2\text{PbSO}_4(s) + 2\text{H}_2\text{O}(l) \]
Market leader in lead-acid batteries for automotive and industrial applications