Developing ambient lighting products for the next generation of vehicles

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Agenda

• Company overview
• Interior lighting research and trends
• Lighting requirements
• Developing ambient lighting products
  – Optical development
  – Electronic development
• Summary
Company at a Glance

Year Founded: 1899

2011 Sales: $6.9 billion

Employees: 45,000 Globally
  » U.S. & Canada  12,000
  » Europe  16,000
  » BRIC & ROW  17,000

Global Locations: 103 Manufacturing and 18 distribution sites operating worldwide in 34 countries

Research & Development: 17 Globally-networked technology centers in North America, Europe and Asia

Key Industries: Automotive, aerospace, energy, heavy-duty, industrial, marine, power generation, railway

Ticker Symbol: FDML – NASDAQ Global Select Market
Interior Lighting Research

Independent research has shown that ambient lighting has several significant positive influences on:

- Space perception
- Interior attractiveness
- Perceived safety
- Functionality
- Perceived interior quality

Source: The Society of Light and Lighting, Sage Publications
Interior Lighting Trends

OEM Objectives

• Differentiation
• Brand Cues
• Customer Satisfaction
• Customer Loyalty

Consumer Preferences

• Control
• Personalization
• Comfort

Photos courtesy netcarshow.com
Global Auto Interior Lighting Market

Million USD

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>$611</td>
</tr>
<tr>
<td>2012</td>
<td>$674</td>
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<td>2013</td>
<td>$701</td>
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CAGR: 5.8%

NOTE: Does not include Instrument Panel lighting

Source: Federal-Mogul and Global Insight
What is Ambient Lighting?

- **Directional**
- **Positional**
- **Ambient**
What is Ambient Lighting?

Colored mood lighting can fill the entire vehicle or just one area for a targeted emotional response.
Better ambient lighting is wanted and now expected by global consumers of automotive vehicles.

Innovative ambient lighting with new materials and integrated designs are the next wave in interior designs.

Ambient Lighting can be successfully used as a major differentiator for OEMs.
Ambient Lighting Requirements

- Keep maximum luminance under 0.1 cd/m²
- Disability and discomfort glare needs to be avoided
- Customer perception is very subjective
Developing Ambient Lighting

Starting Point
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Optical Development
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First Simulation
114.5 : 1 Uniformity
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1. Too much light extracted at the beginning of the pipe

2. Not enough light left to fill the rest of the light pipe
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Light traveling through the light pipe

Light extraction

Optics
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Simulation
2 : 1 Uniformity
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Final Simulation

Illuminance

Rendering
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Direct Illumination

Light Source

Higher light concentration

Lower light concentration

Target Area
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Chrome look by day, ambient lighting by night
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- LED lighting that uses NovaLens™ technology to allow usage of 12mm thick interior lighting modules
- 67% reduced height and 50% lower mass, allowing more styling options and more headroom
- 75% lower power consumption vs. incandescent
- Available immediately and currently under consideration at multiple OEMs
- Patented NovaLens™ technology directs and softens LED lighting to achieve desired lighting effects, with fewer LEDs

Simulation pattern showing impact of NovaLens™

Ultrathin LED Lamp

Typical Incandescent Lamp

36mm

12mm

Typical LED lighting pattern showing “hot spots”

More uniform light pattern

Fewer LED’s

NovaLens™ LED Diffusion technology
Developing Ambient Lighting Products

RGB LED

- RED
- GREEN
- BLUE
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1. PWM – Pulse-width modulator

**DISADVANTAGES**

- Extensive wire required throughout the vehicle
- Typically same light output on all nodes
- Overall light output from all ambient lighting is not homogenous
Developing Ambient Lighting Products

2. LIN (Local Interconnect Network) RGB

LIN RGB architecture combined with smart lighting modules reduces the wiring requirements for full vehicle electrical module management, resulting in fewer and lower gage wiring system requirements.
Developing Ambient Lighting Products
Summary

• Ambient lighting is essential for OEM branding and differentiation

• Optical development is critical for improved light output

• New electronics allow increased personalization and ensure a homogenous light output throughout the cabin even with different finishes and textures

• Exterior draws you to the showroom, but the interior closes the sale
Thank you for your time!

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