Agenda

• SEMI and LEDs
• Market Overview
• LED Manufacturing
• Summary
SEMI & LEDs

- **SEMI**: Global Association for the Microelectronics Supply Chain
  - 1900 member companies
  - Semiconductors, Solar PV, Display, LED, MEMS, Printed/Flex Electronics
  - Regional Advisory Committees

- **Major LED Events**:
  - 9th Annual LED Korea, co-located with SEMICON Korea (Feb. 4-6, 2015)
  - LED China 2015 Forum and Pavilion, SEMICON China (March 17-29, 2015)
  - LED Taiwan 2015, held in conjunction with the Taiwan Int’l Lighting Show (March 25-28, 2015)

- **Industry Research**: Opto/LED Fab Watch and Forecast
- **Manufacturing Standards development**
- **Public Policy**
LED Market Outlook
LEDs in Lighting

27% CAGR

US$ Millions

2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018

$4,443.16 | $8,300.44 | $11,348.34 | $14,137.40 | $14,609.09 | $14,920.10 | $15,255.86

Others | Lighting | Signage | Automotive Lighting | Mobile Devices | Backlight in Displays and Monitors

Strategies Unlimited

PennWell
Packaged LED Revenue Growth by Applications

Source: Strategies Unlimited
LED Luminaire Markets by Regions

Luminares shipment revenue ($B)

- Eastern Europe
- Japan
- Western Europe
- North America
- Middle East and Africa
- Rest of Asia Pacific
- Latin America
- China

Source: Strategies Unlimited
LED Capacity and Investment Outlook
Revenue Trend of Taiwan LED Suppliers

Combined Monthly Revenues- 3 Mo. Avg. (Epistar, Forepi, Lextar, Everlight, and Unity Opto)

CAGR 111% from 2010 to 2014

Source: Company Data, Compiled by SEMI
LED Dedicated Fabs
Changing LED Landscape

<table>
<thead>
<tr>
<th>Year (begin operation)</th>
<th>2001</th>
<th>2008</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total count of LED fabs*</td>
<td>36</td>
<td>103</td>
<td>172</td>
</tr>
<tr>
<td>Capacity in 4-inch EQs w/m</td>
<td>127,124</td>
<td>501,250</td>
<td>(144 EPI) ~3,500,000</td>
</tr>
</tbody>
</table>

*Fab number includes both LED epitaxy and chip facilities.

Source: SEMI Opto/LED Fab Forecast, February 2015
LED Capacity Trend – World & China

LED Epitaxy capacity (4” equivalent per month)

Source: SEMI Opto/LED Fab Forecast, February 2015
LED Fab Capacity by Region, 2015

Worldwide LED Epitaxy capacity to reach 3.1 M in 2015 (4” equivalent per month)

Source: SEMI Opto/LED Fab Forecast, February 2015
LED Epitaxy Wafer Size Transition

2012 Epi Capacity

- 50% 2"
- 30% 3"
- 17% 4"
- 3% 6"
- 3% 8"

2015 Epi Capacity

- 32% 2"
- 26% 3"
- 39% 4"
- 1% 6"
- 2% 8"

Source: SEMI Opto/LED Fab Forecast, February 2015
LED Wafer Fab Equipment Spending

Source: SEMI Opto/LED Fab Forecast, February 2015
Equipment Spending by Region
China contributes about 45% of the investment in 2015

Source: SEMI Opto/LED Fab Forecast, February 2015
China MOCVD Market

Source: SEMI China, 2014
LED manufacturing remains the largest market for sapphire.

Mobile and wearable devices is expected to take more share in the near future.

Source: SEMI China, 2015
### The Trend of Localization

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Trend</th>
<th>Material</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOCVD</td>
<td></td>
<td>MO</td>
<td>↑</td>
</tr>
<tr>
<td>Etch</td>
<td>↑</td>
<td>Ammonia</td>
<td>--</td>
</tr>
<tr>
<td>PECVD</td>
<td></td>
<td>Photoresist</td>
<td>↑</td>
</tr>
<tr>
<td>Lithography</td>
<td></td>
<td>Silicone Encapsulant</td>
<td>↑</td>
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<tr>
<td>Track</td>
<td>↑</td>
<td>Bonding Wire</td>
<td>↑</td>
</tr>
<tr>
<td>Die Bonding</td>
<td>↑</td>
<td>Phosphor</td>
<td>↑</td>
</tr>
<tr>
<td>Wire Bonding</td>
<td>↑</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: SEMI China, 2014

### MO Region Share

- **2008**:
  - Overseas: 90%
  - Local: 10%

- **2013**:
  - Overseas: 35%
  - Local: 65%

Dow, Albemarle … Phasing out in China
Summary

- From backlighting to lighting: LED lighting is expected to surpass backlight in terms of shipment this year.
- Fab investment is expected to rebound this year thanks to fast adoption of LED in lighting. China is the driving force of the new investment this year and next.
- 4” production to become mainstream this year. 6” production is expected to see more traction at tier 1 & 2 suppliers.
- MOCVD market are seeing healthy growth this year, fueled by throughput and uniformity improvement from new models.
- The rise of mid-power LEDs will help China suppliers enter more lighting application markets.