Trends in the industry and a perspective from Asia

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Some things change, some stay the same...

**Changed:**
- IP
- IoT is a real thing
- Spectral modification looks promising
- Two tiers of quality
- Supply chain uncertainty
- Regulatory help
- UV applications beginning to take shape

**Same:**
- IP
- Binning
- Drive for lower cost
Recent IP Enforcements

**TIER 1**
- Major LED Companies

**TIER 2**
- LED Makers (Lacking Patent Portfolios)

**CUSTOMER**
- Downstream Sellers

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Nichia Files Four New Patent Infringement Suits against U.S. TV Makers and LED Distributors

Matching Nature Spectrum With LED

Spectrum closer to the natural sunlight

(CRI Typ. 97)
UV LED Roadmap Coming Together

**Direction of development**

- **Industrial**
  - Black light (Forensic, Nightclub, Blood sugar)
  - Stepper (PCB)
  - Hardening (Paints/Coating/Ink/Resin)

- **Residential**
  - Mosquito Trap
  - Tanning
  - Photo catalyst purification
  - Surface / Space purification
  - Water purification

- **Bio**
  - Medical
  - Bio
  - Horticulture
  - NEW

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**UV LED Applications**

- **Curing**
- **Exposure Equip.**
- **Printing**
- **Multi Surface Disinfection**
- **Water Disinfection**
- **Air Purifier for Automotive**
- **Bio / Medical Device**
Two Tiers of Quality?

- Different performance (LPW)
- Different Lumen Maintenance
- Different LED solution
- Different cost

<table>
<thead>
<tr>
<th>#</th>
<th>Category</th>
<th>General Application</th>
<th>Minimum Light Output (lm)</th>
<th>Minimum Efficacy (lm/W)</th>
<th>Minimum Warranty (years)</th>
<th>Minimum Efficacy (lm/W)</th>
<th>Minimum Warranty (years)</th>
<th>CCT / CRI / L70</th>
<th>Primary Use***</th>
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<tbody>
<tr>
<td>1</td>
<td>Outdoor</td>
<td>Low Output</td>
<td>250-5,000</td>
<td>90</td>
<td>5</td>
<td>110</td>
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<td>2</td>
<td>Outdoor</td>
<td>Mid Output</td>
<td>5,000-10,000</td>
<td>95</td>
<td>5</td>
<td>115</td>
<td>5</td>
<td>≤5700 / ≥65 / ≥50,000</td>
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<td>3</td>
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<td>High Output</td>
<td>10,000-30,000</td>
<td>100</td>
<td>5</td>
<td>120</td>
<td>5</td>
<td>≤5700 / ≥65 / ≥36,000 / ≥50,000</td>
<td>Outdoor Pole/Arm-Mounted Area and Roadway Luminaires</td>
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<tr>
<td>4</td>
<td>Outdoor</td>
<td>Very High Output*</td>
<td>≥30,000</td>
<td>100</td>
<td>120</td>
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<td></td>
<td>Parking garage luminaires</td>
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</tbody>
</table>

***Outdoor Pole/Arm-Mounted Area and Roadway Luminaires
- Outdoor Pole/Arm-Mounted Decorative Luminaires
- Outdoor Full-Cutoff Wall-Mounted Area Luminaires
- Outdoor Non-Cutoff and Semi-Cutoff Wall-Mounted Area Luminaires
- Bollards
- Parking Garage Luminaires
- Fuel Pump Canopy Luminaires
- Landscape/Accent Flood and Spot Luminaires
- Architectural Flood and Spot Luminaires
- Stairwell and Passageway Luminaires
- Specialty:______
## Supply Chain Consolidation

<table>
<thead>
<tr>
<th>Year /Month</th>
<th>Buyer</th>
<th>Target</th>
<th>Buyer's Ventures</th>
<th>Target's Ventures</th>
<th>Acquired Stake</th>
<th>Status</th>
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<tbody>
<tr>
<td>2016.12</td>
<td>Grand Chip Investment</td>
<td>Axitron</td>
<td>Chinese Investor</td>
<td>MOCVD Maker</td>
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<td>Halted</td>
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<td>2016.11</td>
<td>IDG Capital (incl. MLS)</td>
<td>Osram Ledvence</td>
<td>Consortium</td>
<td>LED application</td>
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<td>Under review</td>
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<td>2016.03</td>
<td>San'an Opto</td>
<td>GCS Holdings</td>
<td>LED chip</td>
<td>Wafer Foundry</td>
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<td>Halted</td>
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<td>2016.03</td>
<td>MLS</td>
<td>Super Trend Lighting</td>
<td>LED packaging, application</td>
<td>Filament Bulb</td>
<td>80.00%</td>
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<tr>
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<td>MLS</td>
<td>Kaistar Lighting</td>
<td>LED packaging, application</td>
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<td>2015.07</td>
<td>Xinda</td>
<td>Glory Sky</td>
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<td>2015.07</td>
<td>Kaistar Lighting</td>
<td>Bridgelux</td>
<td>LED chip</td>
<td>LED chip, packaging</td>
<td>100.00%</td>
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<tr>
<td>2015.06</td>
<td>Refond</td>
<td>LT Photoelectricity</td>
<td>LED packaging</td>
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<td>85.00%</td>
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<tr>
<td>2015.06</td>
<td>Nationstar</td>
<td>Invenlux Technology</td>
<td>LED chip, packaging</td>
<td>LED chip</td>
<td>62.50%</td>
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<tr>
<td>2015.04</td>
<td>Go Scale Capital</td>
<td>Lumileds</td>
<td>Private Equity Firm</td>
<td>LED packaging</td>
<td>80.10%</td>
<td>Halted/Apollo Capital acquired 2016.12</td>
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<tr>
<td>2015.04</td>
<td>Hua Tian Technology</td>
<td>MIC LED Light</td>
<td>Industry Outsider</td>
<td>LED packaging</td>
<td>51.00%</td>
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Source: Recent Acquisitions and Merger in Chinese LED Industry by LEDinside, Sept. 2015 & Various Sources
Musical Channels

- Old Order
- New Order

Apr 28, 2016
May 4, 2016
July 21, 2016
Regulatory Help

Obama set to block sale of German LED equipment maker to China

Published on: December 2, 2016
By Mark Haiper
Contributing Editor, LEDs Magazine, and Business/Energy/Technology Journalist

Aixtron develops deposition gear in California. Its acquisition by Fujian Grand Chip is in doubt out of national security concerns.

Another day, another Chinese takeover of a Western LED technology company in doubt, as US President Barack Obama looks set to block the acquisition of German manufacturing equipment maker Aixtron SE by a unit of Fujian Grand Chip Investment Fund LP, out of national security concerns.

German Government Puts Chinese Consortium Acquisition of Osram’s LEDVANCE on Hold

The German government has temporarily halted Chinese consortium headed by strategic investor IDG Co Partners (IDG) to acquire Osram’s general lighting business LEDVANCE, and have put the deal under review, Reuters cited German magazine WirtschaftsWoche recent report.

IDG and lighting partner Forest Lighting (also known as MLS) proposed acquisition of Osram for EUR 4 billion (US $4.395 billion) has been delayed over financial issues, according to the magazine this could be cleared by German authority for another three to four months before it would be cleared by German authority.

Philips and GO Scale Capital led Consortium Terminate Lumileds Transaction

Royal Philips announced that Philips and GO Scale Capital have terminated the agreement pursuant to which the consortium led by GO Scale Capital would acquire an 80.1% interest in Lumileds.

- Parties withdraw CFIUS filling and terminate agreement, because of inability to resolve CFIUS unforeseen concerns
- Philips is engaging with other parties that have expressed an interest in the Lumileds business
- Termination of the agreement does not impact Philips’ separation process

Despite the extensive efforts of Philips and GO Scale Capital to mitigate the concerns of the Committee on Foreign Investment in the United States (CFIUS), regulatory clearance has not been granted for this particular transaction.
Price Continues to Decline

ASP Declines, 2014-2015

*Strategies Unlimited ’16 The Worldwide Market for LEDs*
But We May Be Finding a Bottom…

Chinese LED Package Price Surge at Record Rate

Early in May, Luxlite, Epistar’s sole distributor in China, has sent out an announcement of price adjustment, listing a number of reasons for price increase, including continuously increased raw materials and manpower costs.

(Official announcements from Luxlite, Smalit and Rishang regarding the rise of LED package price)

Chinese LED chips manufacturers San’an Opto and HC Semitek followed suit Epistar’s lead in raising LED chip prices, which was considered as an early sign of recovery from the heated price war since 2014. Major LED package manufacturers including Smalit, Honglitronic, Xuyu Optoelectronics, and SAMSUNG have announced to raise price this week.

http://www.ledinside.com/node/26718
Cost Savings Through Manufacturing

- World-class manufacturing cost basis
- Chip P&T and packaging
- Opening March 2017

Hanam (Near Hanoi City)
Cost Saving Through Innovation

Next Generation of LED – Truly Packageless

- Drops in to standard 3535 HP sockets
  - Significantly brighter, lower cost
  - 18% smaller
  - Standard pick and place recipes
  - Great thermal performance
  - No change in TIR optic
  - >100% better color over angle (u’– v’)
  - +9K hrs LM80
Summary

• Many changes
• Many constants
• Cost reductions have been breathtaking but the low hanging fruit may soon be gone
• Uncertainty in the supply chain
  – Consolidation has started in China
  – Several of the major LED suppliers are making major structural changes;
  – Distribution channel is maturing
• Innovation will continue to be the real engine to enable new cost points and new applications
• The companies, shareholders who pay for that innovation should be repaid for their investment