



LED Packaging

From “One Size Fits All” to “Application Specific”

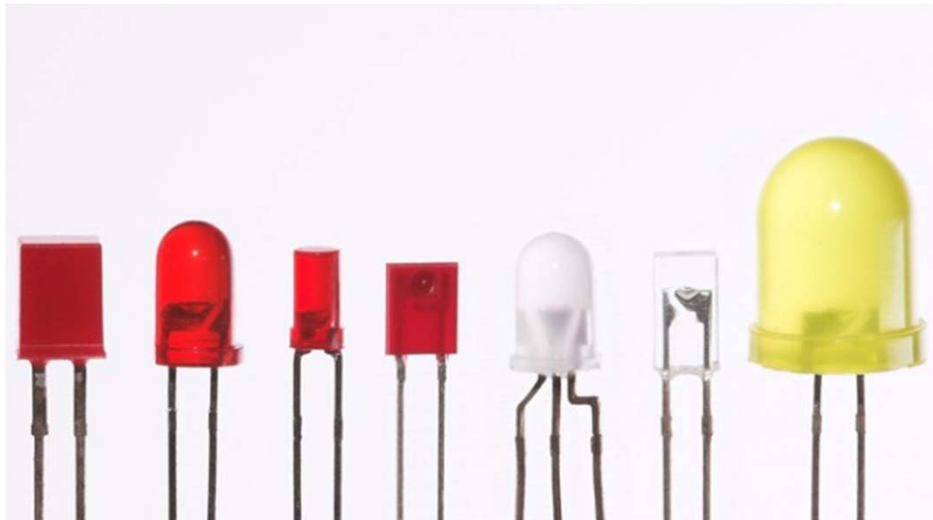
Ron Bonné, L.C.,

Philips Lumileds Lighting Company

ECTC 2013 LED Panel; Las Vegas, May 28, 2013

A Decade Ago...

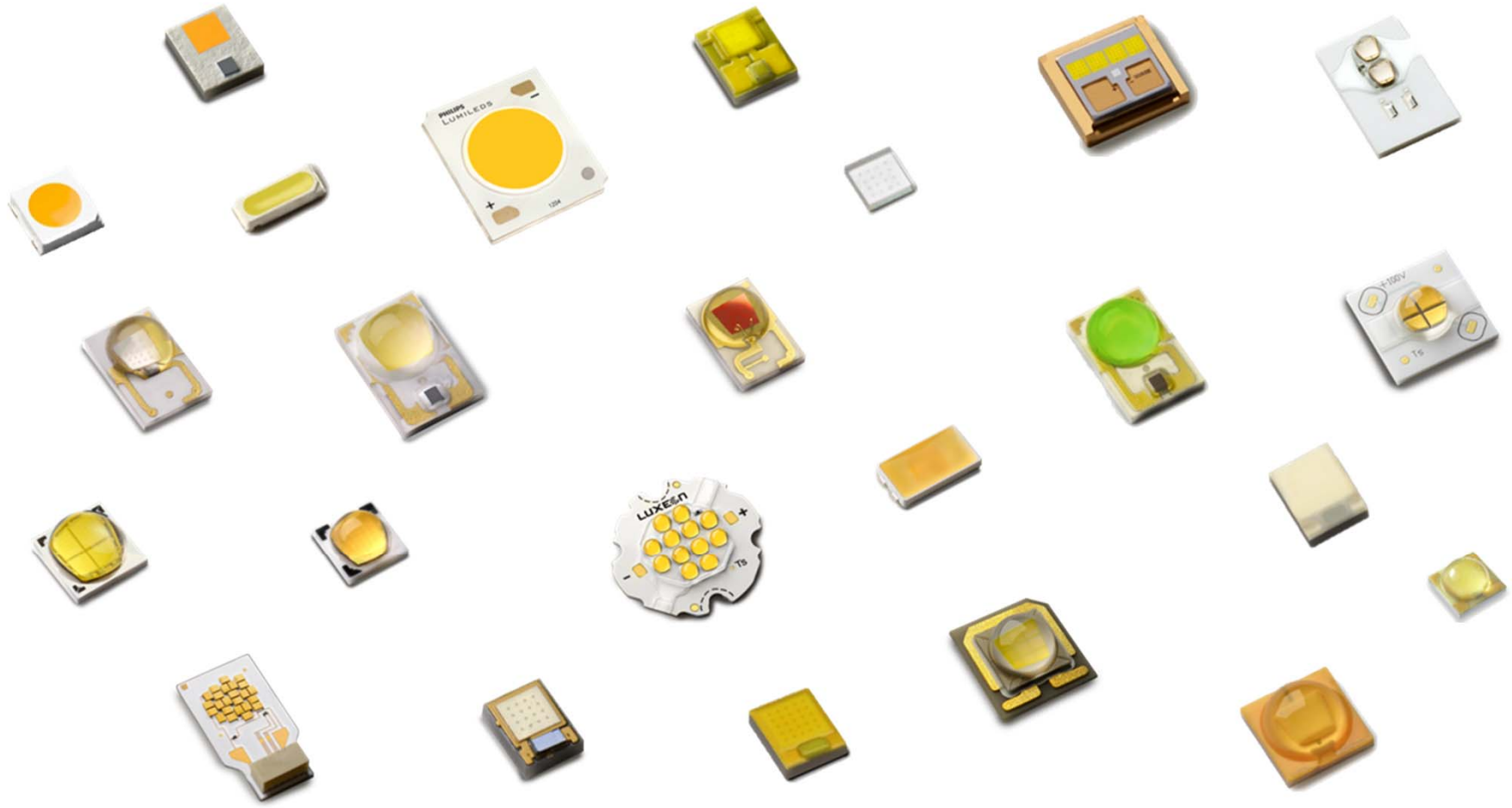
Indicator LEDs



“Power” LEDs



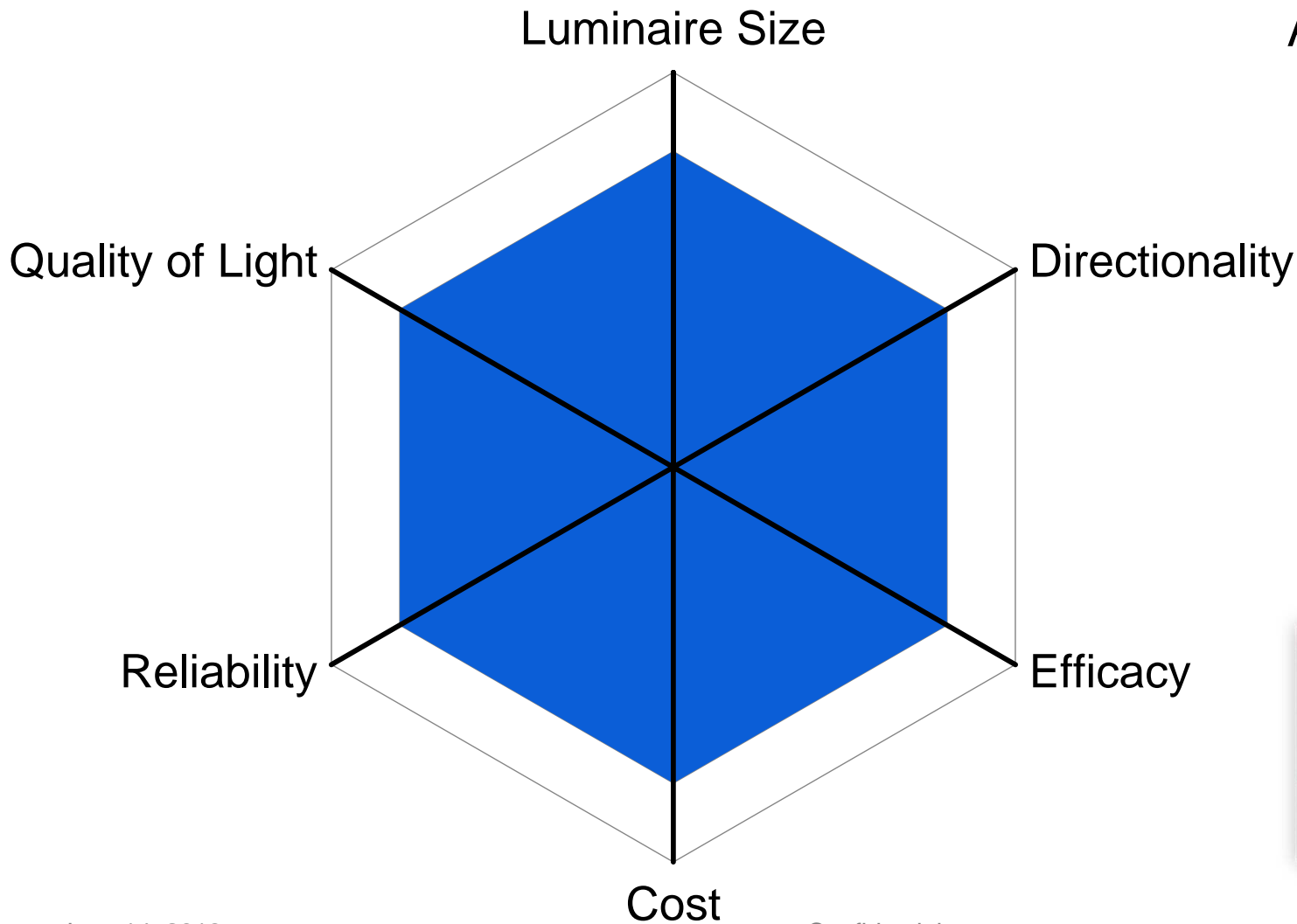
Now...





Application Considerations

- Illumination

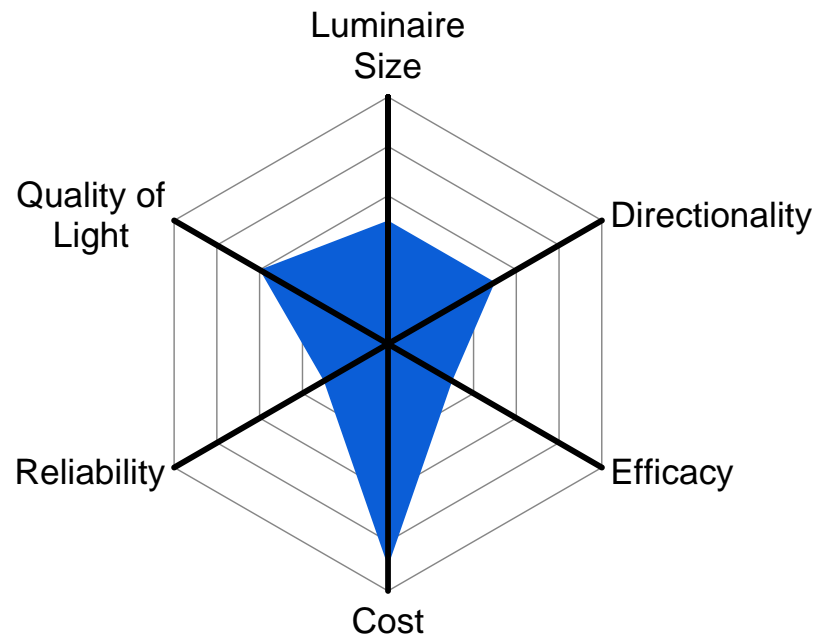


- Specific Applications

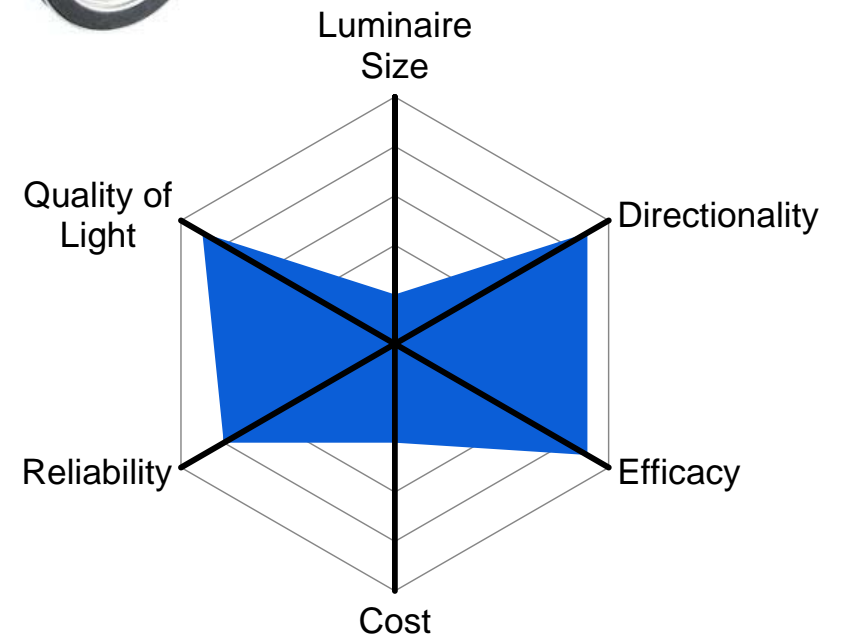


Examples

▪ Bollard



▪ Retail Spot Light

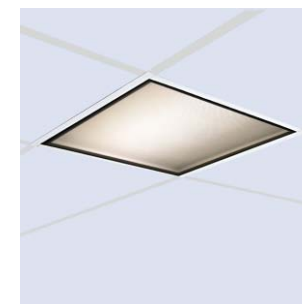


Luminaire Size

Small



Large



- High Packing Density
- Package almost “die” sized
- Low R_{th}



- Large array for high uniformity
- Mid/Low Power
- Low Cost/Package

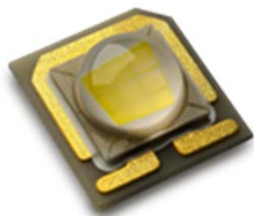


Directionality

High



- Small Source Size
- CBCP Important



Low



- Source Size not relevant
- Smooth distribution

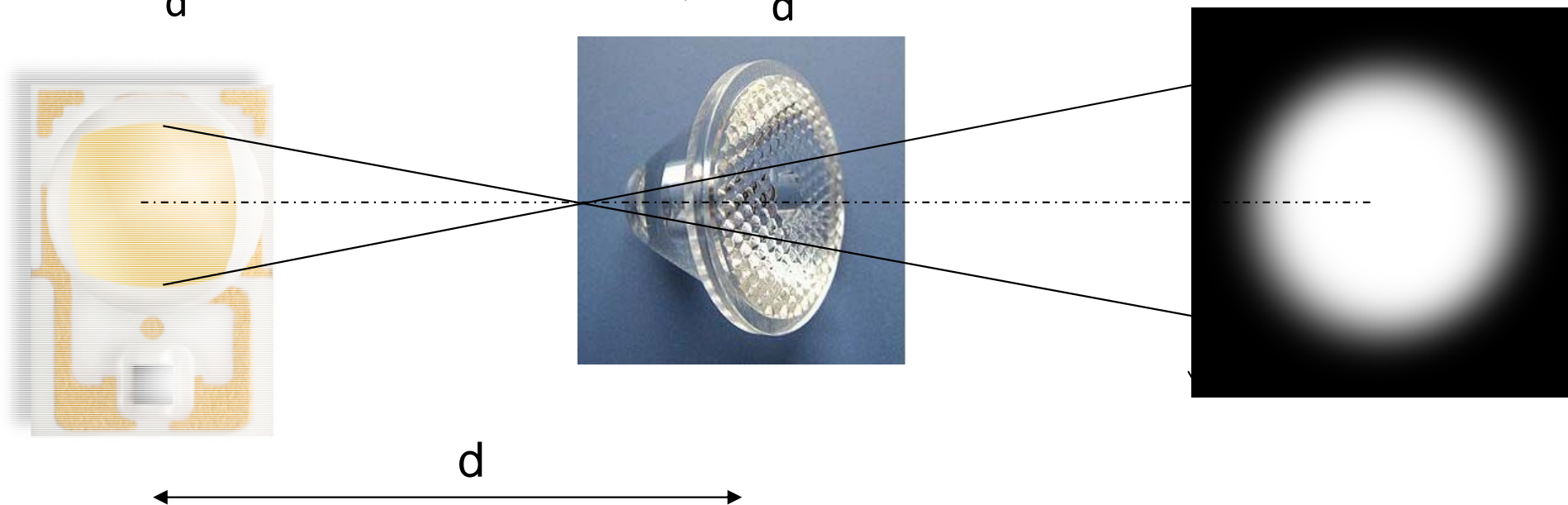


Directionality - Etendue

- LED Source Size Determines Size of Optical System

$$\Omega_{\alpha} = \frac{A_{LED}}{d^2}$$

$$\Omega_{\beta} = \frac{A_{Lens}}{d^2}$$



$$\frac{A_{LED}}{\Omega_{\alpha}} = d^2 = \frac{A_{lens}}{\Omega_{\beta}} \Rightarrow \Omega_{\beta} A_{LED} = \Omega_{\alpha} A_{lens}$$

Source Etendue = System Etendue



Efficacy

- Factors into Total Cost of Ownership
- Trade-Off with Cost, Quality of Light
- Optical and Electrical System Interaction
 - High Voltage Die with Class 1 Driver
 - Un-Domed LEDs with Small Reflector Optics
- Determined by:
 - Internal Quantum Efficiency of Die
 - Conversion Efficiency of Phosphor
 - Extraction Efficiency of Package



Cost

- Expressed as:

- lm/\$

- lm/W/\$

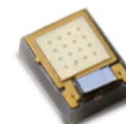
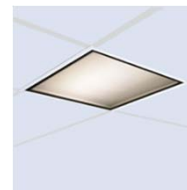
- Initial Cost

- Lifetime Total Cost of Ownership

- Interaction with System

- Drive Electronics – HV Die

- Optical System – Domeless LED



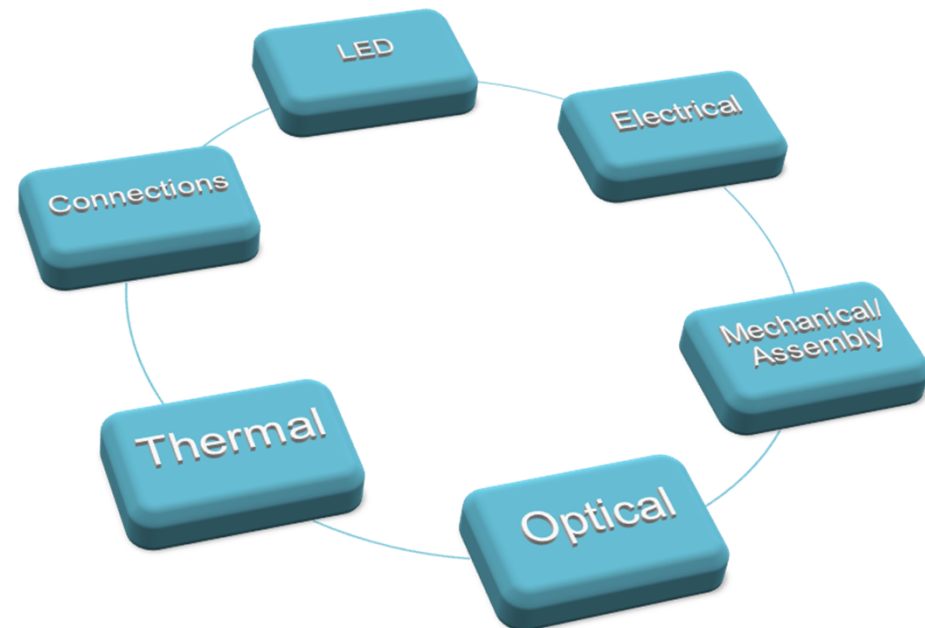


Reliability

- BxxLyy
 - Lyy: Light Output as % of 0-hours Considered as Failing
 - Bxx: % of Fixture Population At or Below the Lyy Failure Criterium
 - Example: B10L80 = 50,000 hours

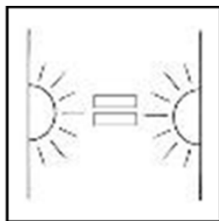
- Other Considerations

- Color Shift
- Catastrophic Failures
- Failure Mode (Open/Short)
- System Reliability
 - Solder Joints
 - Interconnects
 - Drivers

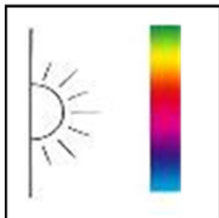




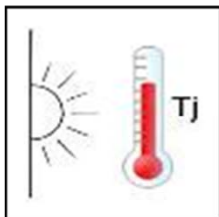
Quality of Light



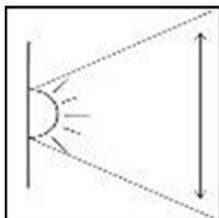
LED to LED consistency
Freedom From Binning



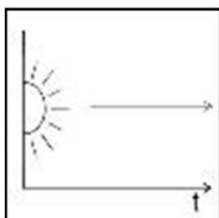
Color Rendering
CRI and R9



Color in application
Hot Testing and Specification

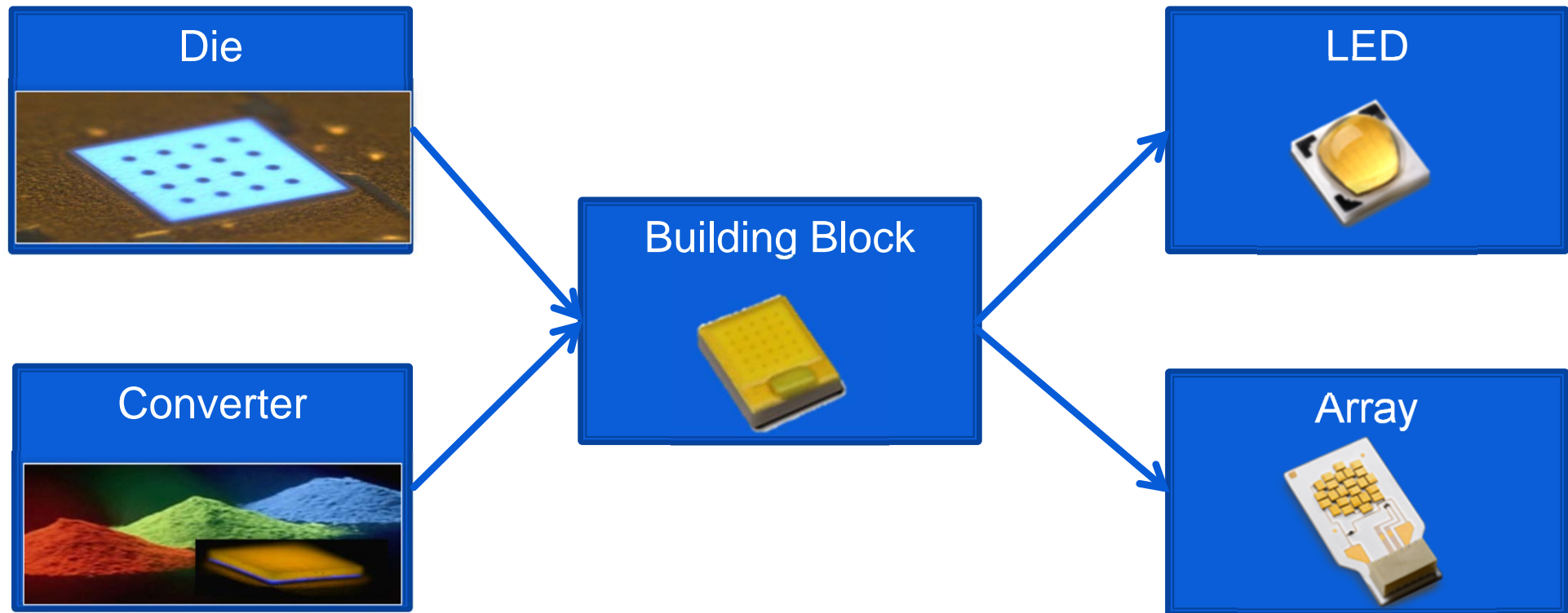


Uniform beam color
Color over angle



Color consistency over time
Color shift per LM-80

LED Packaging – Building Block Approach





LED Packaging - Developments

- Explosive Growth in Mid and Low Power Devices

- Proliferation of LED Arrays and Chip-On-Board Products

- Novel Solutions
 - Dome-Less LEDs
 - Forward Voltages 3...200V
 - Narrow-Band Red Phosphors
 - New Epi and Package Substrates

