Integration of LEDs and electronics

Wouter Soer
Philips Lumileds
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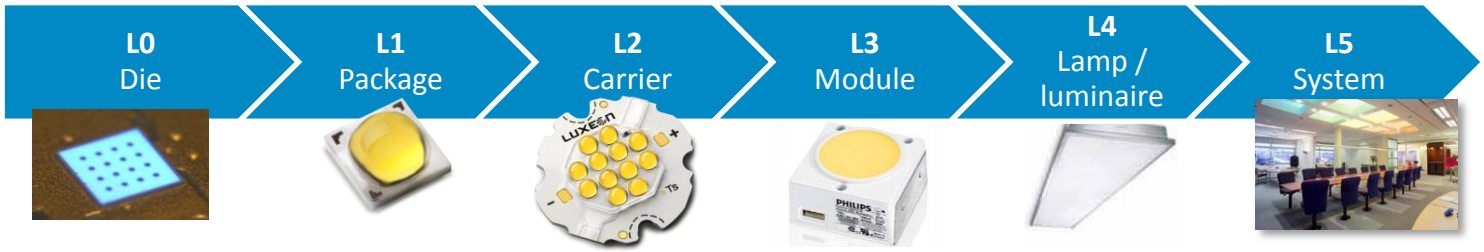
The LED system ladder



Why is the industry organized along these levels?

- Established manufacturing capabilities
- Simple design with modular standardized components
- Low SKU count
- Easily adaptable to regional requirements

Why will it be more integrated in the future?

- System cost reduction
  - Better utilization, less redundancy, lower BOM
- System performance improvement
  - Fewer interfaces, tighter specs, new architecture options

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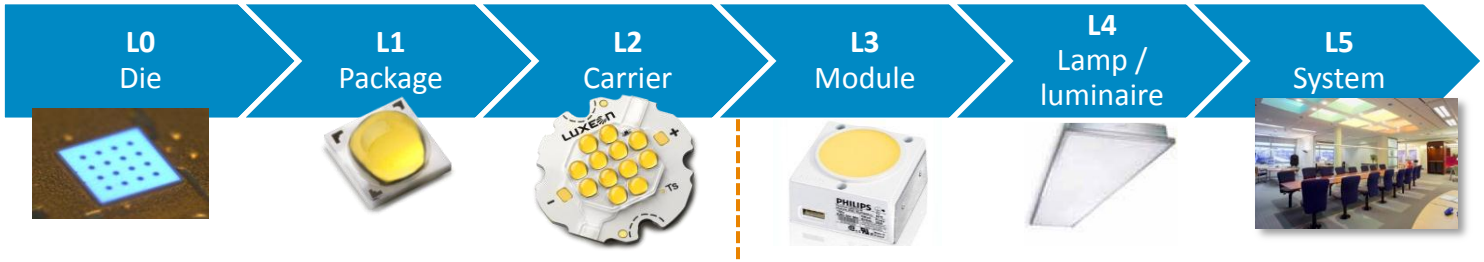
LEDs and electronics



Current status

Interface between LEDs and electronics

- Forward voltage range
- Forward current range
- Flux, efficiency
- Tolerances and distributions
- Peak voltage / current rating

- Footprint and layout
- Electrical connections
- # of channels and drive requirements
- Thermal management
- …

Target

Improve system cost and performance by better integration

Two examples:

1. Hybrid light engines with integrated color control
2. High voltage light engines with integrated driver

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Hybrid light engine

Phosphor-converted and direct-emitting LEDs in a single light engine

Today

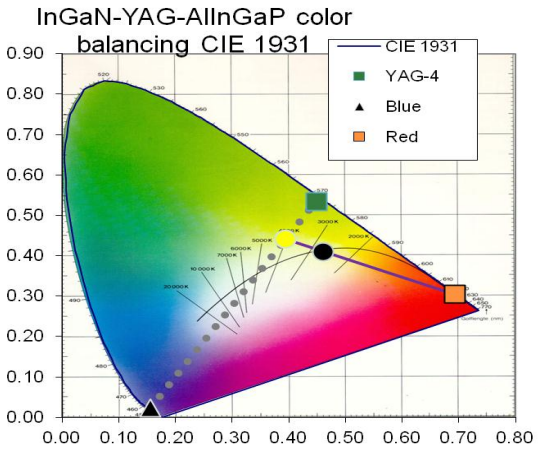
High efficiency at CRI>90
with off-white InGaN
and direct red AlInGaP LEDs

Future

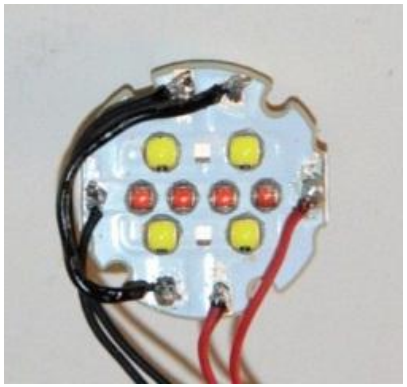
High efficiency for all CRIs
and color tunable products

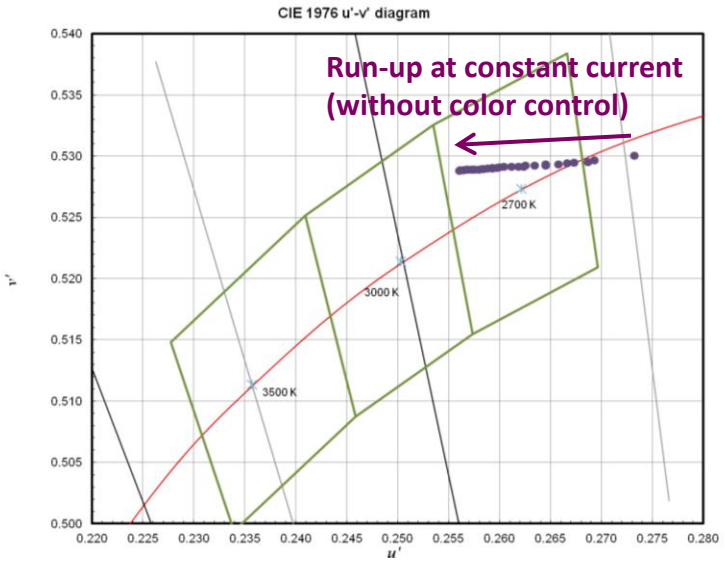
Challenge: color control

InGaN and AlInGaP LEDs show different behavior as function of current and temperature



140 lm/W at 700 lm,
3000K/90CRI, 85°C





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Hybrid light engine with integrated color control electronics

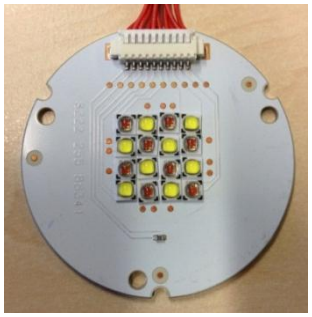
Benefits of integration

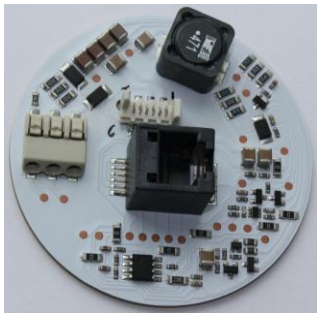
Cost:

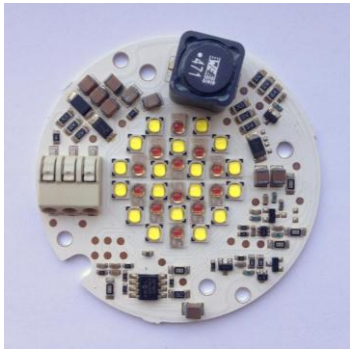
- Simplifies higher level system design and allows for use of standard drivers
- Utilizes test data already available – eliminates test redundancy
- Avoids unnecessary specs on LEDs – better use of production distribution

Performance:

- More accurate control by co-location of sensors and LEDs







See demo and poster #9:
High Power Warm White Hybrid LED Package for Illumination

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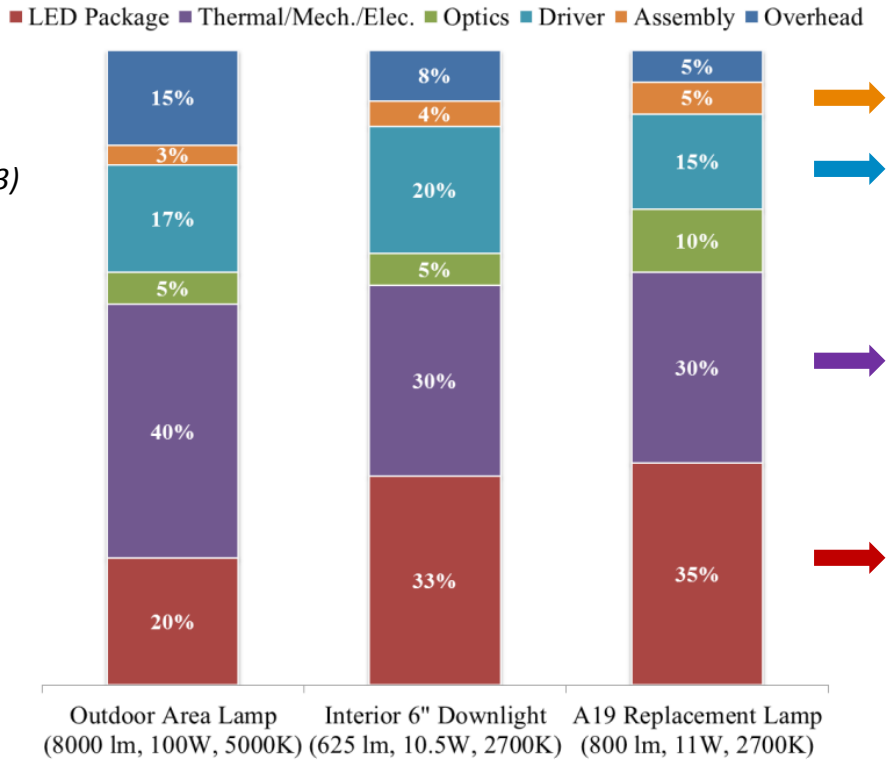
Driver integration

System cost reduction will drive a higher level of driver integration

- LED cost is now similar to cost of other system components
- Further system cost reduction will be realized by optimization of the whole system

From DOE SSL Manufacturing Roadmap (2013)



Driver integration enables…

→ Simpler assembly process

→ Lower driver BOM

→
- Simpler luminaire design
- Lower-cost housing
- More space for low-cost heat sink

→ LED array package cost reduction

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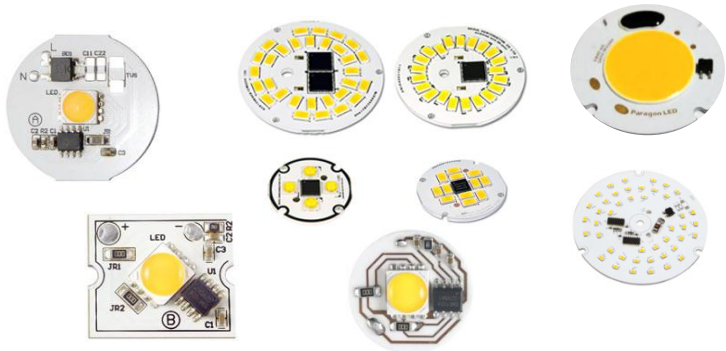
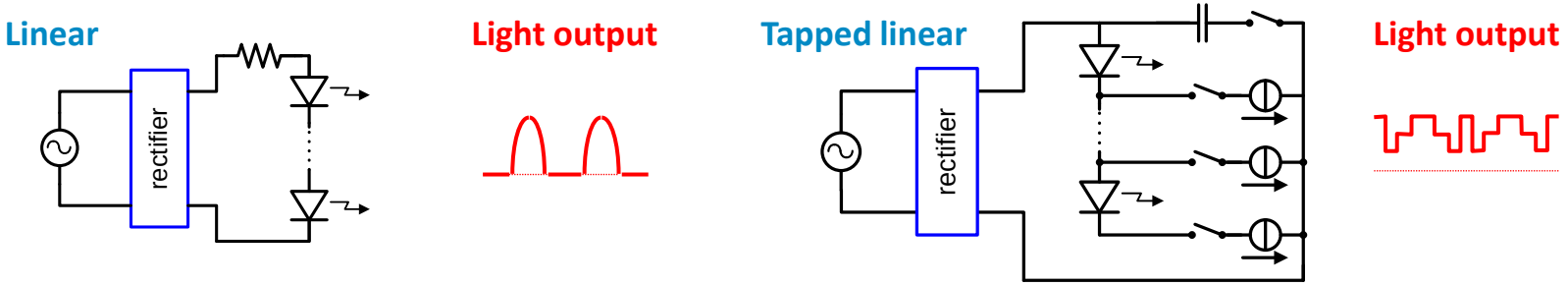
Current driver-integrated products

Various products on the market today

- AC-LEDs with integrated rectifying diodes
- Arrays with integrated (tapped) linear driver





Benefits

- Small size (easy to integrate)
- Low electronics BOM
- High power quality
- No electrolytic capacitors → long lifetime

Limitations

- Flicker
- Lack of Vf flexibility
- No integrated surge protection
- No universal mains voltage
- …

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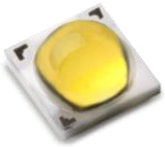
Future driver-integrated products

R&D challenges and opportunities

- Integrated architectures optimized for key application requirements
  - Efficiency, power quality, thermal performance, isolation (safety), line transients, LED ripple, dimming control, ease of configurability, …

- Driver integration with both high-power and mid-power LEDs
  - Enabling a wide range of applications
  - Requires a set of LED building blocks with range of forward voltages
    - E.g. for high-power:



LUXEON T/TX (**3V**)

LUXEON T (**6V**)

LUXEON T (**12V**)

LUXEON H50-2 (**50V**)

- Universal mains voltage
- Peak and transient current/voltage mitigation
- Additional functions for on-board electronics

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Conclusion

Better integration of LED lighting systems enables system cost reduction beyond individual optimization of system functions

Integration of LEDs and electronics enables

- System cost reduction
  - Better utilization, less redundancy, lower BOM (on all system levels)
- System performance improvement
  - Fewer interfaces, new architecture options

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Thank you