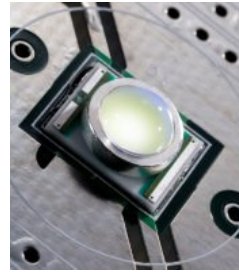




Light Emitting Diodes: Technology Update

Carol Jones
PNNL
June 15, 2006



Cree, Inc.

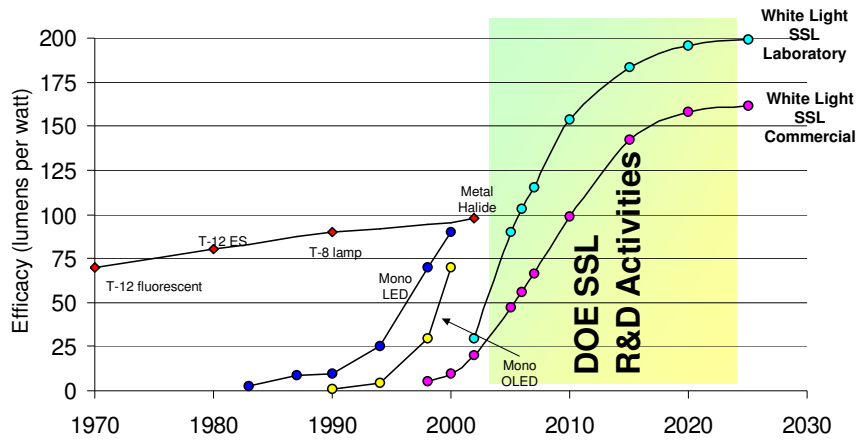


Outline

- **Energy efficiency of white LEDs**
 - R&D targets
 - Source vs system efficacy
 - Important caveats and trade-offs
- **Test procedures and standards**
- **Niche application products**



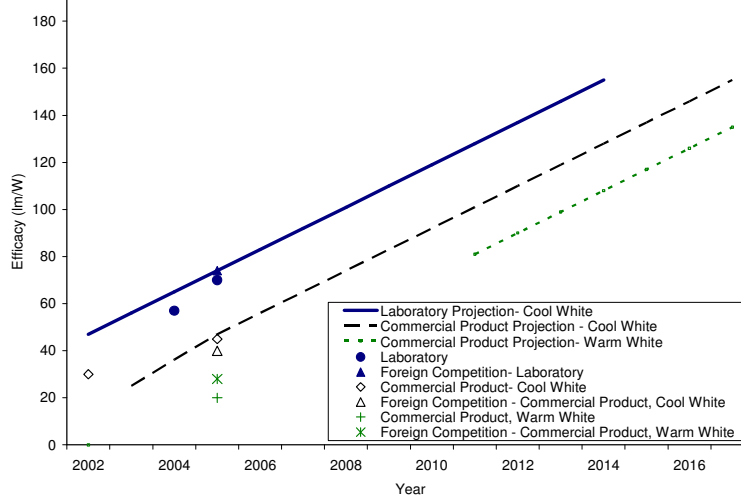
White Light SSL



SSL Laboratory and Commercial Curves, revised September 2004



White Light Efficacy Targets

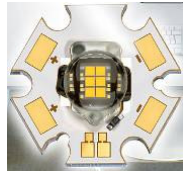


Note: Efficacy projections assume CRI=70 → 80, Color temperature = 5000-6000°K, 350ma drive current, and lamp-level specification only (driver/luminaire not included), reasonable lamp life.

Source: DOE SSL Multi-Year Program Plan, March 2006



New LEDs and Packages



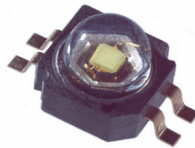
Osram OSTAR



Cree XLamp



Lighting Services Inc.



Luxeon K2



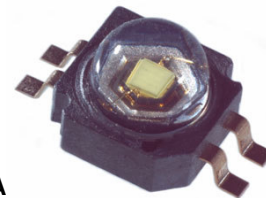
Lamina Ceramics

5



LED Source Efficacy

- **Philips Lumileds Luxeon K2**
 - 45-60 lumens at 350 mA
 - 1.2 watts and 38-50 lpw
 - 100-120 lumens at 1000 mA
 - 3.72 watts and 27-32 lpw
 - 25% efficacy decrease compared to 350 mA
 - High CCT: 6500 K
 - CRI = 70
 - Max temp rating 185 C



Luxeon K2

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LED Source Efficacy

- Cree XLamp 7090 XR
 - 350 mA drive current
 - 5000-10000 K: 33-56 lpw
 - 3500-5000 K: 33-47 lpw
 - 2600-3500 K: 25-43 lpw
 - CRI in the 70s



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Comparing System Efficacy

- ENERGY STAR lighting specs based on system (lamp+ballast) efficacy
 - Minimum 50 lpw
- LED drivers typically 85% efficient
 - High CCT white LEDs: ~40 lpw
 - Warm white LEDs: ~25 lpw
 - Warm white high CRI LEDs: ~17 lpw



+



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Color Quality

- High efficacy LEDs are high CCT (5000 K +)
- Warm white only marginally more efficacious than incandescent
- What is acceptable color for the application?



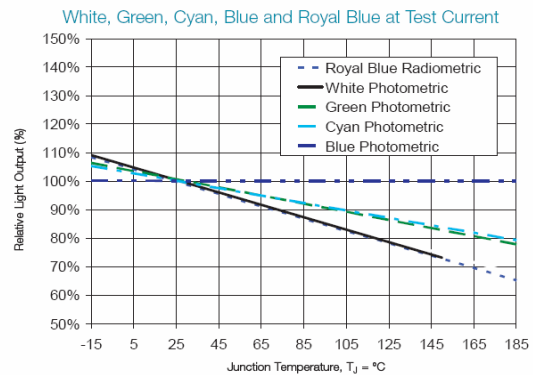
GELcore



Thermal Effects

Typical Light Output Characteristics over Temperature

- Typical lumens based on pulse at 25 C
- Operating temp under constant current typically around 90 C
- Some manufacturers recommend 10% lumen discount for heat

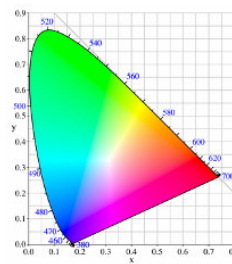


Source: Luxeon K2 Datasheet DS51 5/06



LED Test Procedures

- **Test procedures under development**
 - Total luminous flux
 - Luminous intensity
 - Color (CCT, CRI)
 - Electrical (voltage, current, power)
 - Life testing/estimating
- **March 1 Standards Workshop**
 - IESNA, NIST, NEMA, IEC, CIE, ANSI
 - Provisional/interim test procedures



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Applications

- **Directed light applications**
 - Task lighting
 - Display cases
- **Source relatively close to illuminated surface**
- **Relatively modest illuminance requirements**

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Refrigerated Case Lights



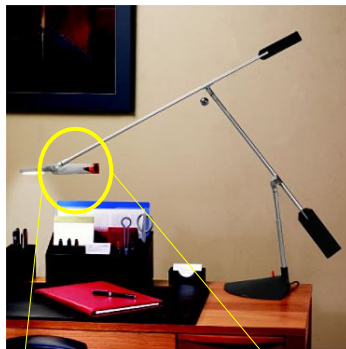
GELcore



Nualight



Portable Desk/Task



Lucesco Halley



Herman Miller Leaf





Undercabinet Lights



Albeo



Cyberlux



Color Kinetics



Alkco

15



Downlights



American Fluorescent



Permlight

- Product testing needed
- LED chip efficacy not conclusive
- Thermal management critical
 - Especially in insulated ceilings

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