Intematix Corporation

Energy-efficient lighting through materials innovation

Intematix Introduction

Focus	Energy-efficient lighting through materials innovation
Core Capability	Proprietary and proven materials design platform • 5x – 10x faster than traditional method Complex design of multi LED chips on ceramic or metal substrates
Business Model	Develop disruptive functional materials for energy efficient lighting Expanding business through subsidiaries and OEM manufacturing Engage strategic partners for custom solutions
Product Lines	Phosphors, LED components and LED modules for high quality lighting
Intellectual Property	~200 US patents or patent applications filed Key patents on Combinatorial material methods, LED phosphors, LED lighting, and Li-ion battery electrode materials
Employees	Over 200 full-time employees, including 20 PhD's US Headquarters, Taiwan Technology Center, China Manufacturing and Sales, Europe
Venture Capital	Draper Fisher Jurvetson, Crosslink Capital, Pacifica Fund, East Gate Capital, and other strategic investors in Japan, Taiwan and Korea

Draper Fisher Jurvetson

CROSSLINK CAPITAL

EAST GATE CAPITAL

PACIFICA FUND

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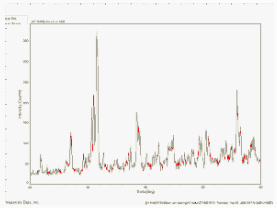
Accelerating Materials Discovery

Traditional Method

Traditional method tests one combination at a time





Materials R&D → **Prototype** → **Manufacturing & Marketing**

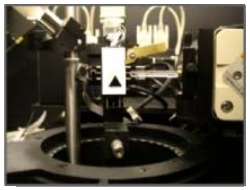
Intematix Method

Materials R&D/ Prototype

Manufacturing & Marketing

Months

Intematix method tests millions of combinations at a time

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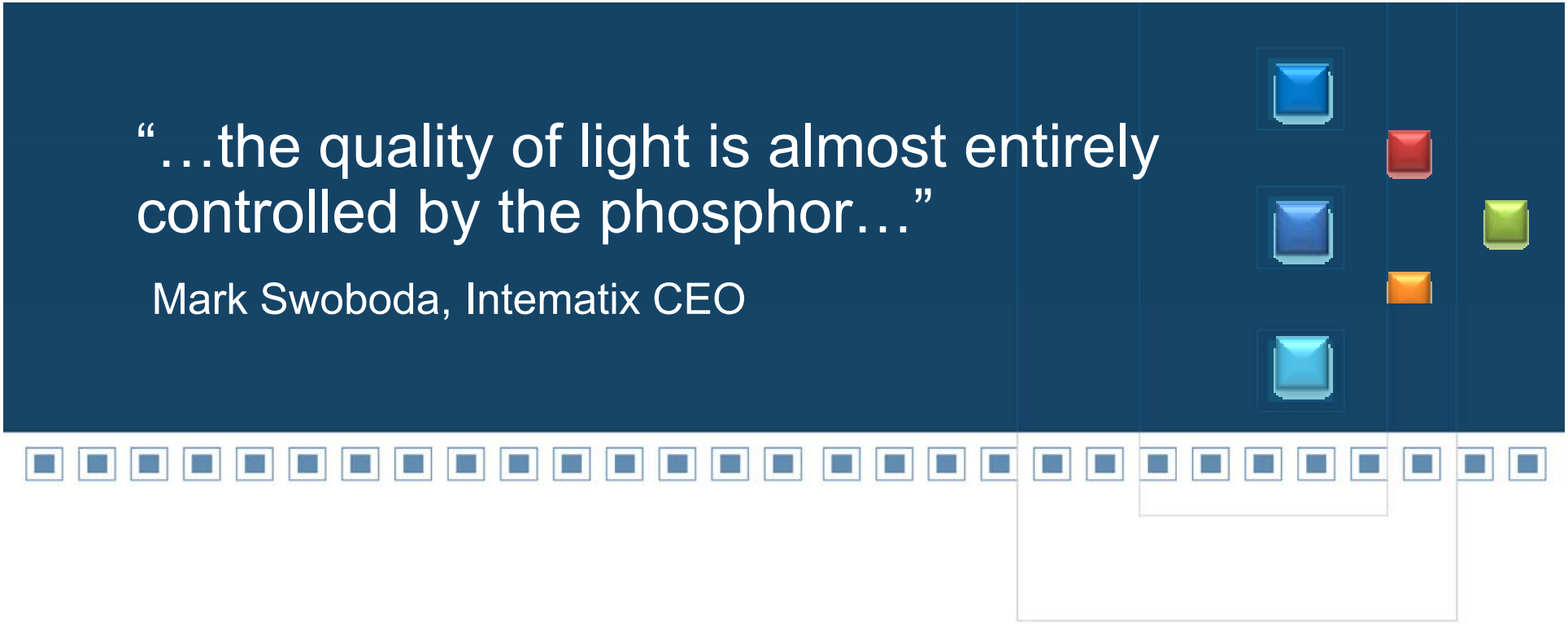
LED Phosphor Market Demand

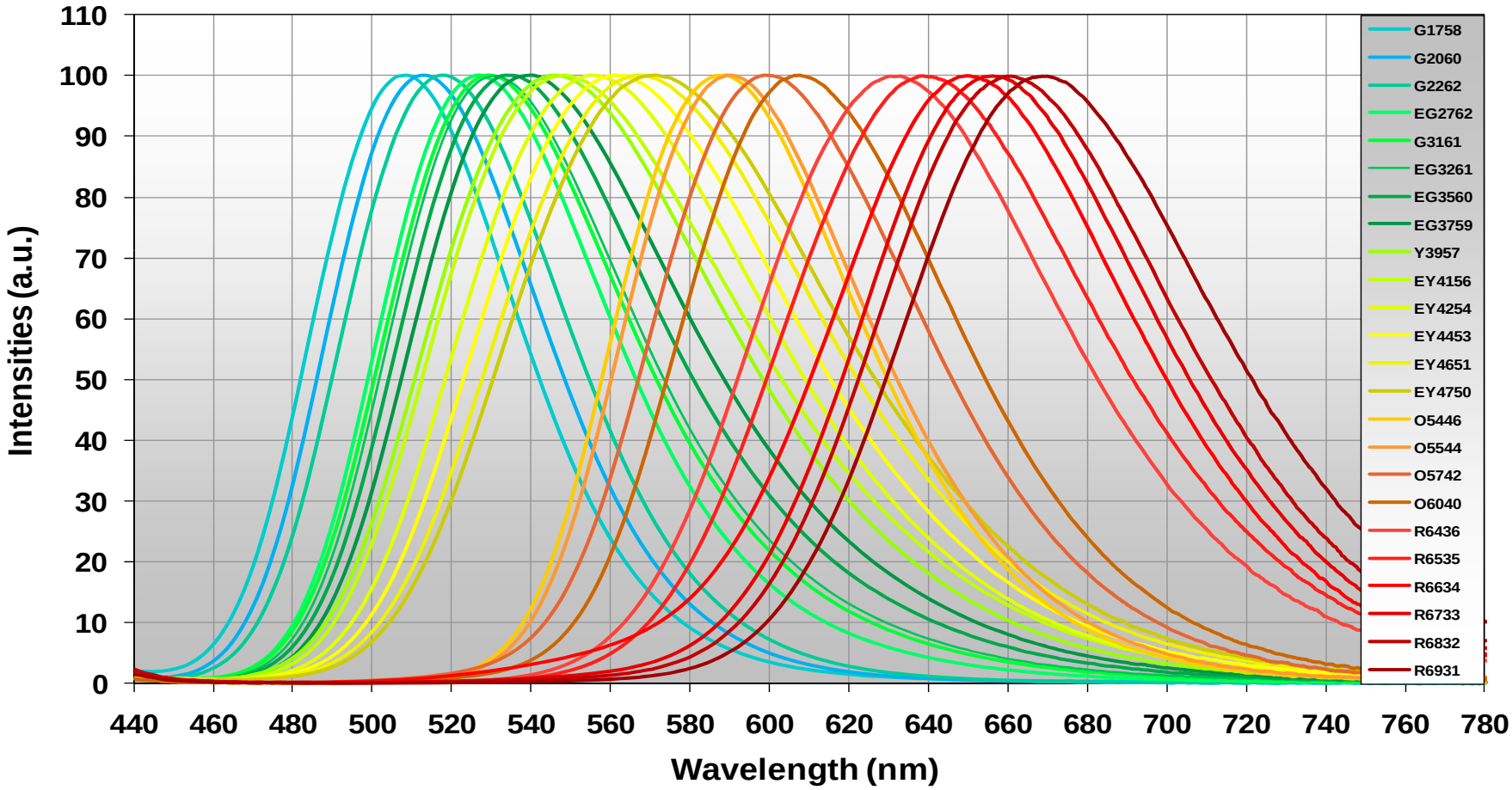
- Phosphor demand is anticipated to increase 5 ½ times over the next 5 years
- Small area displays, automotive lighting, laptops, desktop displays and mobile applications are expected to show only minimal gains
- The primary increase will be seen in LED TV and general lighting applications

“…the quality of light is almost entirely controlled by the phosphor…”

Mark Swoboda, Intematix CEO



Scope of LED Phosphor Offerings



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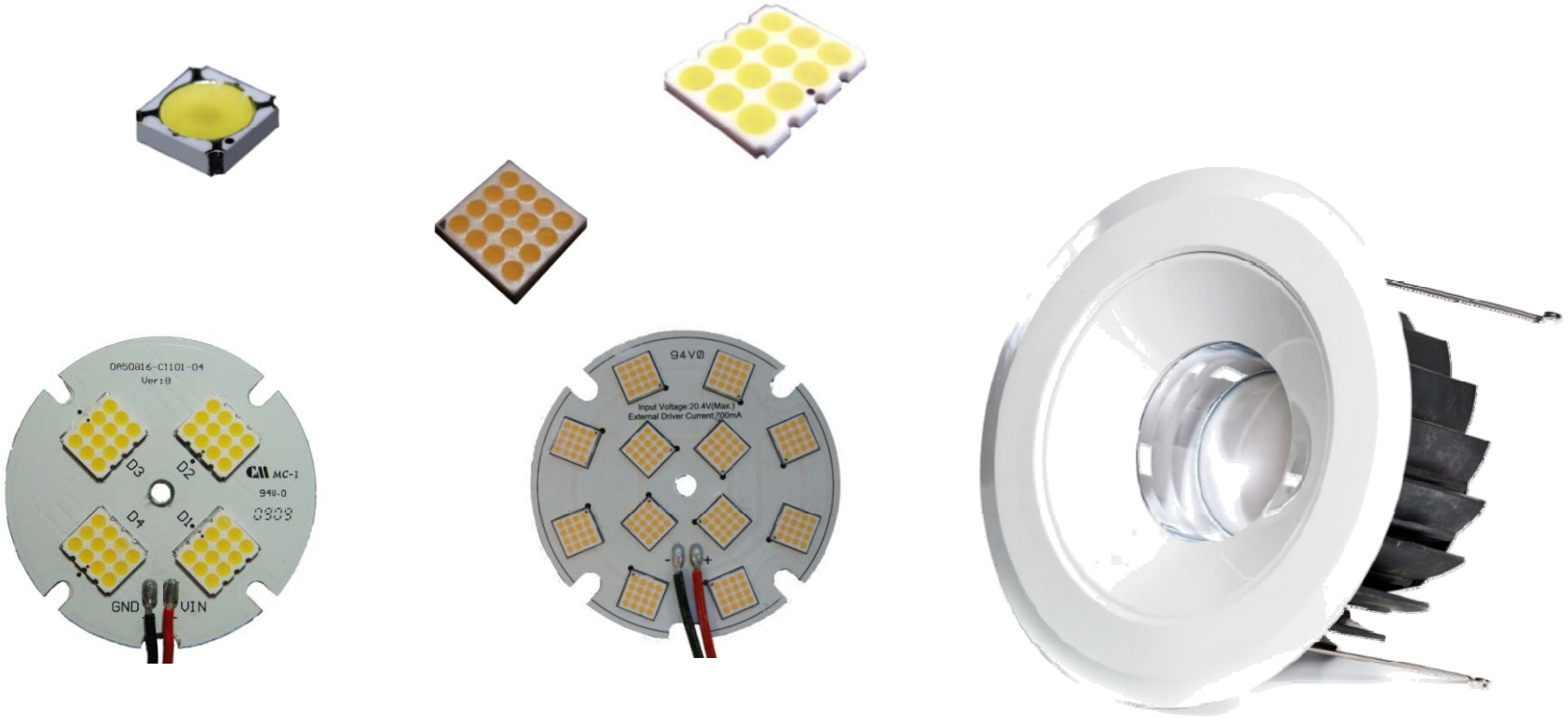
Intematix LED Offerings

- Intematix gained insight into market needs when it began packaging LEDs, and creating reference designs



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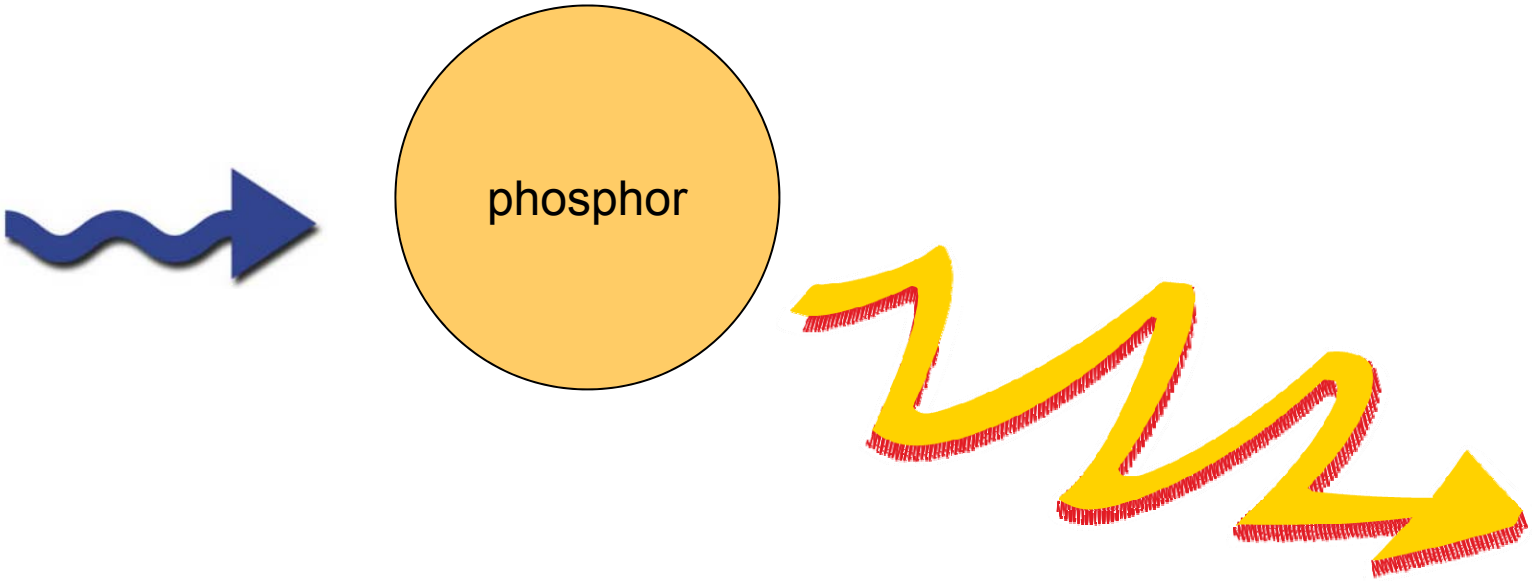
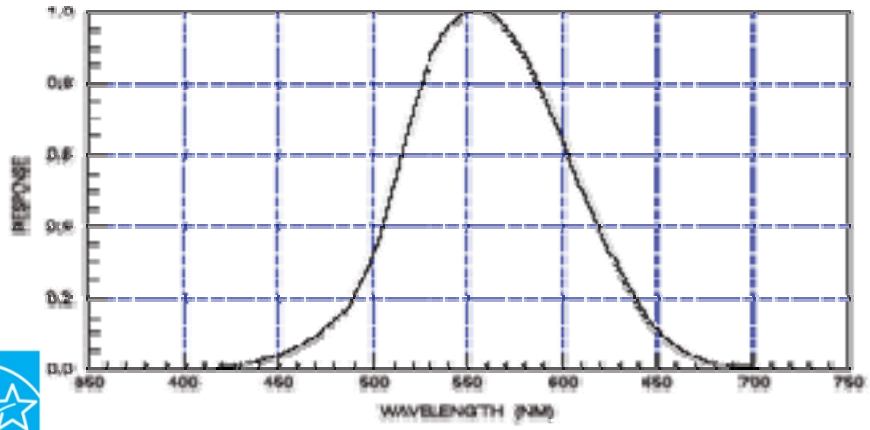
What Is A Phosphor

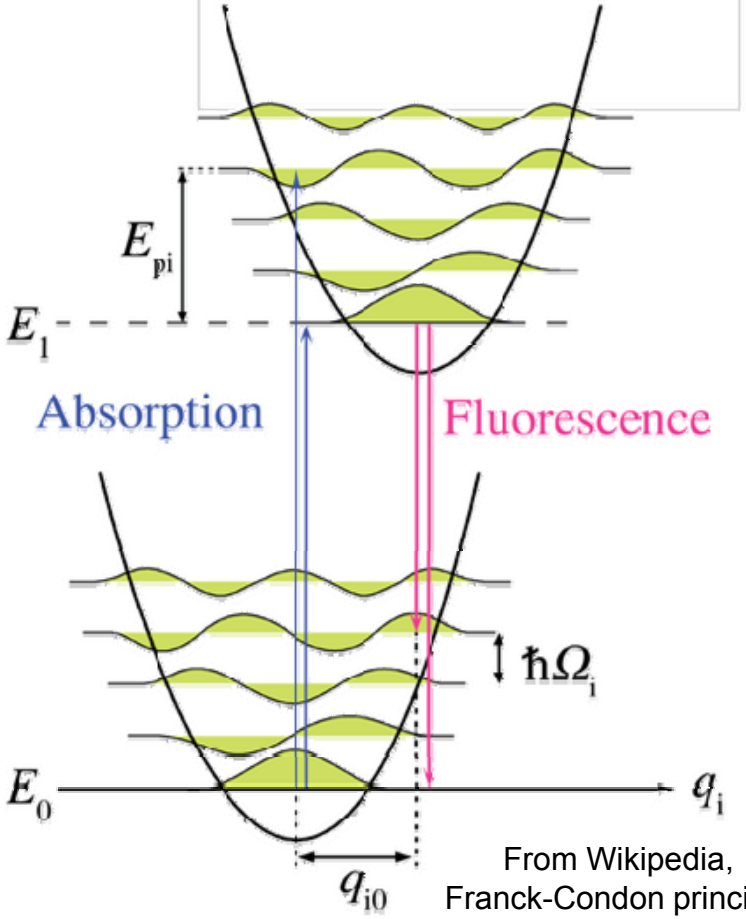
- A material that absorbs a photon of one wavelength and emits a photon of another wavelength



How It Works/Terminology

- Quantum Yield/Efficiency
  - Photons in → Photons out
- Stokes Shift (Loss)
  - Energy loss between the photon in and the photon out
- Lumen
  - Power of Light perceived by the human eye





From Wikipedia, Franck-Condon principle

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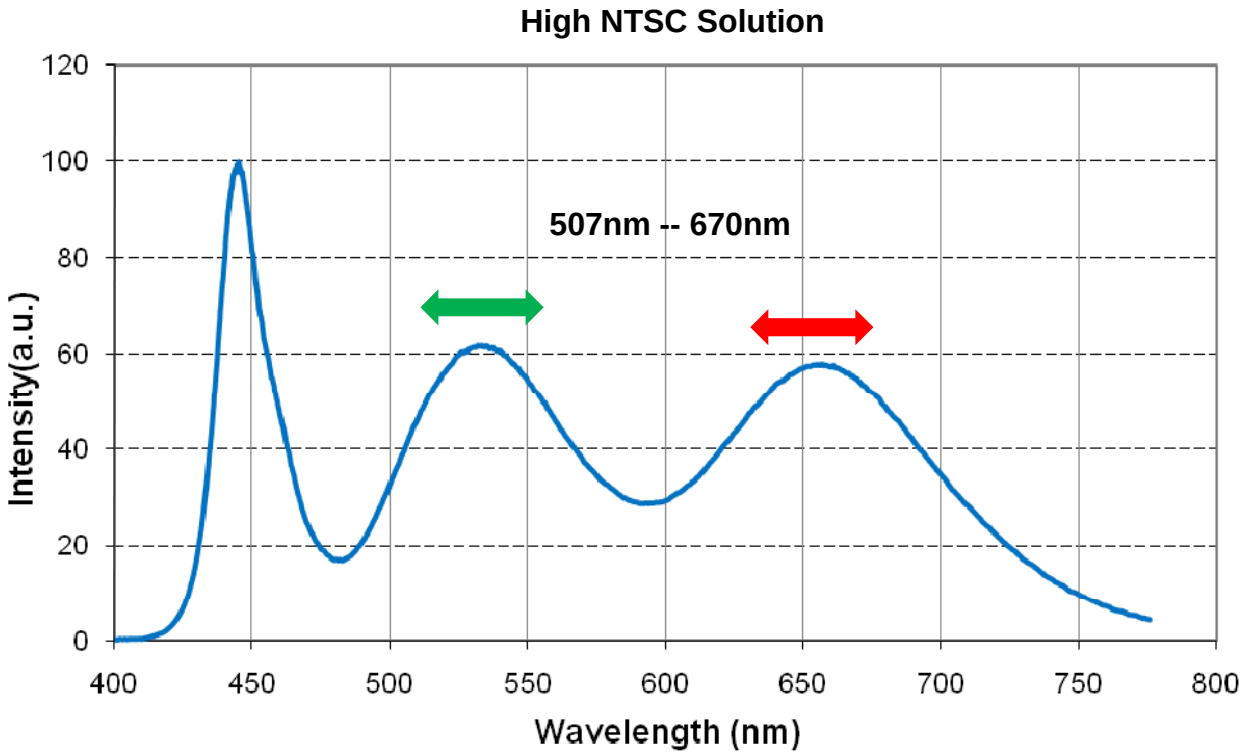
LED Phosphor for Backlighting

- Phosphor enables RGB , with little wasted photons off-peak



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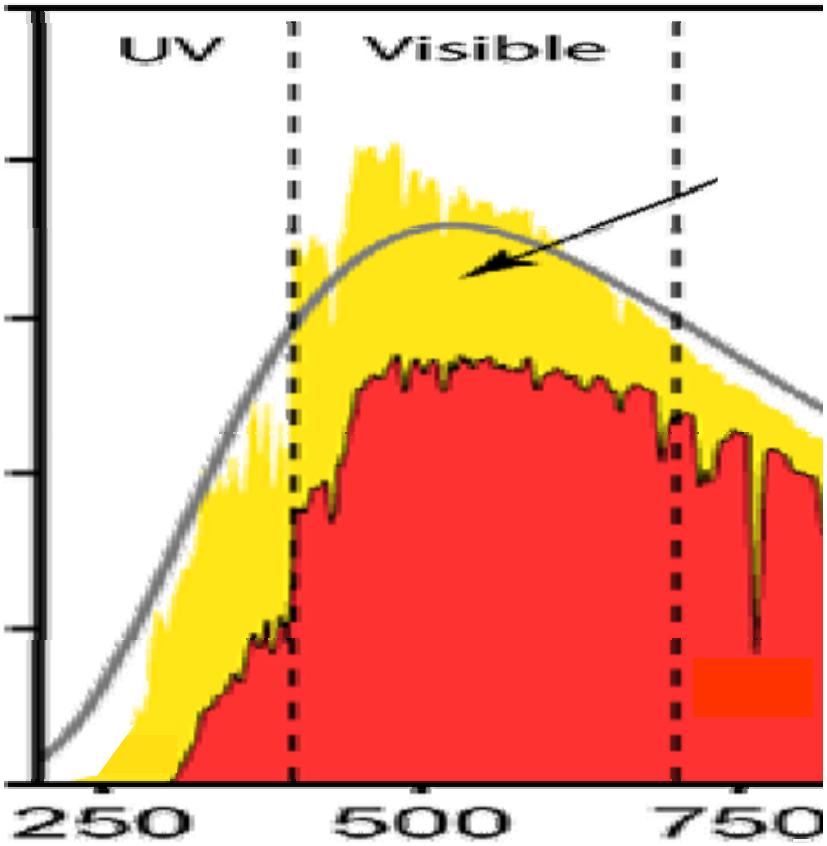
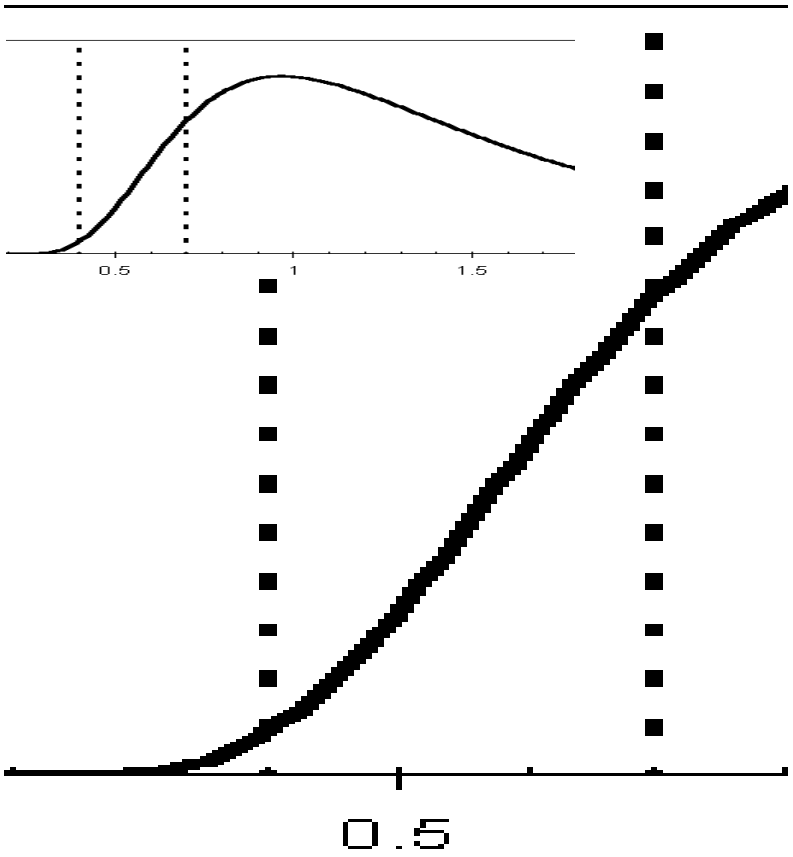
What is Our Target for Lighting?

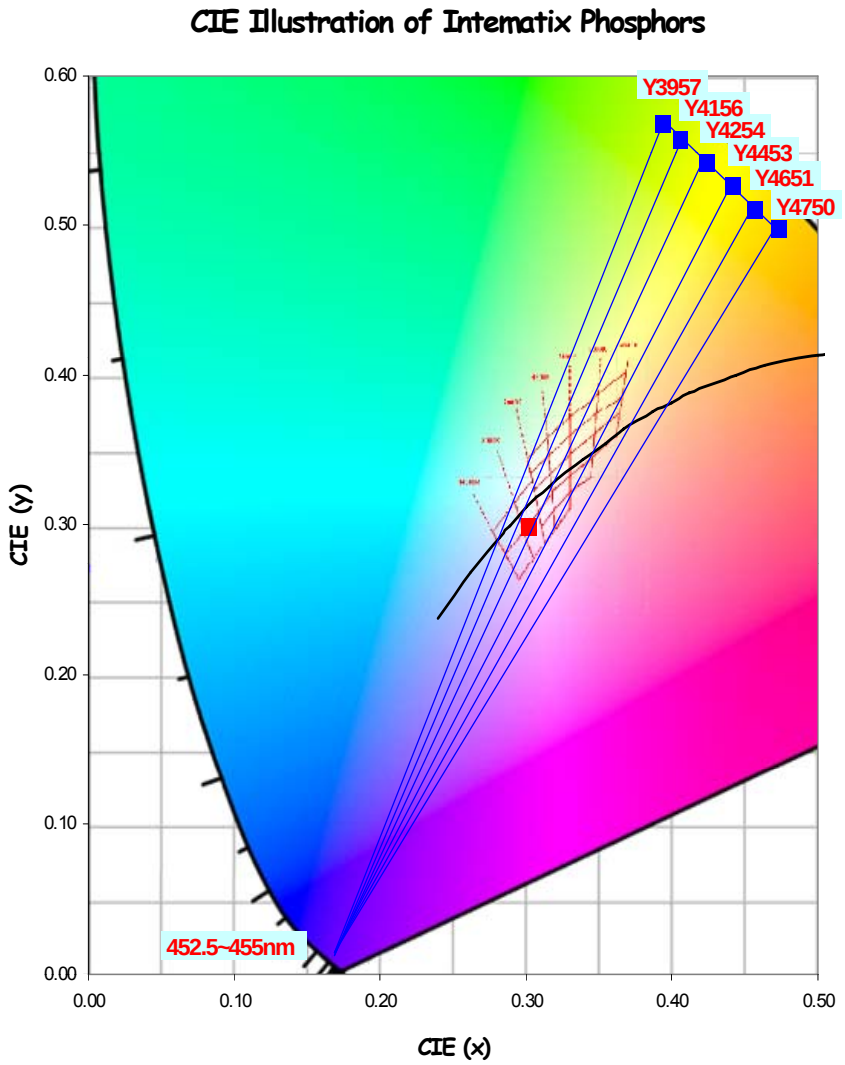
- Sunlight (in red), ~6000K
- 60W Incandescent, ~3000K





General Color

- Phosphor color, phosphor amount and LED wavelength determine final CIE (and CCT)



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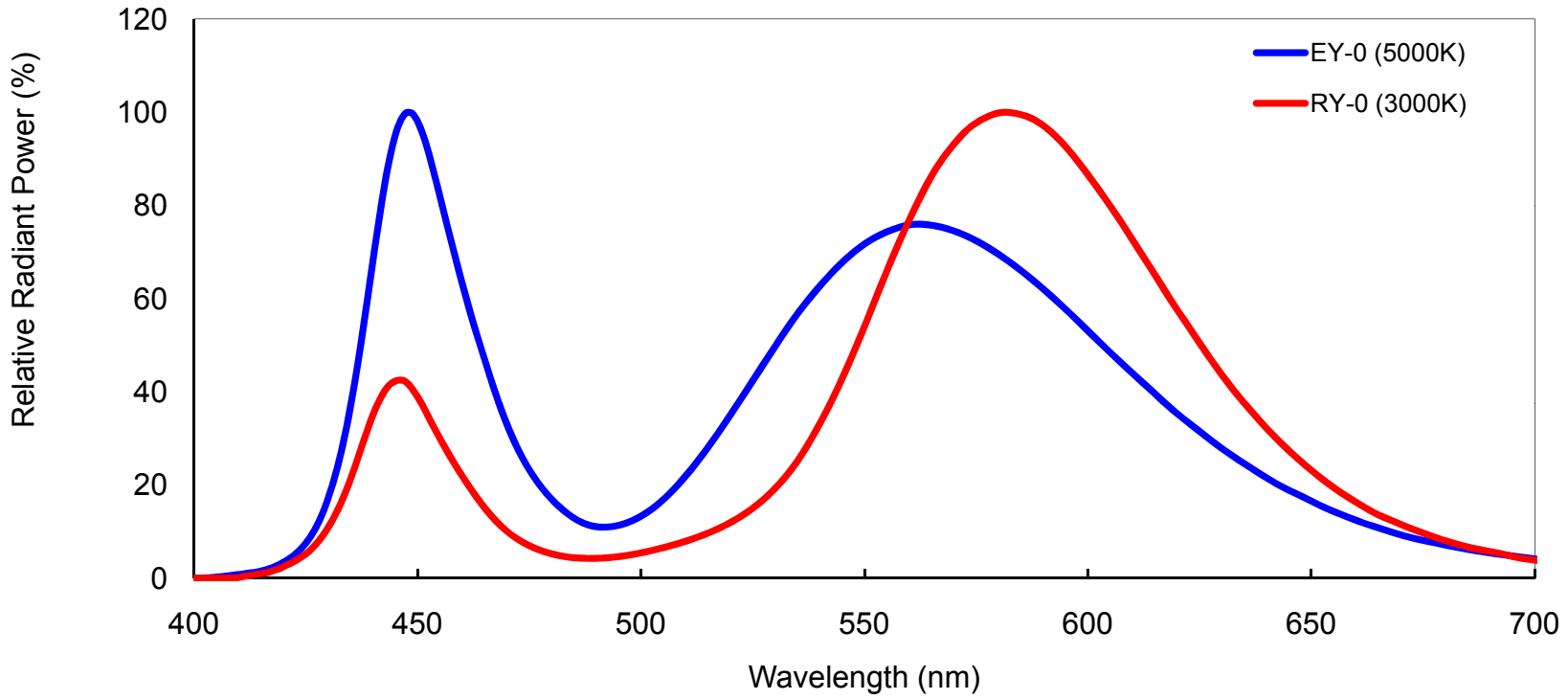
Simplest Case – Low CRI White LEDs



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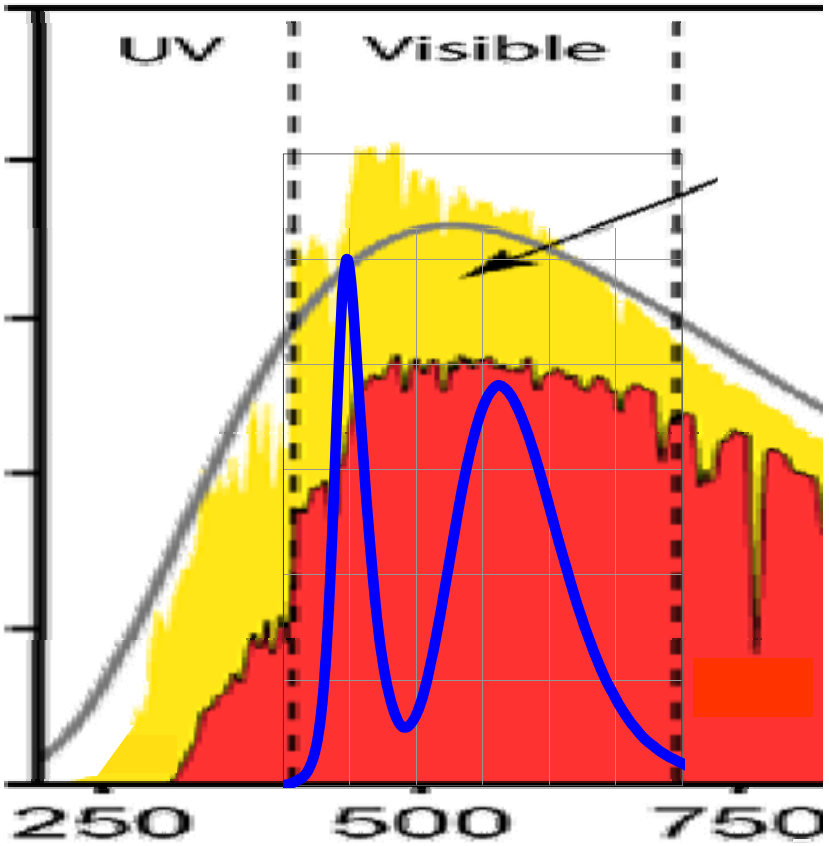
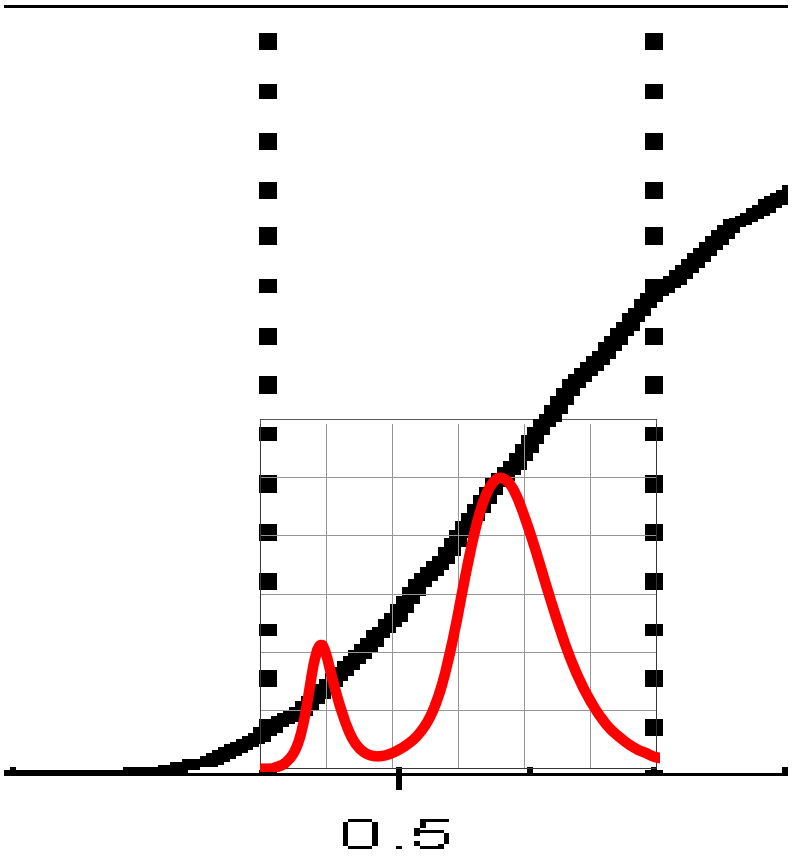
How Does the Industry Match Up Using Lo-CRI

- Sunlight (in red), ~6000K
- 60W Incandescent, ~3000K





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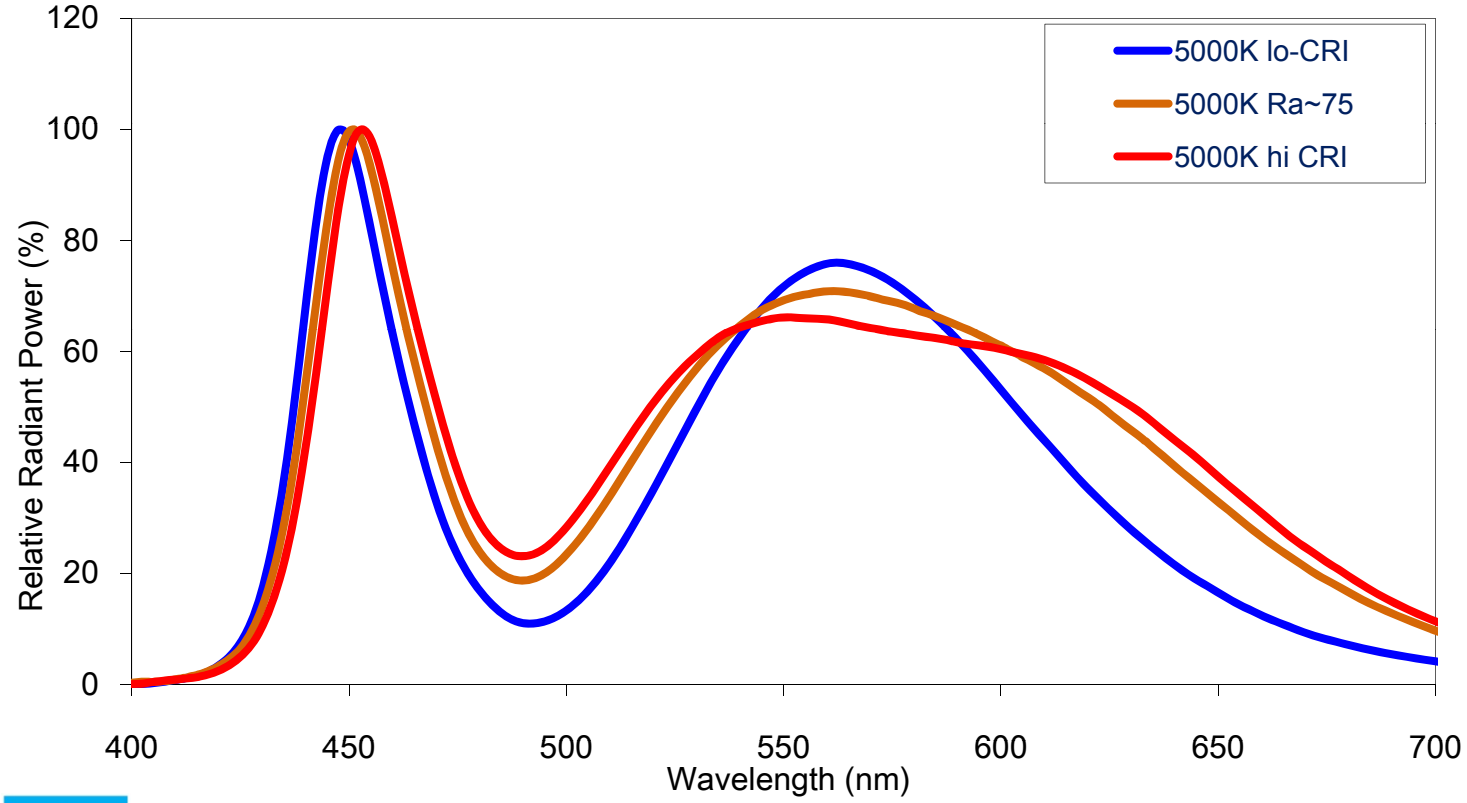
Mixing Phosphors Increases Spectral Coverage

- Small increases in CRI enabled by adding orange or red
- Larger increases in CRI must shift yellow phosphor toward green



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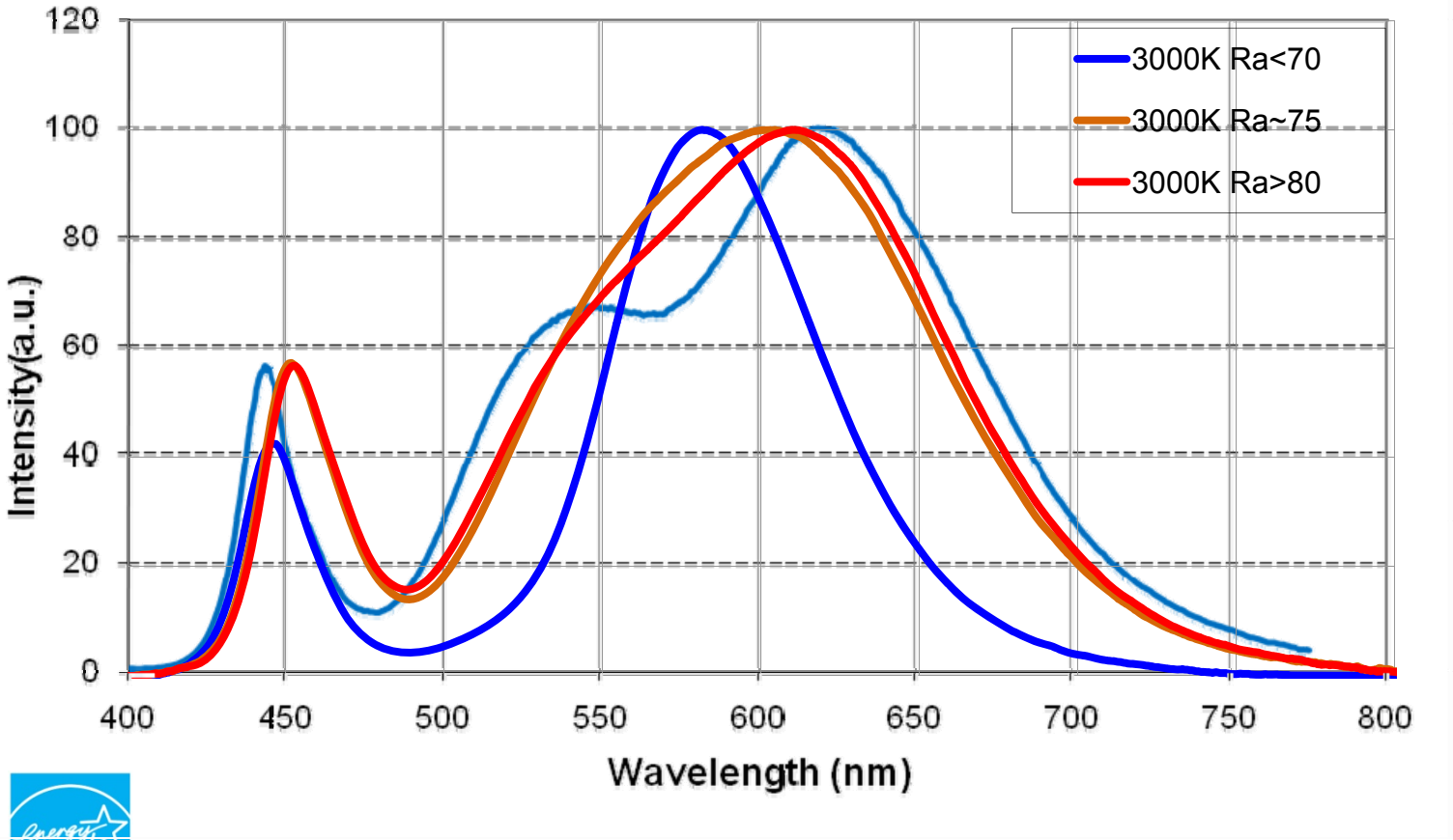
Mixing Phosphors Increases Spectral Coverage

- Identical phosphor strategies for warm white
- Light blue curve Ra>90



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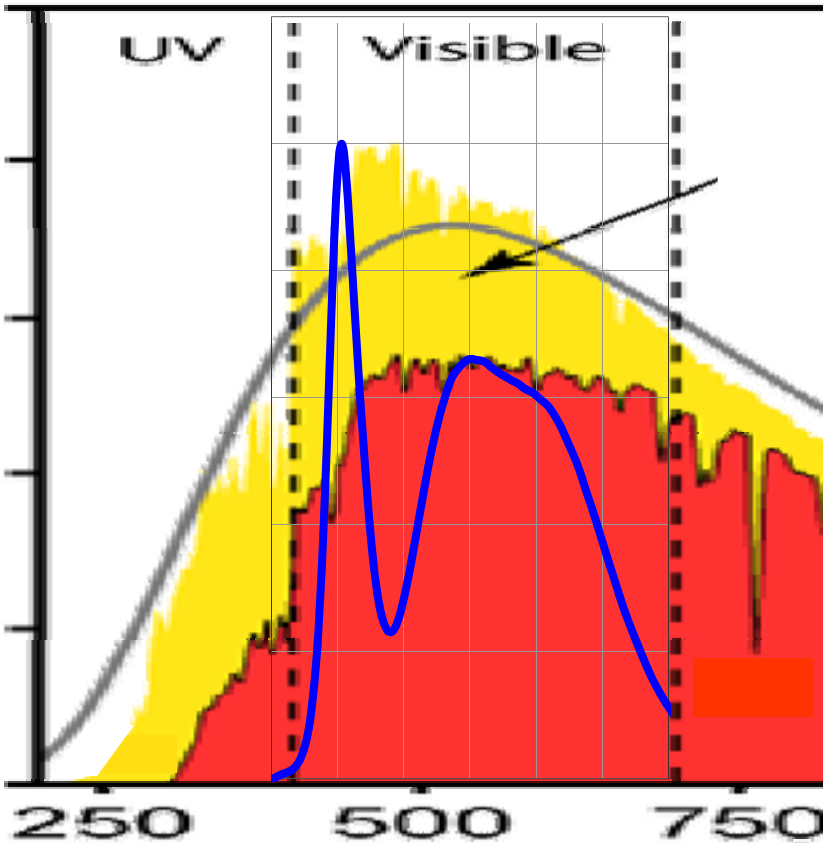
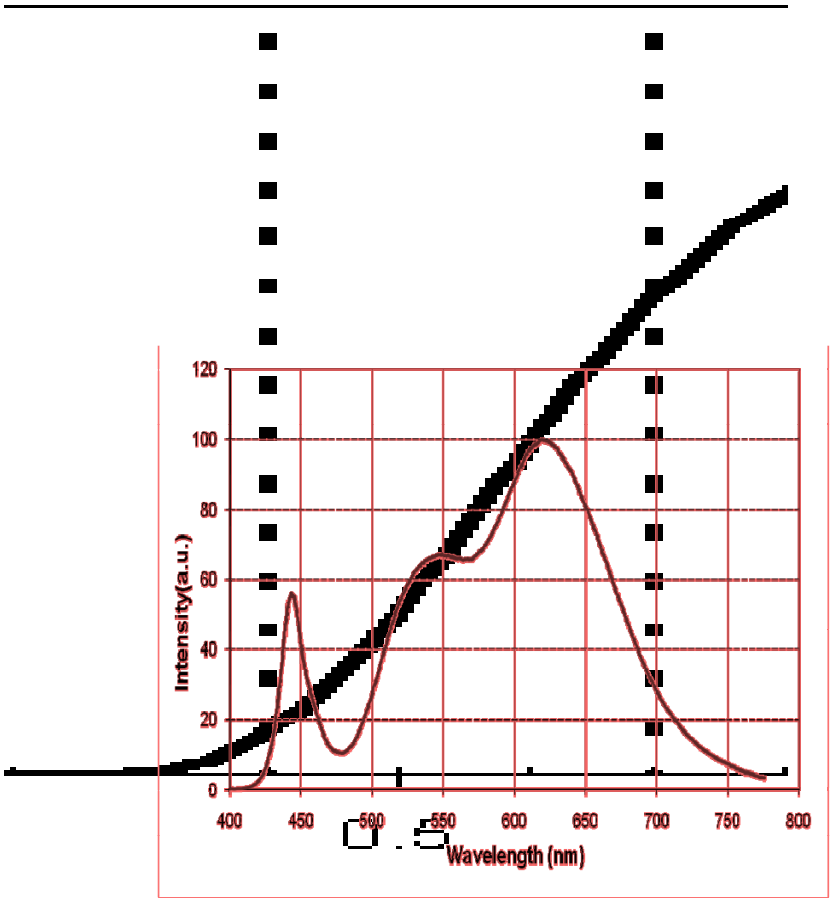
Hi CRI LEDs Better for Match Target Spectra

- Sunlight (in red), ~6000K
- 60W Incandescent, ~3000K





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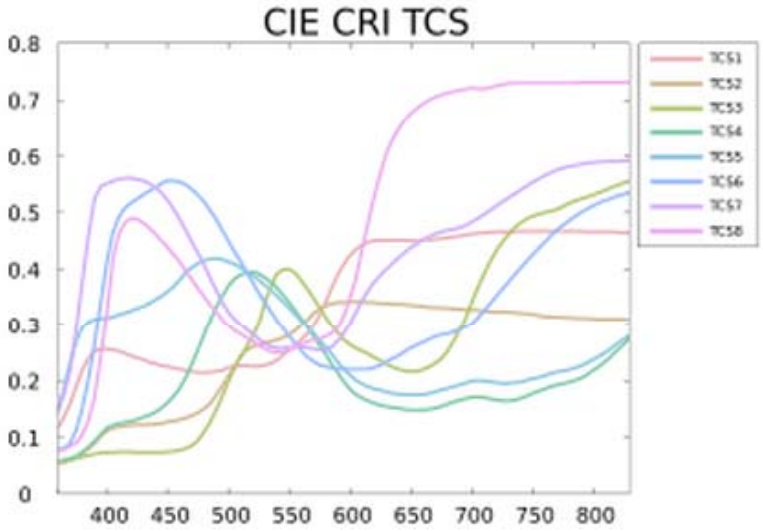
More About CRI

- Color Rendering Index is quantified by rendering of color swatches because quality of light is perceived by looking at colors under the light, not looking at the light itself



Name	Appr. Munsell	Appearance under daylight	Swatch
TCS01	7,5 R 6/4	Light greyish red	
TCS02	5 Y 6/4	Dark greyish yellow	
TCS03	5 GY 6/8	Strong yellow green	
TCS04	2,5 G 6/6	Moderate yellowish green	
TCS05	10 BG 6/4	Light bluish green	
TCS06	5 PB 6/8	Light blue	
TCS07	2,5 P 6/8	Light violet	
TCS08	10 P 6/8	Light reddish purple	
TCS09	4,5 R 4/13	Strong red	
TCS10	5 Y 8/10	Strong yellow	
TCS11	4,5 G 5/8	Strong green	
TCS12	3 PB 3/11	Strong blue	
TCS13	5 YR 8/4	Light yellowish pink	
TCS14	5 GY 4/4	Moderate olive green (leaf)	

Comparative Lumens

	Ra<70	Ra~75	Ra~82
3000K	89%	80%	72%
5000K	100%	89%	80%

- 1 yellow-green photon (558 nm) produces as many lumens as 10 blue or 10 red photons
- Cool White has dominant wavelength very close to photopic curve maximum, therefore more lumens than warm white
- Increased CRI comes from broader spectral coverage, resulting in lower intensity near 558 nm, and thus fewer lumens than lower CRI
- Decreased efficacy at high CRI exacerbated by lower EQE of non-yellow phosphors

Conclusions

- User experience is enhanced by good spectral matching of white LED to traditional illumination sources (Sun, incandescent bulb)
- Improvement of the blue die is vital, but improvement of phosphors is "vital x 2"
  - Roughly, >95% of the lumens come from phosphor emitted photons
- There are many factors to judge phosphors by
  - Emission wavelength
  - Quantum yield
  - Thermal stability
  - Parasitic absorption
- New, better materials, such as the red nitride family of phosphors, result in more choices, more recipes, and ultimately better light
  - Increased CRI, increased R9