A Greentech Media Webinar

Greentech Lighting:

The OIDA's Solid State Lighting Technologies and Roadmaps

Speaker:

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President and CEO

OIDA

OPTOELECTRONICS INDUSTRY DEVELOPMENT ASSOCIATION

greentechmedia:

Overview

- ***Opto***mism
  - The next 10yrs for optoelectronics
- Technical trends for solid state lighting
  - Areas that will impact all of us; our lifestyle, our family
  - Technical challenges for LEDs, OLEDs and lasers
- Roadmaps for lighting with High Brightness LEDs
- Summary

Mission → Vision

Promote optoelectronics *worldwide*, &

Advance competitiveness of it's members

Focus on quality

Broaden horizon of OE

Leverage DC government center of mass

Grow membership base

Primary reference in OE

Develop and participate in industry-university development initiatives

Recognized internationally

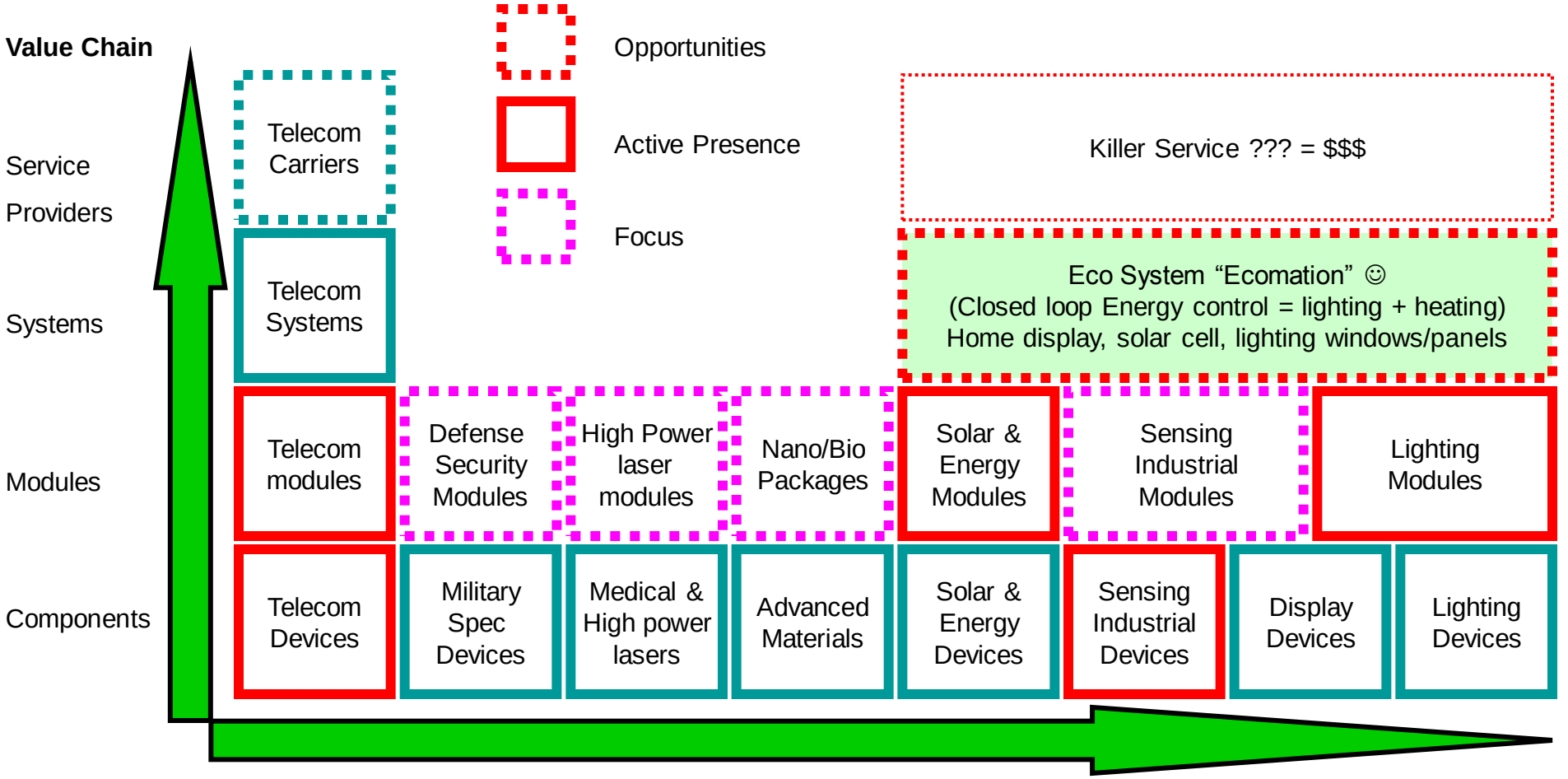
Organize key trade show

OIDA is the focal point for OE industry vision, transformation, and growth

Focus on the business of technology, not just technology itself

Optoelectronics = OE

OIDA is broadening optoelectronics with "Green" opportunities



Sources: OIDA, Erwin Vergeest, ALiveLights

Balanced perspective in optoelectronics

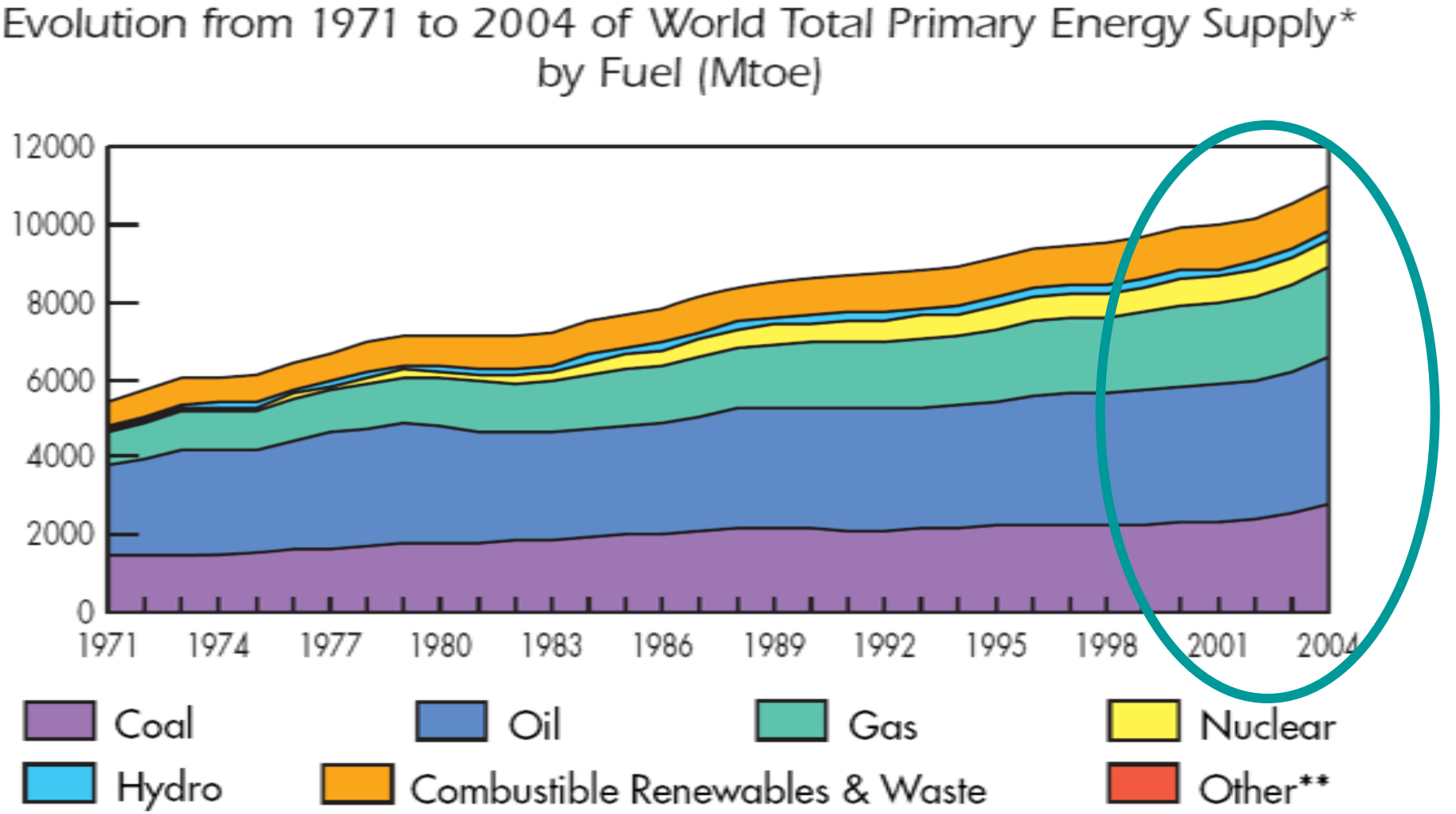
Next decade in Optoelectronics

In a decade…

our communicator…our PIP (personal information pet)

Sources: OIDA, Philips, RIM, Digital Optics, Sony Ericsson, HP, Siemens, Apple, OIDA members

Optoelectronics *will* support our lifestyle



Why energy matters…

Source: IEA

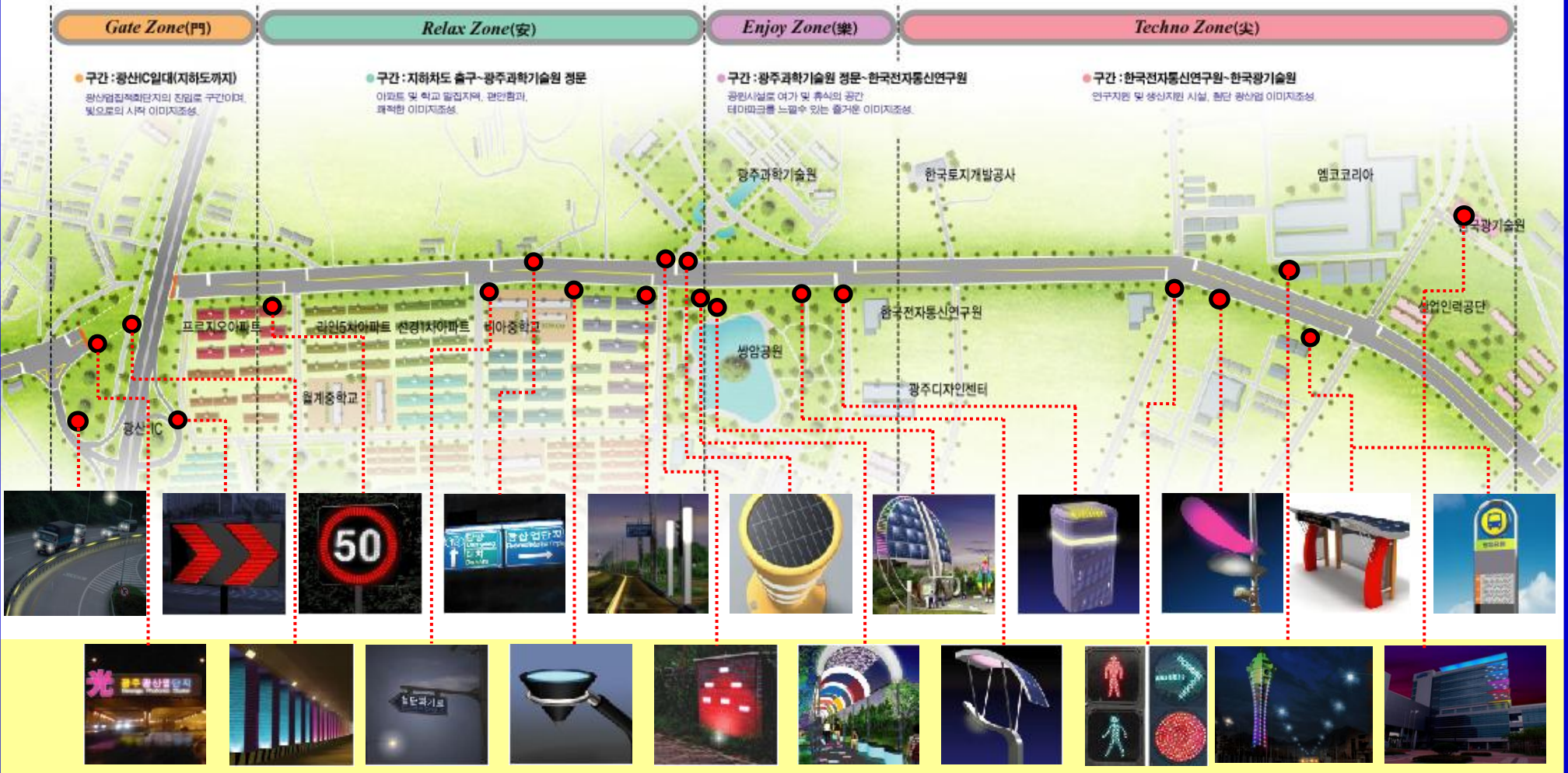
Double 1971 - 2004

Solid State Lighting "-abilities"

- Using electron transitions in solid materials for light
  - Efficiency: materials technology is limitation, but theoretically nearly perfectly efficient
  - Reliability: no moving parts, no leaking gases, no filaments, no bulbs to break, low heat
  - Disposability: not toxic, not fragil
  - Colorability: tunable, adjustable color and mood
  - Designability: no more traditional light bulbs, fixtures opens up design space, can use anything from emitting panels to fiber optics
  - Flexibility: unique surfaces and shapes

But….

In a decade…solid state lighting is everywhere

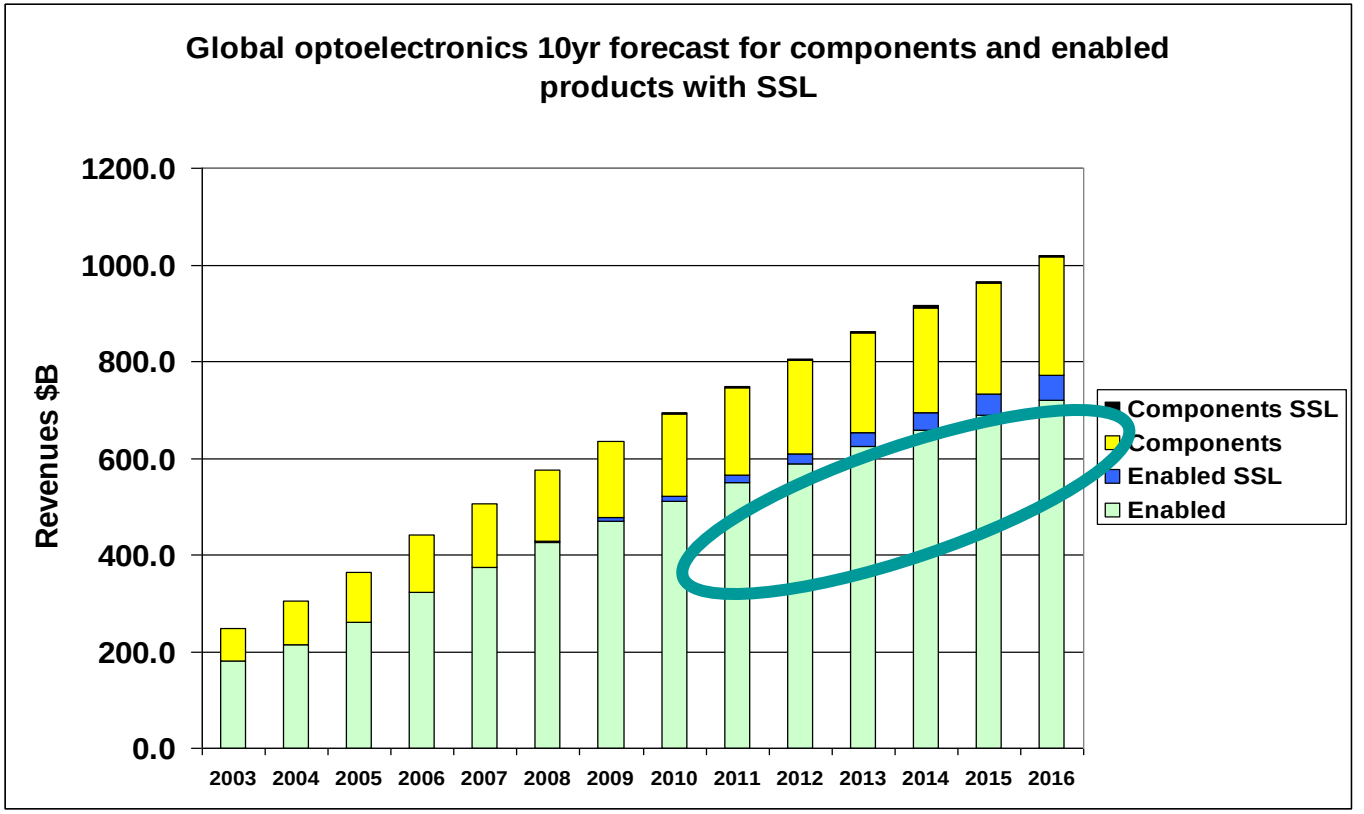


Source: Kaist, KAPID

Ubiquitous in everyday life…

Next decade in optoelectronics

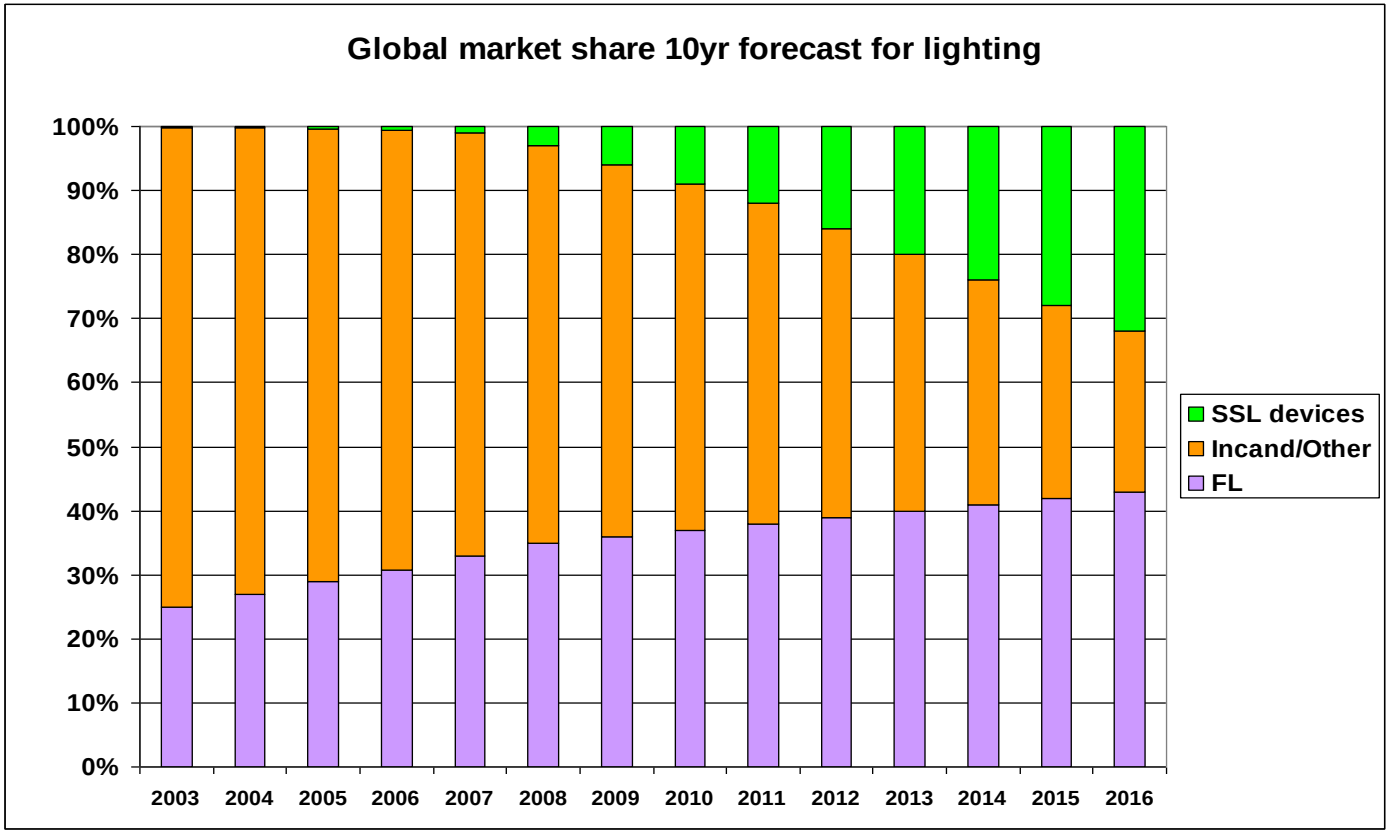
- Combined OE components and enabled products
  - 2004-16 CAGR 11% with SSL lighting ~$50B by 2016



SSL grows quickly in a $T industry

Lighting market share forecast

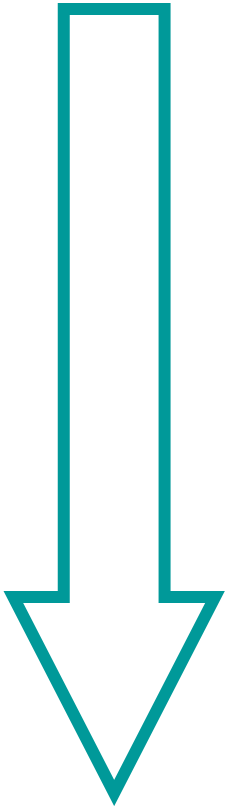
- SSL will grow quickly over next decade



SSL fueled by LEDs and OLEDs

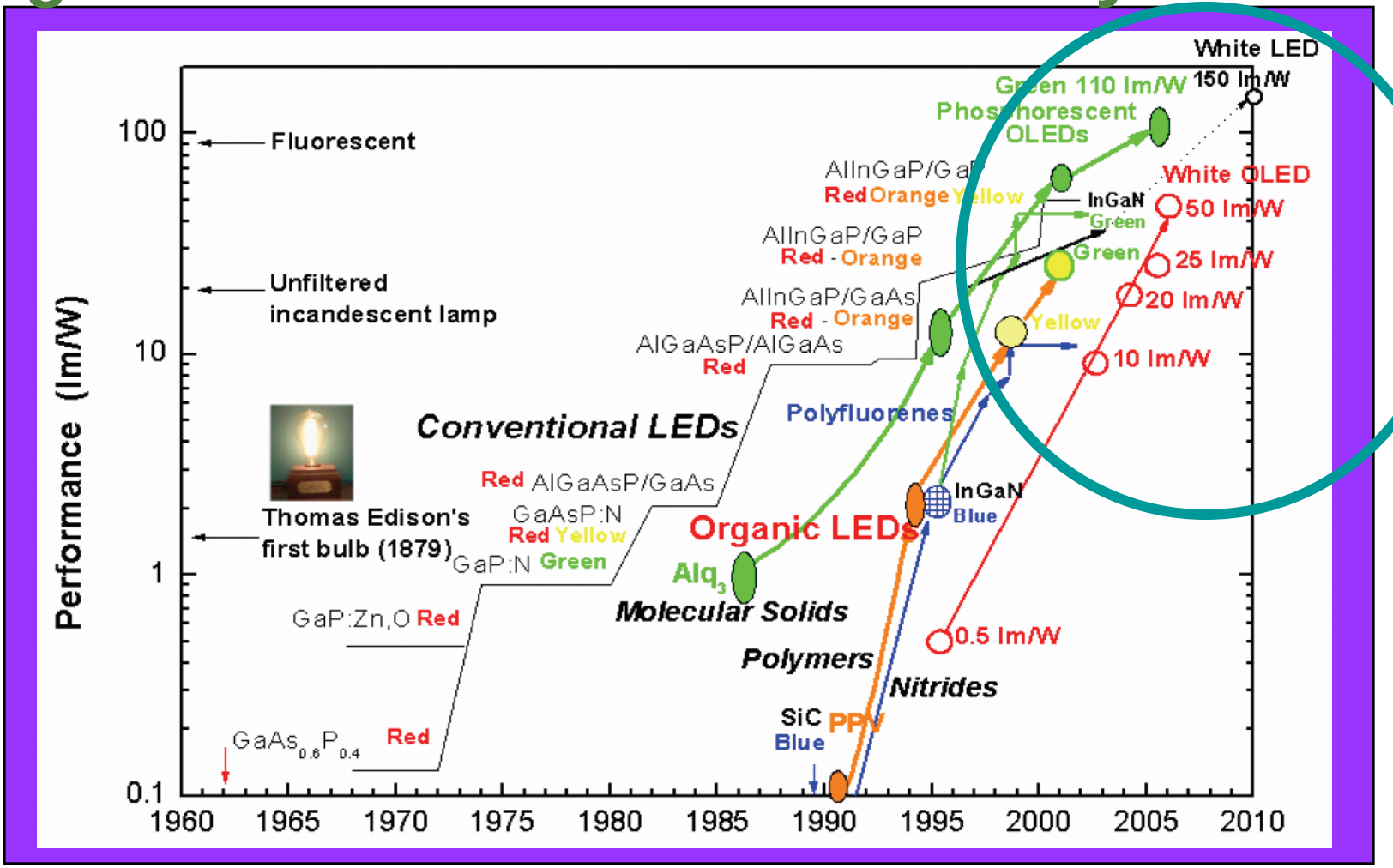
Comparative efficacies

Category	Source	luminous efficacy (lm/W)	luminous efficiency (%)
Combustion	candle	0.3	0.04%
Incandescent	100 W tungsten incandescent	17.5	2.60%
	glass halogen	16	2.30%
	quartz halogen	24	3.50%
	high-temperature incandescent	35	5.10%
Fluorescent	28 W fluorescent tube (T5)	104	15.20%
Light-emitting diode	white LED	26–70	3.8%–10.2%
	white LED (prototypes)	up to 150	up to 22%
Arc lamp	xenon arc lamp	30–50	4.4%–7.3%
	HID (auto)	80	12%
Gas discharge	high pressure sodium lamp	150	22%
	low pressure sodium lamp	183 up to 200	27%
	1400 W sulfur lamp	100	15%
Other sources	Ideal black-body radiator at 4000 K	47.5	7.00%
	Class G star (Sun, Capella), 5800 K	80	12%
	Natural sunlight	93	14%
	iIdeal black-body radiator at 7000 K	95	14%
	Ideal white light source	242.5	35.50%
	Ideal monochromatic 555 nm source	683	100%
Source: Wikipedia - http://en.wikipedia.org/wiki/Luminous_efficacy, 17 July 2007			



LEDs are making excellent progress...

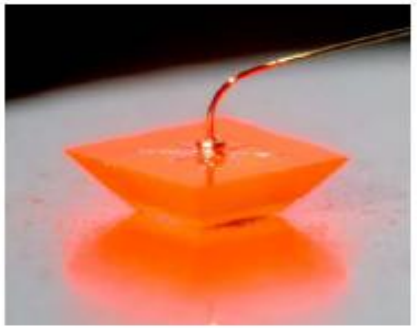
Progress in LED and OLED efficacy

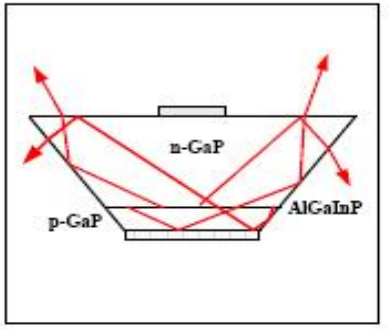


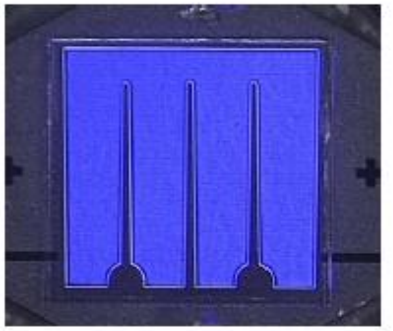
Source: Prof. *Changhee Lee, SNU, Korea*

HBLED white technology

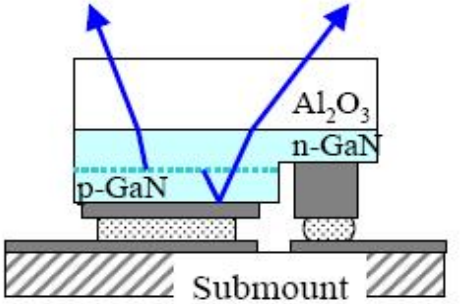
HB-LED Technology



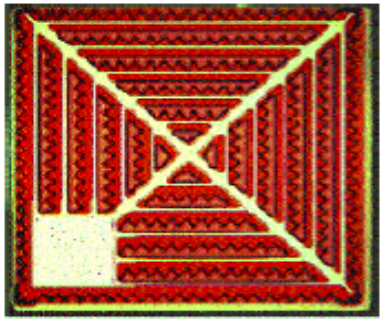


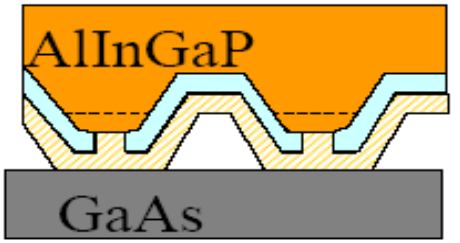


AlGaInP/GaP truncated inverted pyramid (Lumiled)

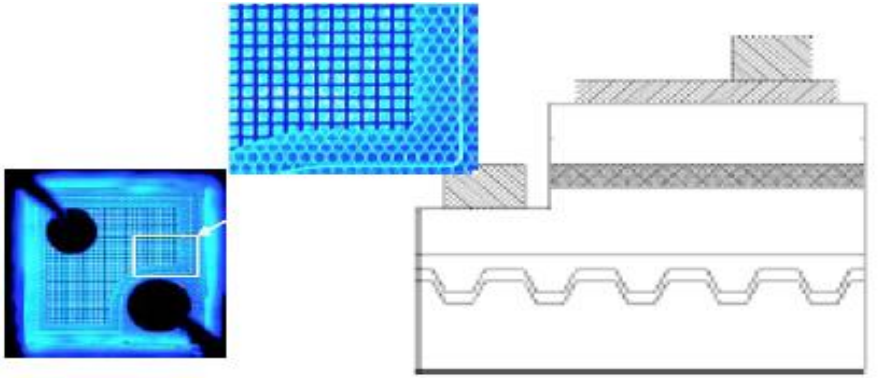


AlInGaN flip-chip (Lumiled)





AlInGaP micro mirror (Osram),



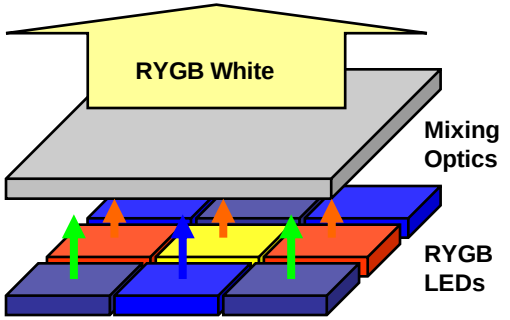
AlInGaN patterned substrate and mesh electrode (Nichia)

Source: Philips LumiLeds, Osram, Nichia

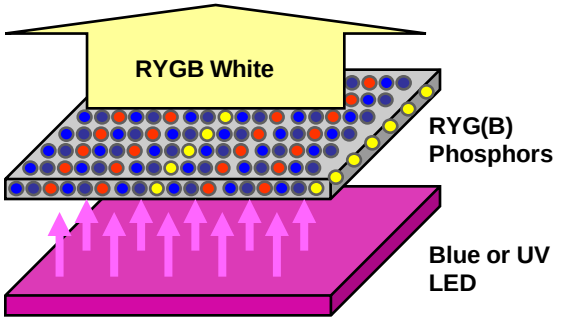
Complex tricks for high brightness

Designing white HBLEDs

Color Mixing



Phosphor Down-Conversion



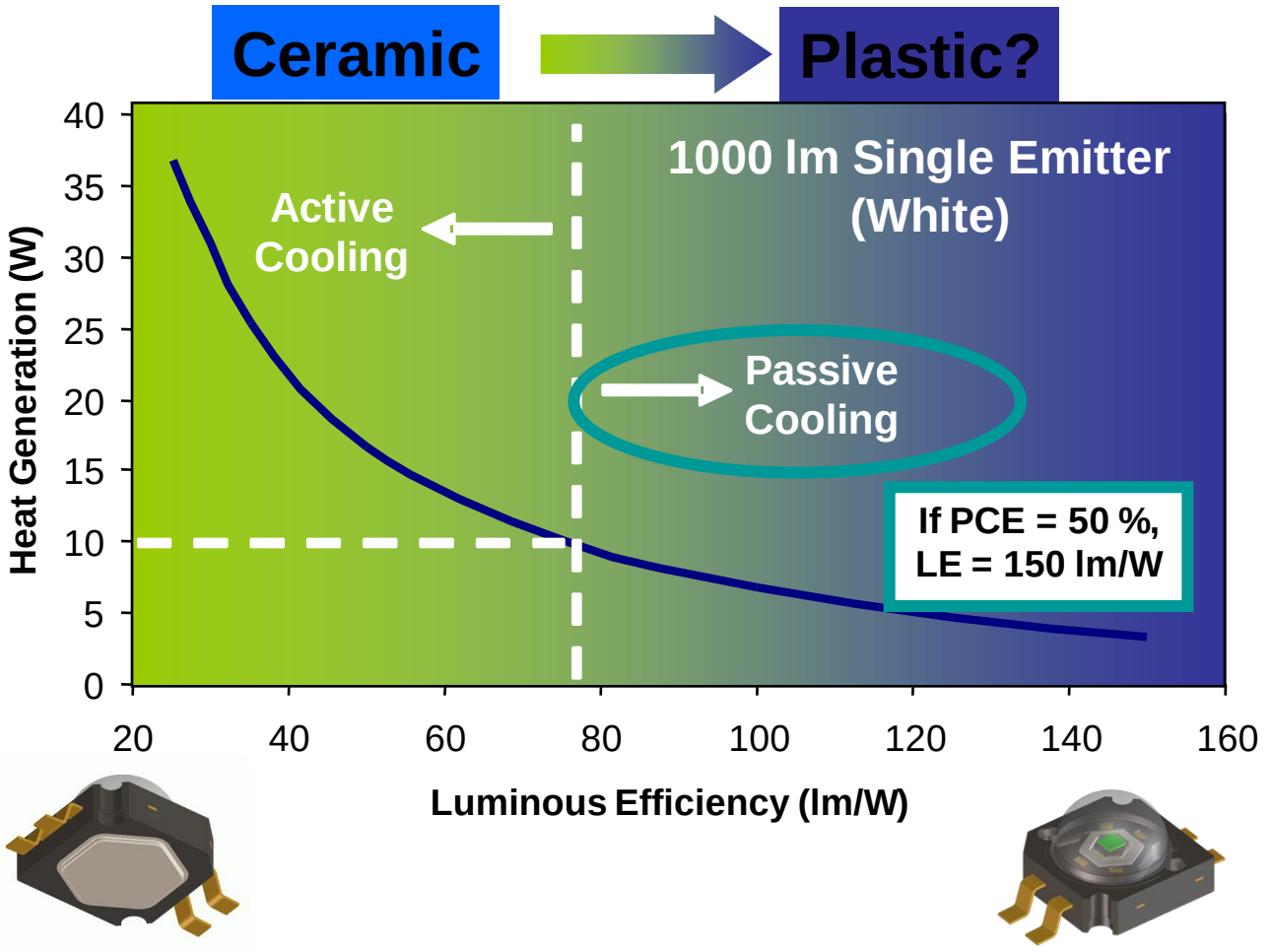
Commercial white today

- **Issues:**
  - Phosphor conversion
    - Quantum deficit, Stokes loss, optical losses, new materials issues, relatively simple, nanotech
  - Color mixing
    - Optical losses, color uniformity, color control circuits (tunable advantage)

Sources: Philips Lumileds, OIDA

Phosphor popular, mixing is tunable

Thermal dynamics in cooling – caveat emptor



Sources: Philips Lumileds, OIDA

- Incandescent
  - 5% visible (90% IR)
- LEDs pass all heat back to heat-sink and fixture
  - 20% visible (80% conducted away)
- Today's efficiency
  - Thermal management is major issue and cost driver
- Future anticipated efficiency
  - Heat management will become straightforward

Issues of complex heat sinking will relax

RGB white for illuminating artwork









Mona Lisa Lighting by Fraen Corporation

- Replicates day-light without harmful UV or IR radiation
- Exact color rendition

Sources: Philips Lumileds, OIDA, Fraen Corp

Exact color rendering

Lighting off-grid

Gimla Yacht – new markets, new opportunities for designers

Sources: Philips Lumileds, LightGraphix, OIDA

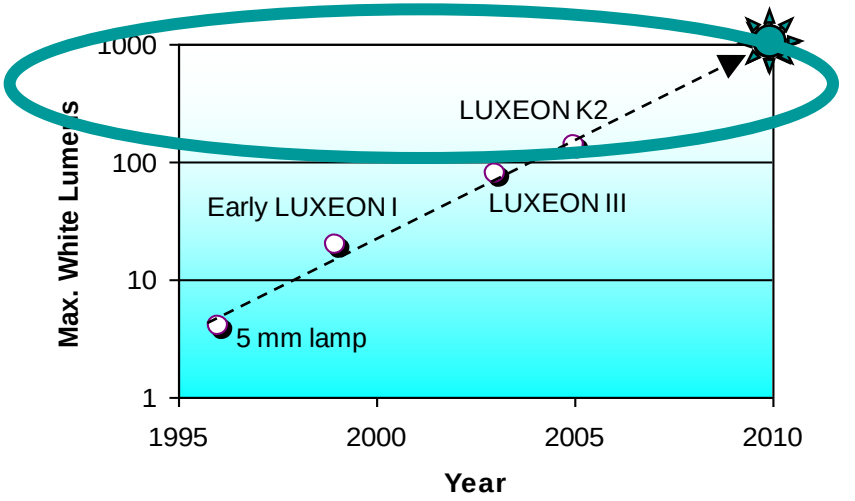
For those who can pay for style…

- Fixtures already on the market in Asia

Designing within the infrastructure…

Cost & efficiency requirement for PC white

- Single-emitter Flux
  1000 lm desirable
  - same as 60 W light bulb
  - today's LEDs: 30 – 160 lm



PC White LED: ~150 lm/W

•Cost of Ownership (COO) Analysis – 1000 lm source

	Input Power	Source cost	Energy cost/yr	COO (1 yr)	COO (5yrs)
1 x 60 W incandescent	60 W	$ 0.25	$ 48	$ 48	$ 240
7 x LUXEON K2 emitters	40 W	$ 18	$ 32	$ 50	$ 178
1 x 150 lm/W LED	**6.7 W**	**$ <2.5**	**$ 5.30**	**$ 8**	**$ 28**

at $0.10 per kWh

Sources: Philips Lumileds, OIDA

High efficiency devices drive the value proposition

Lighting for off-grid homes using LEDs

- Electric light transforms the lives of the poor, making it possible for families to stay active - and children to study - after night falls. But electricity is scarce in many developing countries; millions of villages are far from the grids, and power is expensive. Now the Light Up the World Foundation has found a way to illuminate whole villages with less electricity than is used by a single 100 watt bulb. Combining simple pedal-powered electric generators with wind turbines and with cutting edge technology from light-emitting diodes it has won a Rolex Award for Enterprise. Already working successfully in Nepalese villages, it is set to spread around the world.

Sources: Philips Lumileds, Photos Courtesy of Light Up the World and PICO Power, www.ourplant.com, OIDA

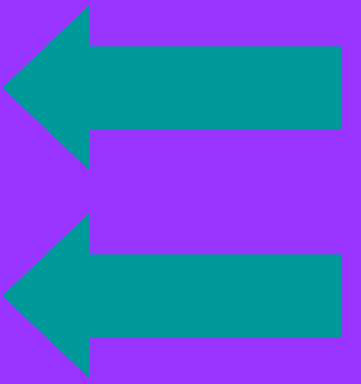
HBLED technology: light for learning

LED Roadmaps

How achievable is 150 lm/W for the roadmap?

EQE = C x IQE

	PC White	
	Today*	**Future**
C_{ext} (%)	~80	**~90**
IQE (%)	~55	**~90**
EQE (%)	~45	**~80**
V_f (V)	~3.3	**~2.9**
WPE (%)	~35	**~75**
LE (lm/W)	~70	**~150**

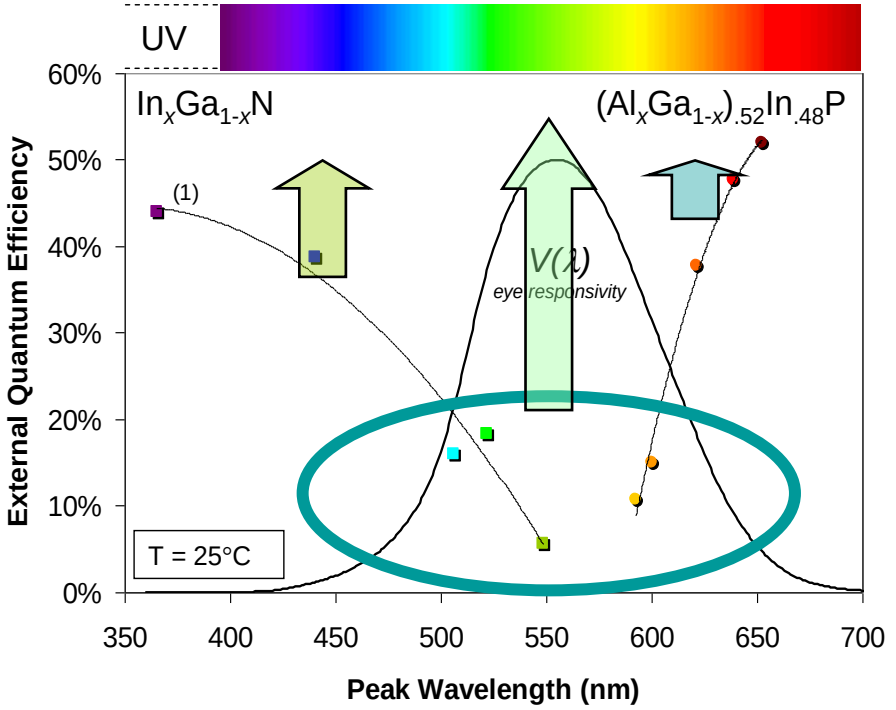


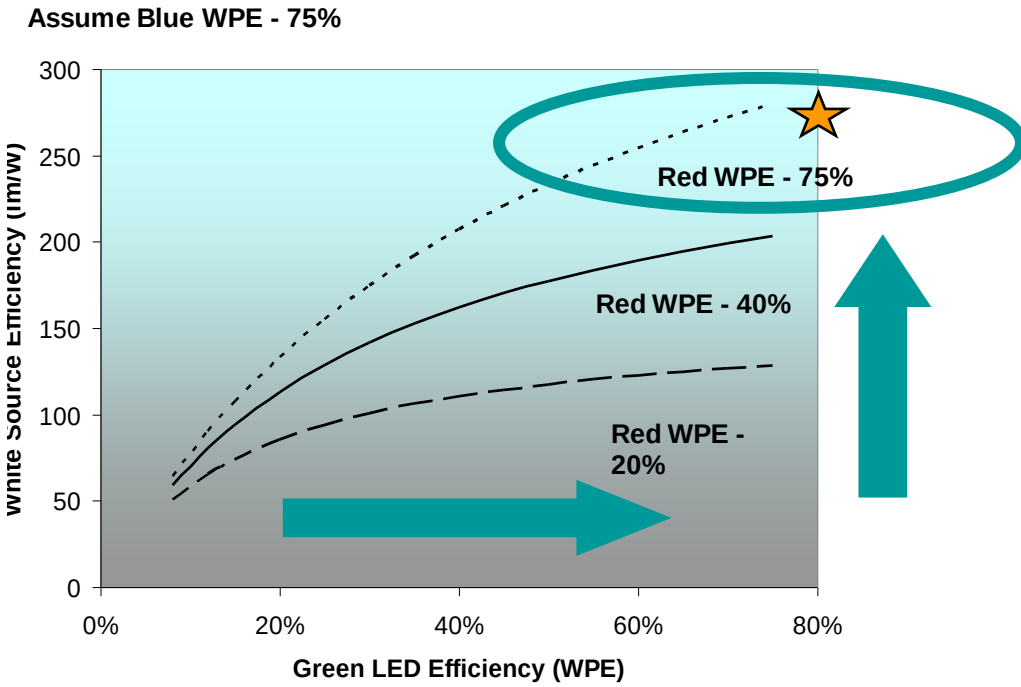
- IQE must increase by >1.5X
  - This table assumes a phosphor conversion on 200 lumens/optical Watt for “cool” white (CCT >5000)
- For “warm” white (CCT 3000 – 4000) is significantly lower (eff) and requires development. This is an issue for illumination.

Sources: Philips Lumileds

Warm white will be the challenge

R-G-B color mixing for warm white illumination





Sources: Philips Lumileds,, OIDA

Color mixing →potential for higher efficacy

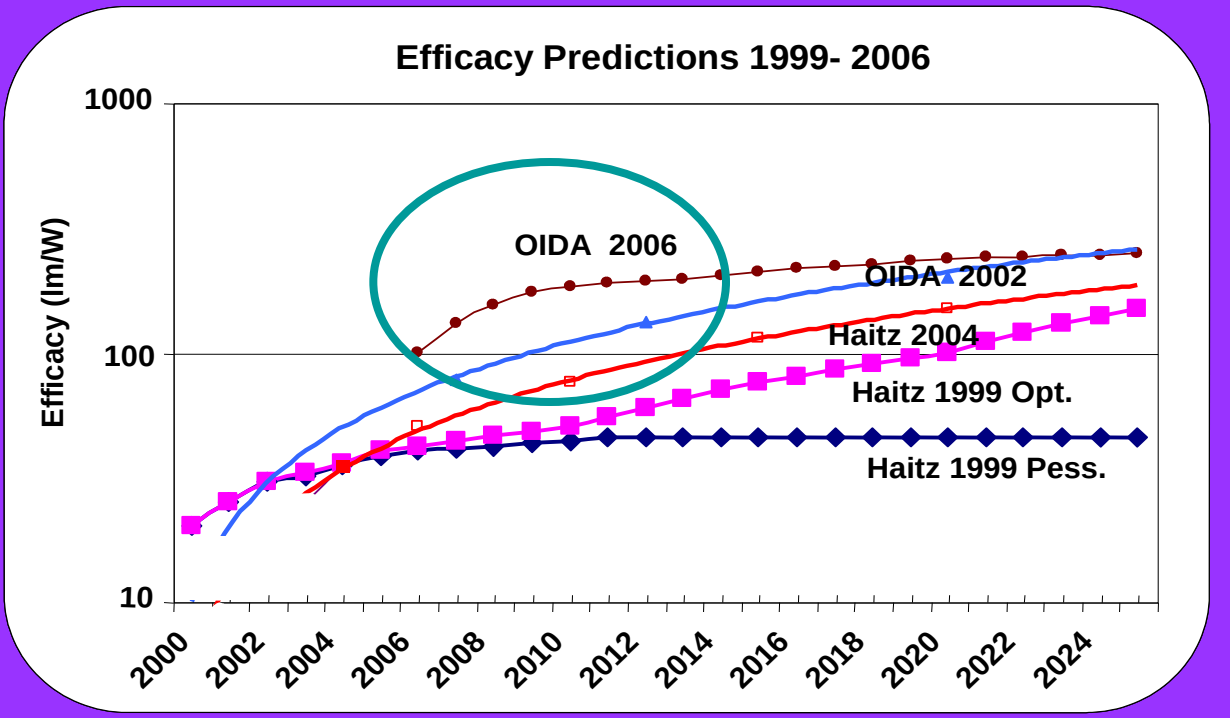
HBLED efficacy predictions

OIDA

HBLED R&D technology roadmap

Research device predictions in 2006

220lm/W by 2016



Sources: Haitz, Philips Lumileds, CREE, OIDA

Industry will solve green efficiency

OIDA LED Technology Roadmap (2007)

OIDA	2005		2009		2013	2017
Lum Efficacy (lm/W)	50	75	*150*	*200*	*210*	*220*
Lifetime (khr)	30	50		*>100*		*>150*
Flux (lm/lamp)	60	150	200		*1000*	*1500*
Input Power (W/lamp)	1	3	5	`	*7.5*	*10*
Lumens Cost ($/klm)	150	100	50	25	*5*	*2*
Lamp Cost ($/lamp)	3	2		1.5	*1*	*<1*
Color Rendering Index (CRI)	75	80			*85*	*90*
Lighting Markets Penetrated	Low-flux	Low-flux	Incandescent		*Fluorescent*	*All*

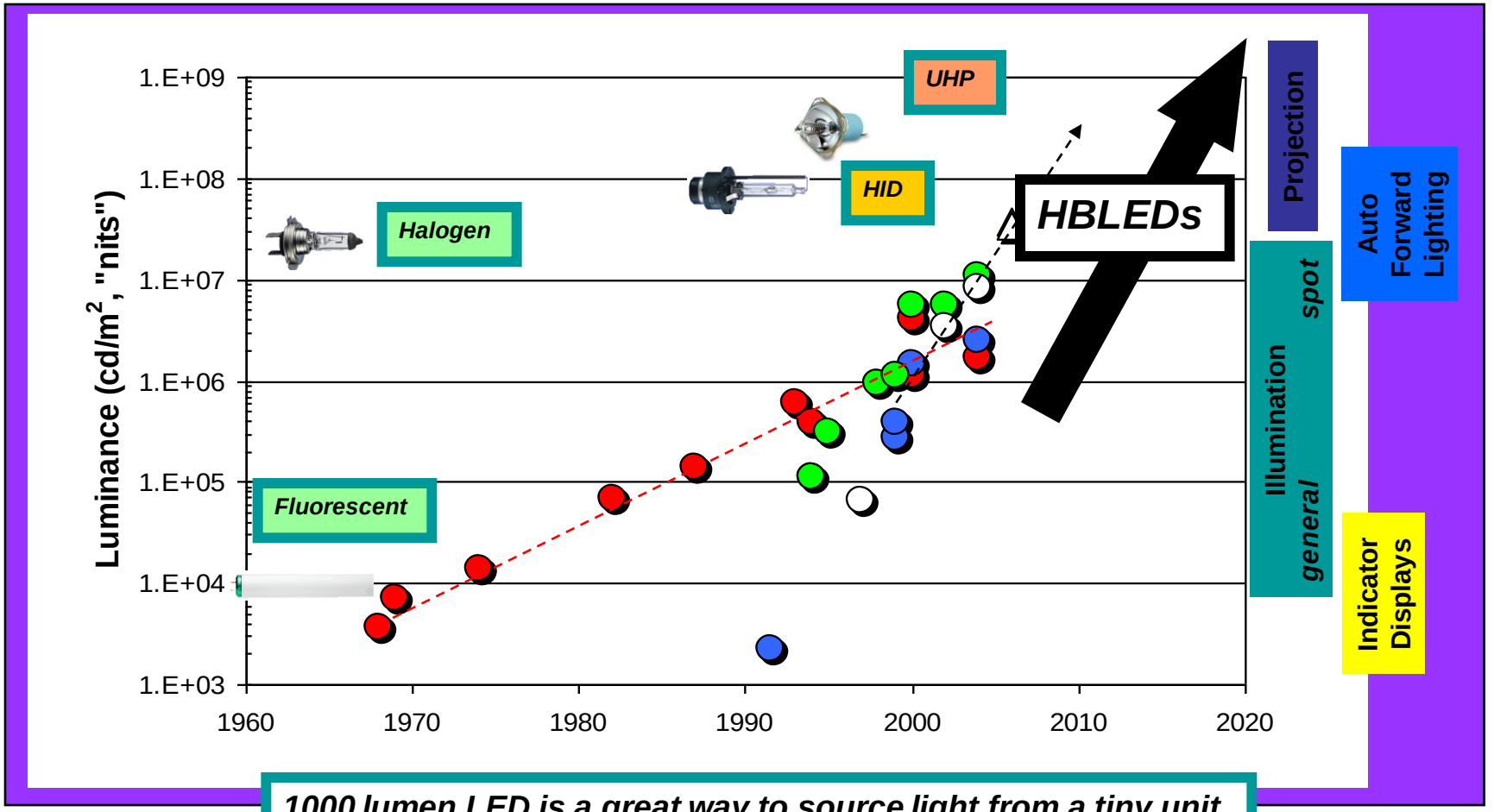
Technology & Components:
Commercial availability in year indicated (Not R&D results!)

Chip Temp	75	85	100	150	*200*	*250*
Phosphor Temp	75	80	90	125	*175*	*200*
I/P Power Density (W/cm^2)	100	200	350	*500*	*750*	*1000*
OEM Chip Cost ($/cm²)	120	100	80	*60*	*45*	*30*
OEM Packaging Cost ($/cm²)	125	110	90	*80*	*60*	*40*

Michael Lebby OIDA (2007)

Slanted Font: Major industry efforts are required for commercialization

Evolution of HBLED source luminance



Sources: Philips Lumileds, OIDA

High luminance LED → small low cost device

Summary predictions

- Light bulbs will slowly be replaced
- Controlling light by turning the power switch is becoming old fashioned!
- Networks are in, and controlling light intensity, color with a touch is fashionable!
- Flexible, throw away display are emerging
- Windows on homes may become displays for lighting
- Ceiling tiles will be OLEDs and not cardboard
- General illumination will be a mix of ambient and task:
  - LEDs for task and OLEDs for ambient

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Questions?

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