Lumiotec lighting panels

Philips O'Leaf

OLED Tutorial

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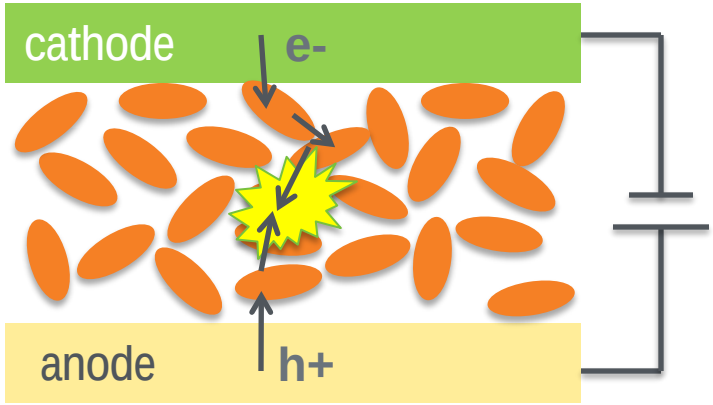
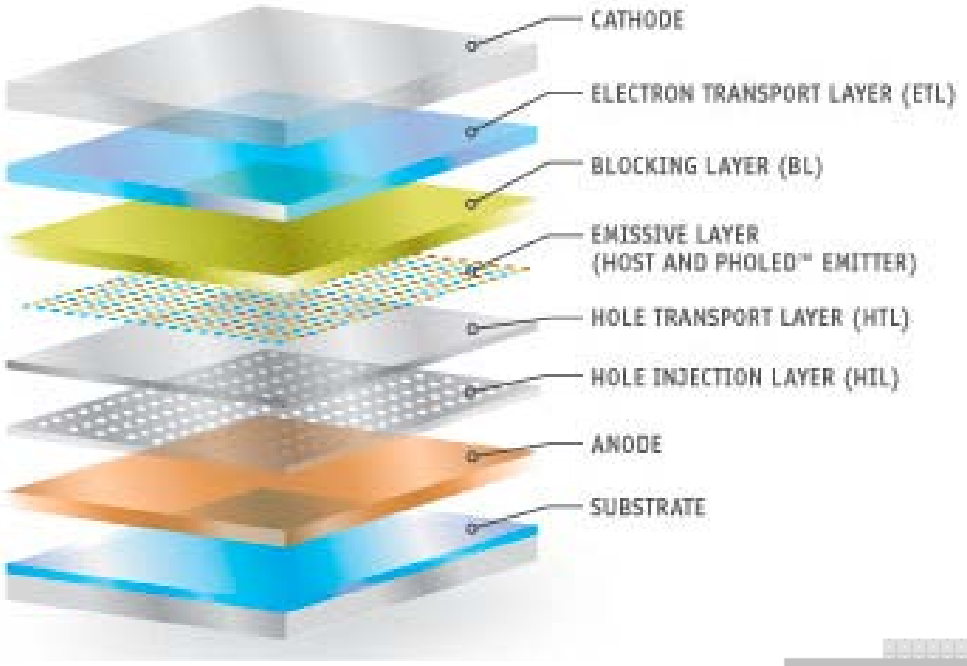
What is an OLED?

- **Organic Light Emitting Devices** are solid state devices comprising a thin electroluminescent organic (carbon-based) semiconductor layer that emits light when electricity is applied by adjacent electrodes
- In order for light to escape from the device, at least one of the electrodes must be transparent
- **Intensity** controlled by amount of current applied
- **Color of light** determined by emissive material used

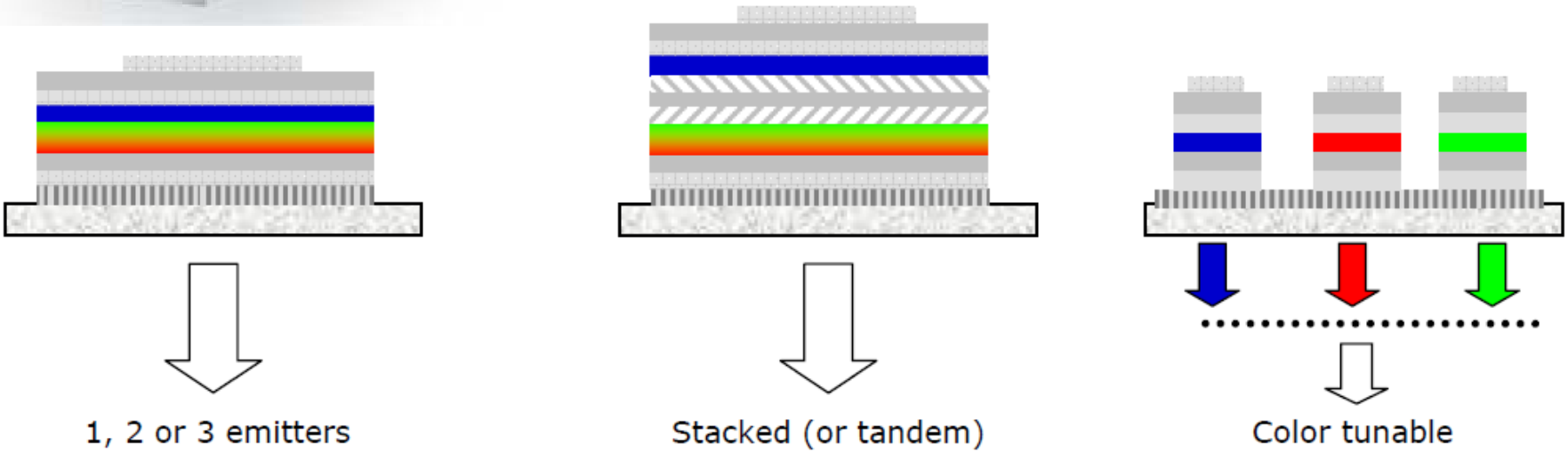


- Organic material can be deposited by **vapor phase** or **solution** deposition
- Intensive research into creating more **efficient materials and structures**

Structure of OLED Stack



OLED device structures
(Universal Display Corporation)



Why Are OLEDs Appealing?

SSL Feature	Appeal
Highly Efficient	Low cost of ownership, environmentally friendly
Long life	Low cost of ownership, environmentally friendly
Durable	Broad lighting applications
No harmful substances	No mercury, environmentally friendly; recyclable
Low voltage	Safe in use
Instant On	
Dimmable	Without decreasing efficiency
Color Tunable	User defined lighting; tune color for natural spectrum

Why Are OLEDs Appealing?

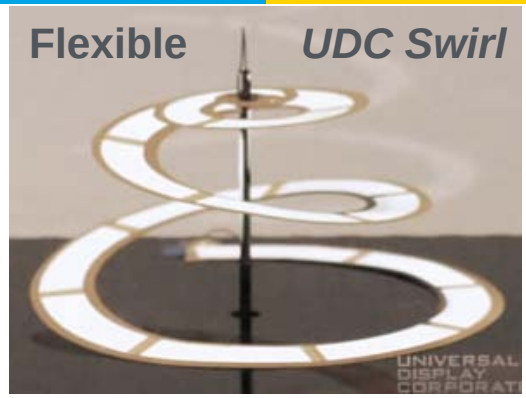
Unique OLED Features	Appeal
Diffuse, low brightness, large area	Glare-free, directly viewable, soft light
Any color, shape	Design freedom
Thin, light weight	Design freedom, integrate with walls, ceilings
Flexible	Design freedom, R2R production on metal or plastic substrates
Transparent	Design freedom; Integrate with windows
Mirror surface	Design freedom

Unique Features

Diffuse light, Thin

Lumiotec

Flexible ***UDC Swirl***



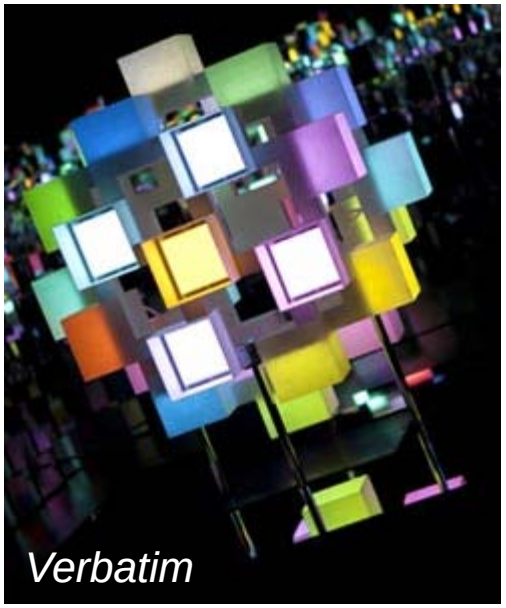
Philips

Any color, shape

Transparent

Novaled

Color Tunable



Verbatim

Mirror

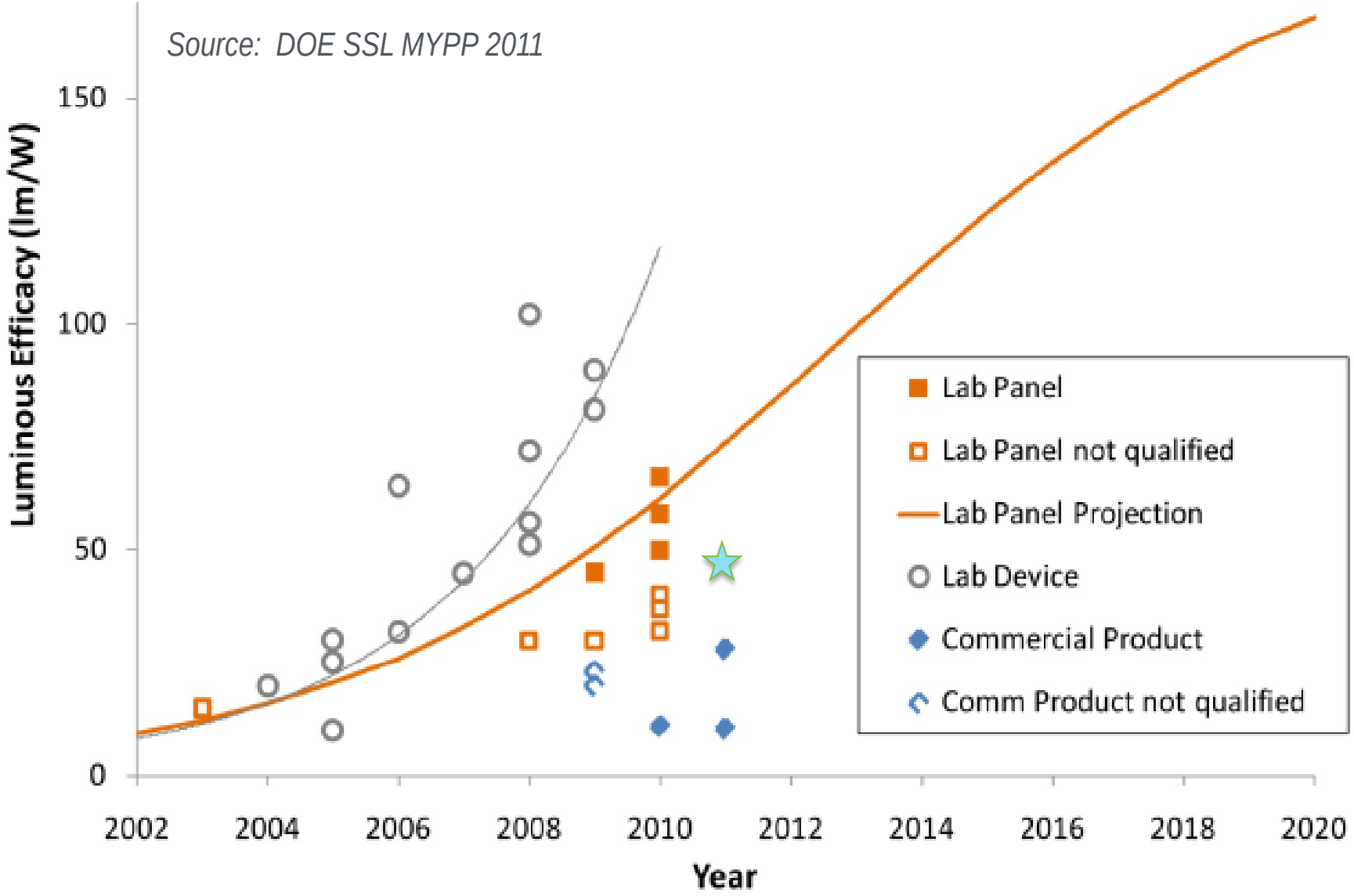
Philips

OLED Potential

	Incandescent	Fluorescent	LEDs	OLEDs (pixels)
Efficacy	17 lm/W	100 lm/W	80-120 lm/W: White 65-80 lm/W: warm white	**102 lm/W : CRI 70 79 lm/W : CRI 80**
CRI	100	80-85	80 – white 90 – warm white	**95 with 40 lm/W**
Form Factor	Heat generating	Long or compact gas filled glass tube	Point source high intensity lamp	**Large area thin diffuse source. Flexible, transparent**
Safety concerns	Very hot	Contains mercury	Very hot in operation	**None to date**
LT70 (K hours)	1	20	50	**> 30 with 79 lm/W > 4 with 100 lm/W**
Dimmable	Yes, but much lower efficacy	Yes, efficiency decreases	Yes, efficiency increases	**Yes, efficiency increases**
Noise	No	Yes	No	**No**
Switching lifetime	Poor	Poor	Excellent	**Excellent**
Color Tunable	No	No	Yes	**Yes**

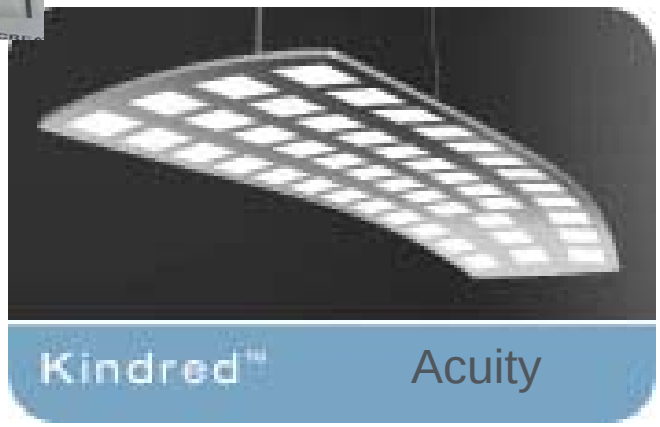
Source: Michael Hack, Universal Display Corporation

OLED Panel Status & Targets



OLED Luminaire Status & Targets

Lumiblade Plus, Philips



	Today (Panel)	2012	2015	2020
Efficacy	45 lm/W	77 lm/W	105 lm/W	148 lm/W
Lifetime	10 khrs	25 khrs	50 khrs	100 khrs
Brightness	3,000 lm/m^2	6,000 lm/m^2	10,000 lm/m^2	10,000 lm/m^2
Cost	$14,000/klm	$235/klm	$50/klm	$15/klm

DOE SSL Research

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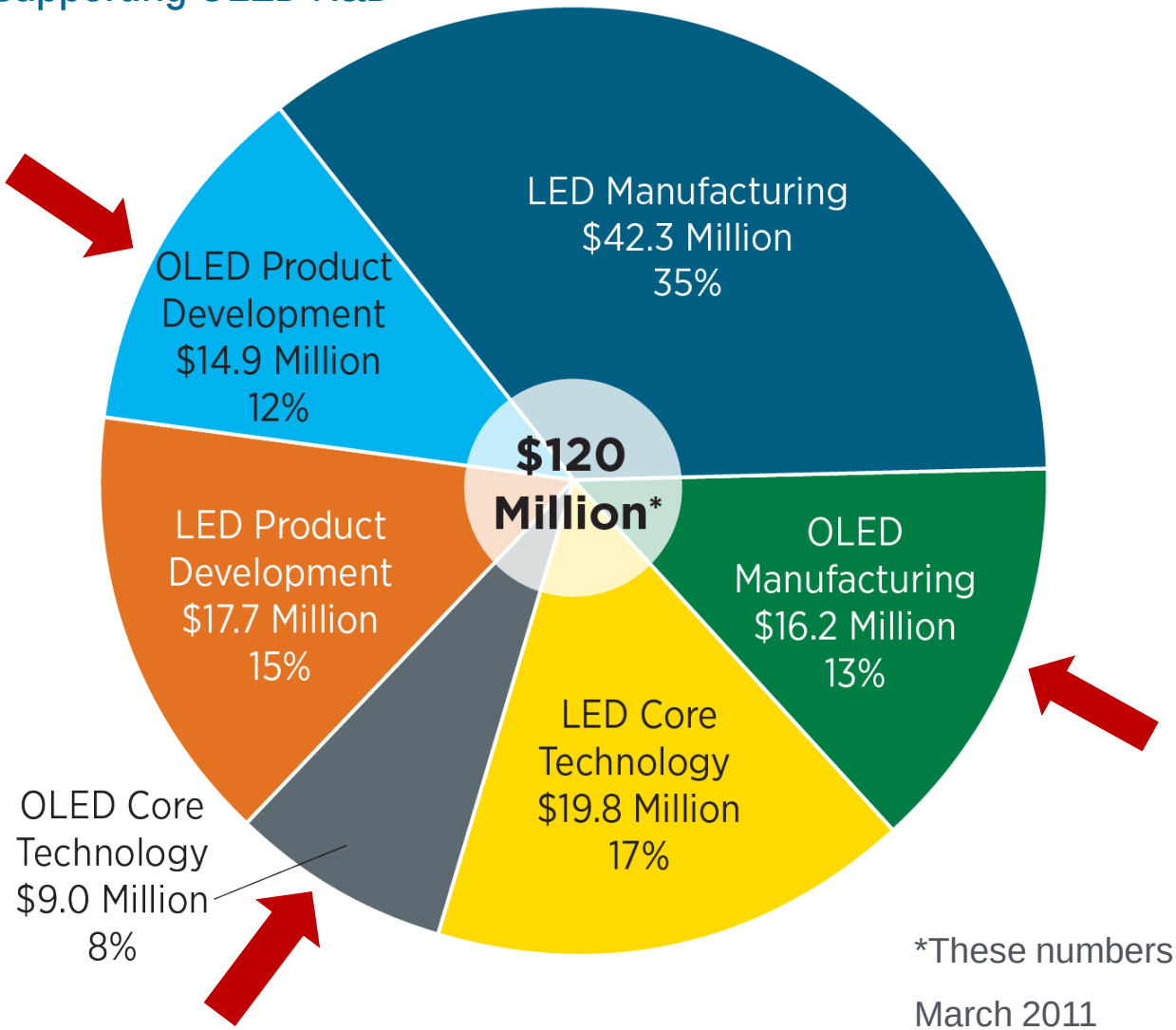
33% of funding supporting OLED R&D

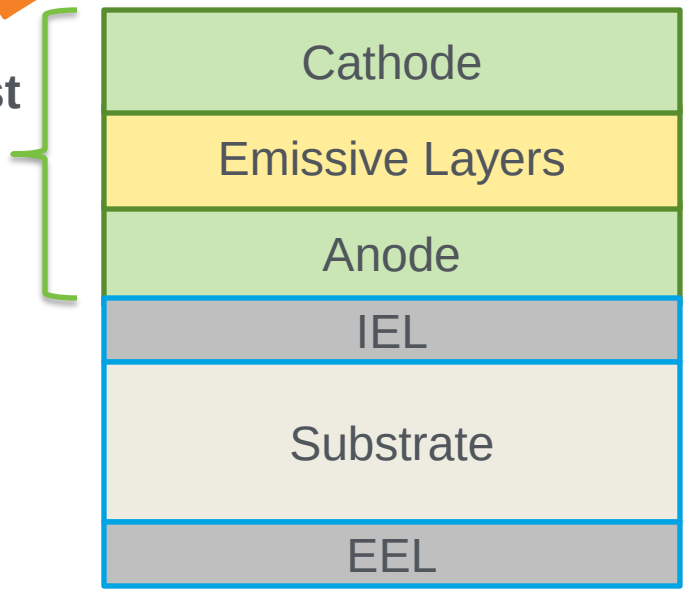


*These numbers are rounded

March 2011

Advances needed – OLED Stack

EFFICACY & LIFETIME:
At high brightness & low cost
Novel Light Emitters
Stable,efficient blue
Narrow red
Novel OLED Structures
PNNL (x2)
University of Rochester
University of Florida/Lehigh
Arizona State University



ENCAPSULATION
Lifetime

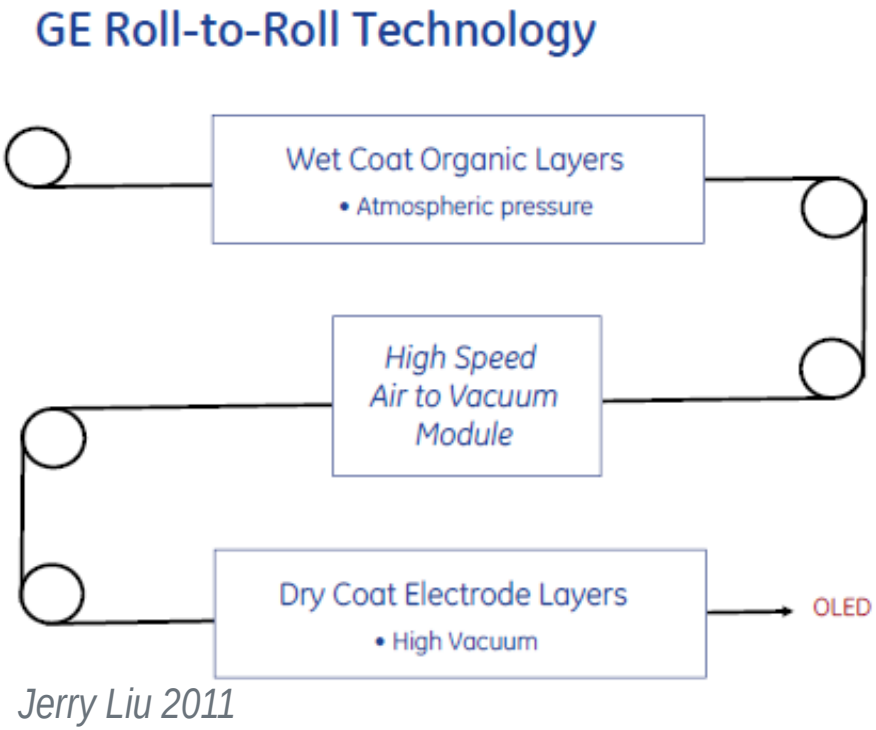
INTEGRATED SUBSTRATES:
Cost
Current Spreading
PPG
Cambrios

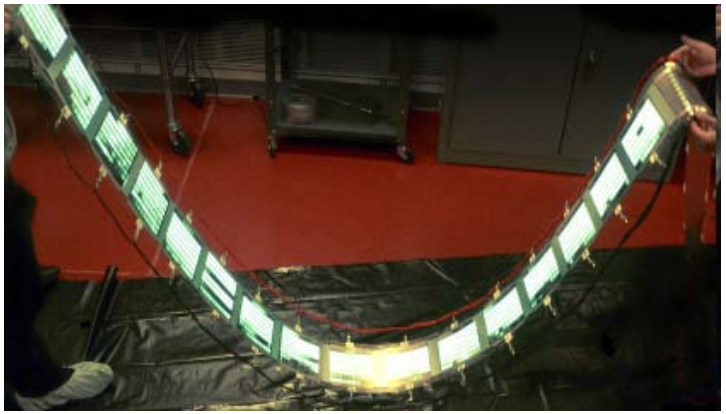
BRIGHTNESS/LIGHT EXTRACTION:
University of Rochester
University of Florida

Advances Needed – Manufacturing

- Infrastructure investment needed to develop commercial products
- Need Improved cycle time, yield, materials utilization
- DOE is supporting two OLED pilot lines in the U.S.
  - GE R2R – solution deposition
  - UDC/Moser Baer – vapor phase deposition

Located in Canandaigua, NY, the STC will house two pilot phosphorescent OLED manufacturing lines.





Advances Needed – Luminaires

- **Optical/Mechanical/Electrical Integration**
  - Form Factor
  - Light Distribution
  - Manufacturing Standardization (panel characteristics, electrical connections, etc.)
- **GE** – High Quantum Efficiency OLED Lighting Systems
- **DuPont Displays** – Solution Processed Small Molecule OLED Luminaire for Interior Illumination
- **Universal Display Corporation** – High Efficacy Integrated Under-Cabinet Phosphorescent OLED Lighting Systems; OLED Ceiling Luminaire (joint project with Armstrong and universities of Michigan and Southern California)

Dupont Displays :Color tunable, printed OLED panels

UDC/Armstrong luminaire – 51 lm/W

Snaps into TechZone ceiling

The Critical Issues

- ***OLEDs have demonstrated feasibility as an energy saving light source***
- ***Critical issue is cost***
- ***Despite the possibility of low-cost manufacturing, the larger area of OLEDs means more material is required***
  - ***Materials costs make it difficult to bring price down***
- ***Research needed to increase luminous emittance, lifetime***

Brightness
> 10,000 lm/m²
High efficiency materials (blue)
High efficiency structure
Light Extraction

Stability
> 50 khrs
Encapsulation
Efficient Materials
Low Voltage, Current Structure

Cost
< $50/klm
Integrated Substrates
Cost effective processes
Cost effective materials

Cost of Materials, Cost of Ownership

Panel Products

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Company	Efficacy (lm/W)	Area (cm^2)	Price (€)	Features
Philips Lumiblade	20	10 - 60	77-269	Various colors, sizes, shapes
Philips Lumiblade Plus	45	50	120	Highly efficient
Lumiotec 2011	11	100 - 300	115-350	Various colors, sizes, shapes
Osram Orbeos	23	50 (circular) 65 (rectangular)	240	Various shapes Mirrored or Diffuse
LG Chem	45-60			Highly efficient; Q1 2012 Availability
Fraunhofer Tabola		25 - 115		Transparent version
Verbatim Velve	28	200		Color tunable
Kaneka	20			Various colors

Adapted from The OLED Handbook ,2011

OLED Luminaires

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