

Thin-Film Encapsulation of Organic Light Emitting Devices (OLEDs)

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About Huntsman

Huntsman is a global manufacturer and marketer of differentiated chemicals.



- \$8 billions annual revenue in 2009
- Operates from multiple locations worldwide
- 11,000 associates

Huntsman Corporation

HUNTSMAN

Enriching lives through innovation

Differentiated				Inorganic
Polyurethanes	Advanced Materials	Textile Effects	Performance Products	Pigments
Adhesives, Coatings & Elastomers Appliances Automotive Composite Wood Products Footwear Furniture Insulation TPU	Base Resins Formulated Systems Specialty Components	Apparel & Home Textiles Specialty Textiles	Performance Specialties Performance Intermediates Maleic Anhydride & Licensing	Titanium Dioxide
				

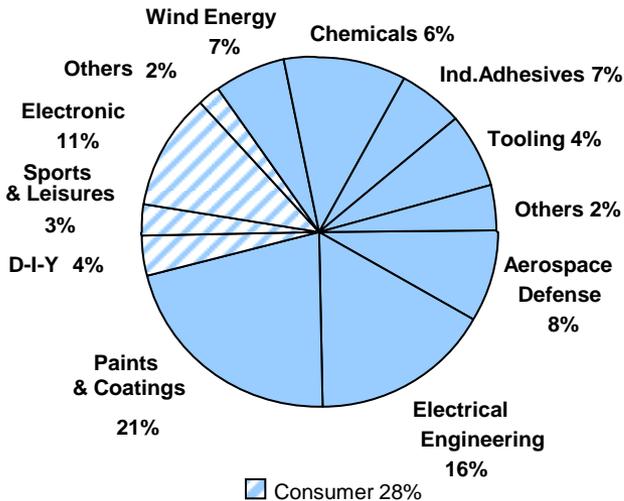
Advanced Materials

HUNTSMAN

Enriching lives through innovation

End Markets

Based on 2009 Revenues



Business Highlights

- Leading global manufacturer, marketer of differentiated chemicals and formulated systems.
- Araldite® brand
- 13 locations worldwide
- ~2,000 employees
- Headquarters in Basel

1Q10 LTM

Revenue
\$1.1b

Locations



Innovation at Advanced Materials

We are a global leader and partner in

- material science and chemistry to replace conventional materials because of their limitations
- innovative material technologies for new applications into new markets

Innovation at Huntsman is globally recognized via numerous prestigious innovation awards (JEC, Materialica, Euromold).



**OLED integrated into
rear view mirror
composite
24h of Le Mans Race**



The New OLED Lighting Market

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Around 19% of all electricity is consumed by lighting

What if OLED gets 10% share in the replacement market for lighting:

~100.000.000 m² OLEDs/year needed!

Earth at Night

More information available at:

<http://antwrp.gsfc.nasa.gov/apod/ap020811.html>

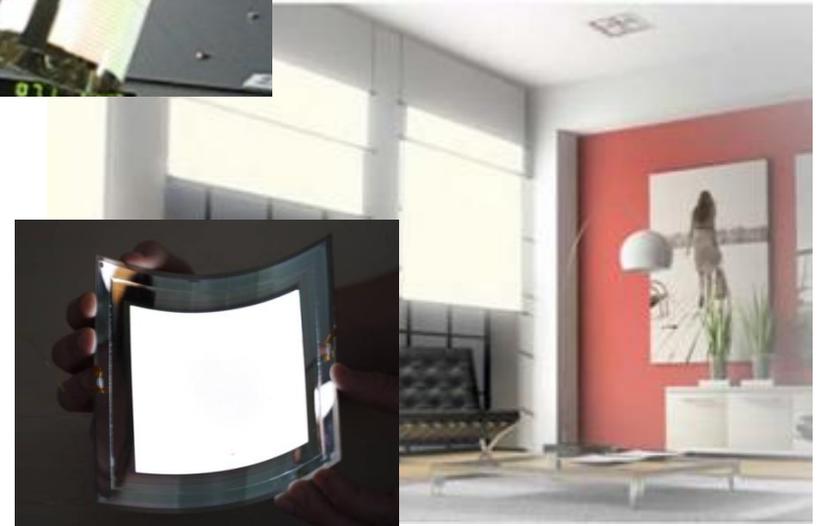
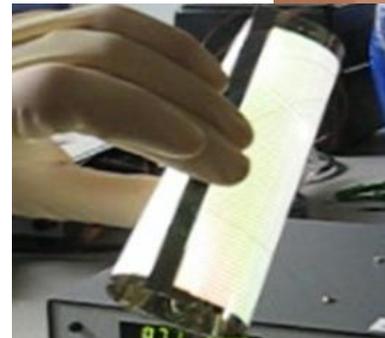
Astronomy Picture of the Day

2002 August 11

<http://antwrp.gsfc.nasa.gov/apod/astropix.html>

Why 'OLED Lighting' ?

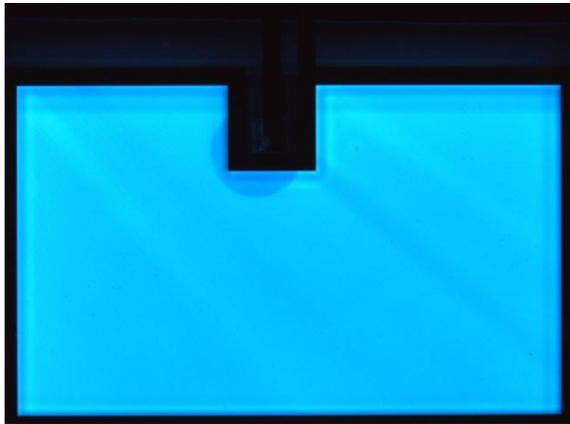
- The organic layers of an OLED allow them to be thin, and light.
- OLED substrates can be plastic rather than the glass which allow them to be flexible.
- They consume very little power.
- They can be made into large, thin sheets.



The Challenge: Encapsulation

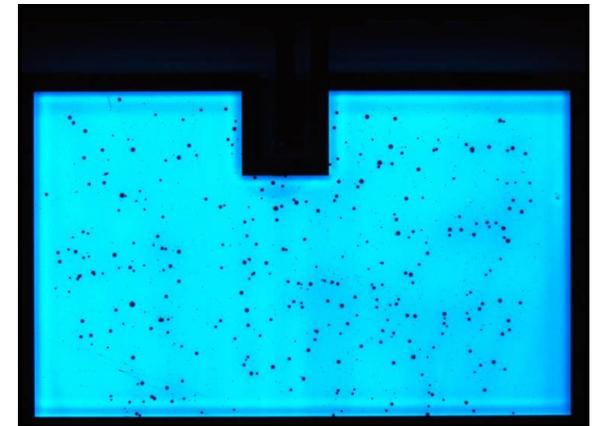
So, what's keeping the industry from selling in large scale?

- Cost, lifetime and brightness of OLED's lighting are key elements.
 - Cost and lifetime are related to **ENCAPSULATION**
 - Water can easily damage OLEDs
 - Flexible and economical encapsulation is the key technology that needs to be developed



Right after processing

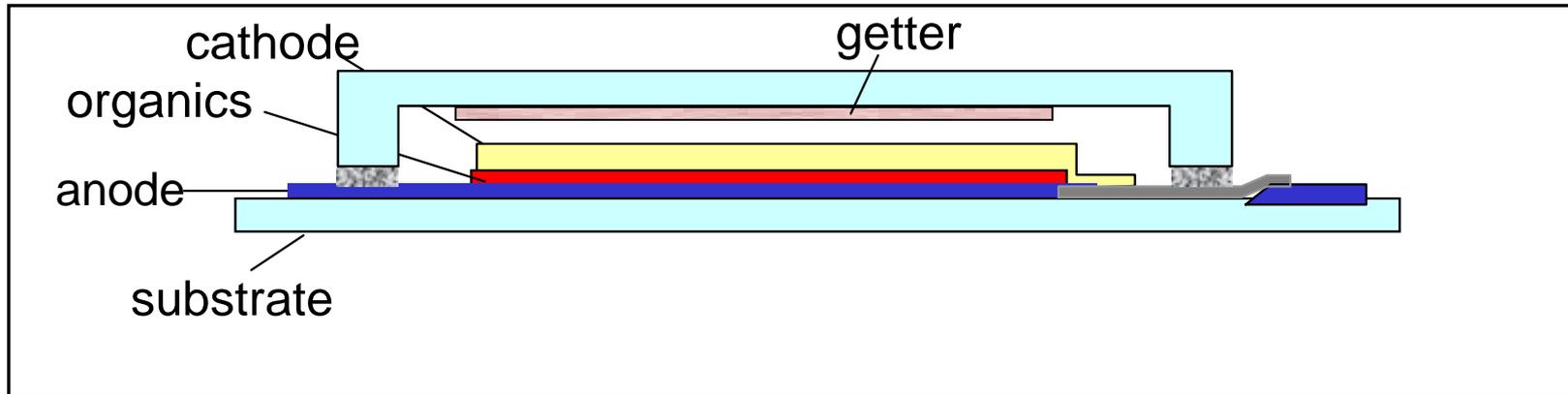
**Cathode oxidation:
local degradation
leading to black spots**



~10h at 20 °C / 50% RH

Standard Encapsulation OLED Lighting

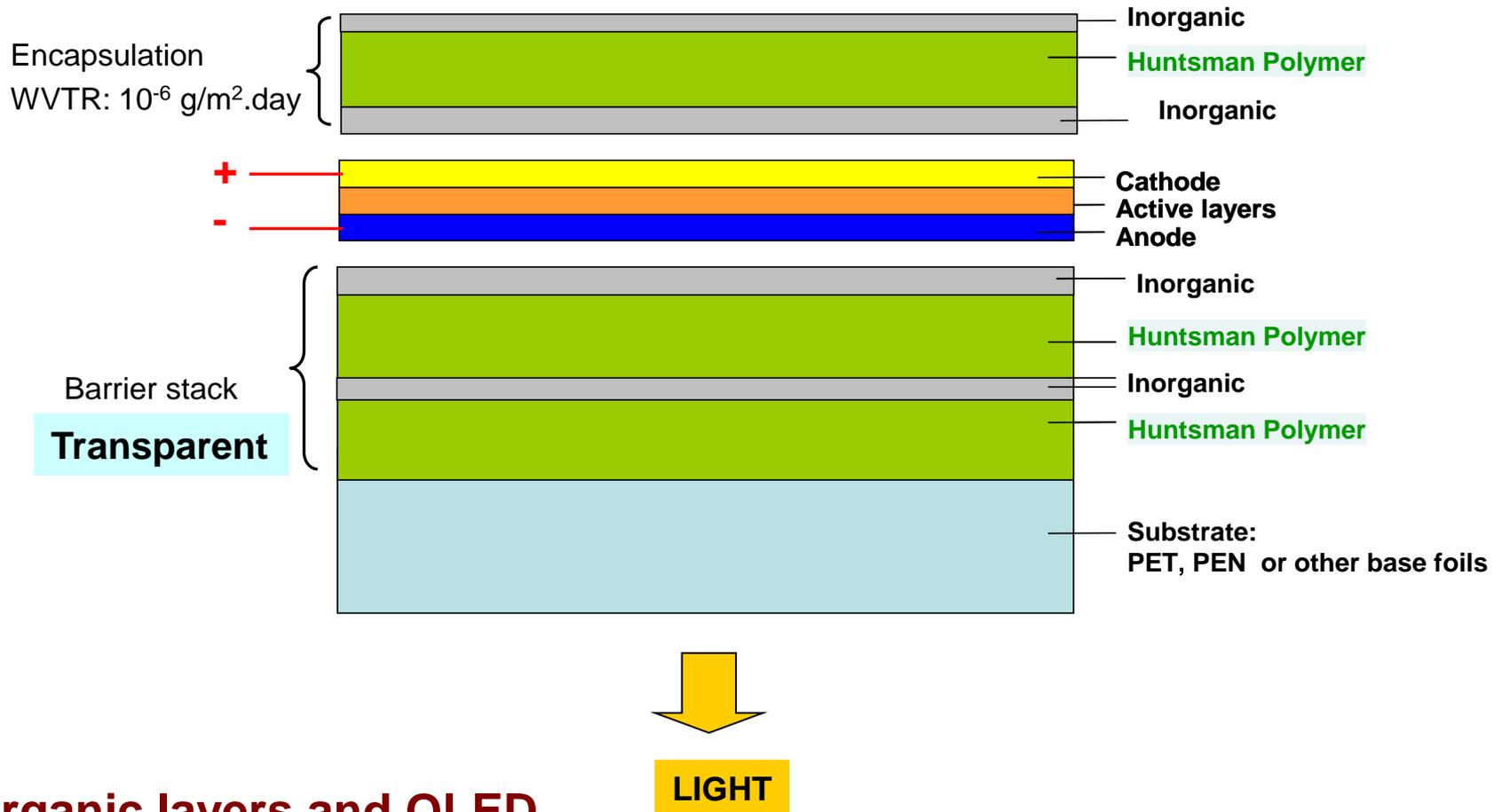
- State-of-the-art encapsulation using metal or glass lid with cavity containing water scavengers (getters)
- No hermetic seal (getter required)



- Price of OLED (m^2) are around 15,000 € – 20,000 €!!
- It is not applicable for:
 - Fast production
 - Large area devices
 - Flexible (foil-based) devices



Flexible OLED Design

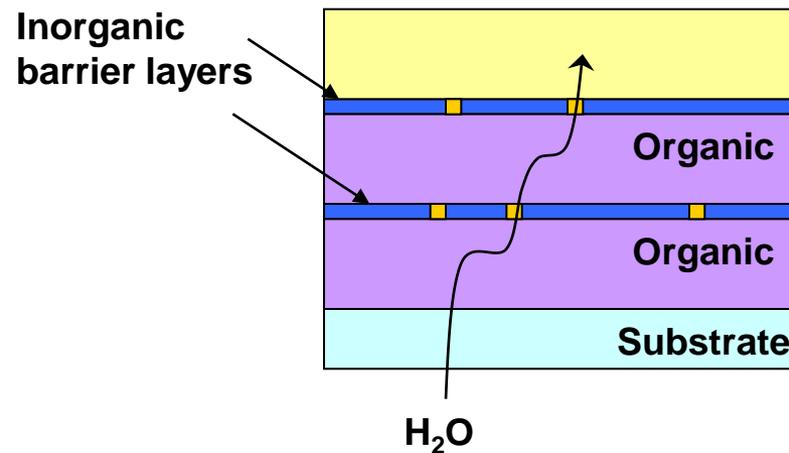


Inorganic layers and OLED processing: Philips and Holst

OLED Barrier and Encapsulation Technology

Multilayer Approach: Organic/Inorganic Barrier film

- Inorganic: The inorganic layer (SiN) is a very good barrier against water with intrinsic WVTR of 10^{-6} g/m².day. However contains lots of defects and holes which affect the barrier performance.
- Organic: polymeric matrix **developed by Huntsman**.



➤ Multi-layering creates a tortuous path through defects for water and oxygen.

➤ Organic layer covers particles and planarizes surfaces for deposition of high quality inorganic layers and absorbing mechanical stress in the layers.

Huntsman Activities in OLEDs

- Involved in barrier and encapsulation technology since 2006.
- Engaged in program TP2 at Holst Center/Eindhoven.
- TP2 program got EU funding from Fast2Light project - around 16 partners participating.



General objective:

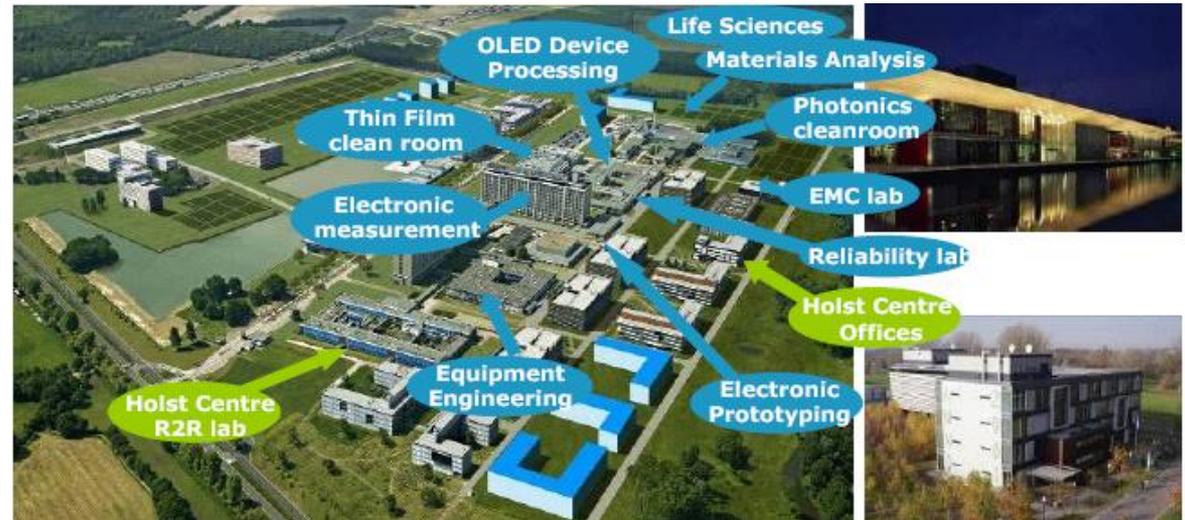
Develop novel, cost-effective, high throughput, roll-to-roll, large area deposition processes for fabricating light-emitting polymer-OLED foils for lighting applications.

Holst/TNO - Open Innovation Center

Open Innovation Center for Wireless Autonomous Microsystems and Systems-in-Foil.

Located on the Philips High Tech Campus
(> 90 companies, 7,000 researchers)

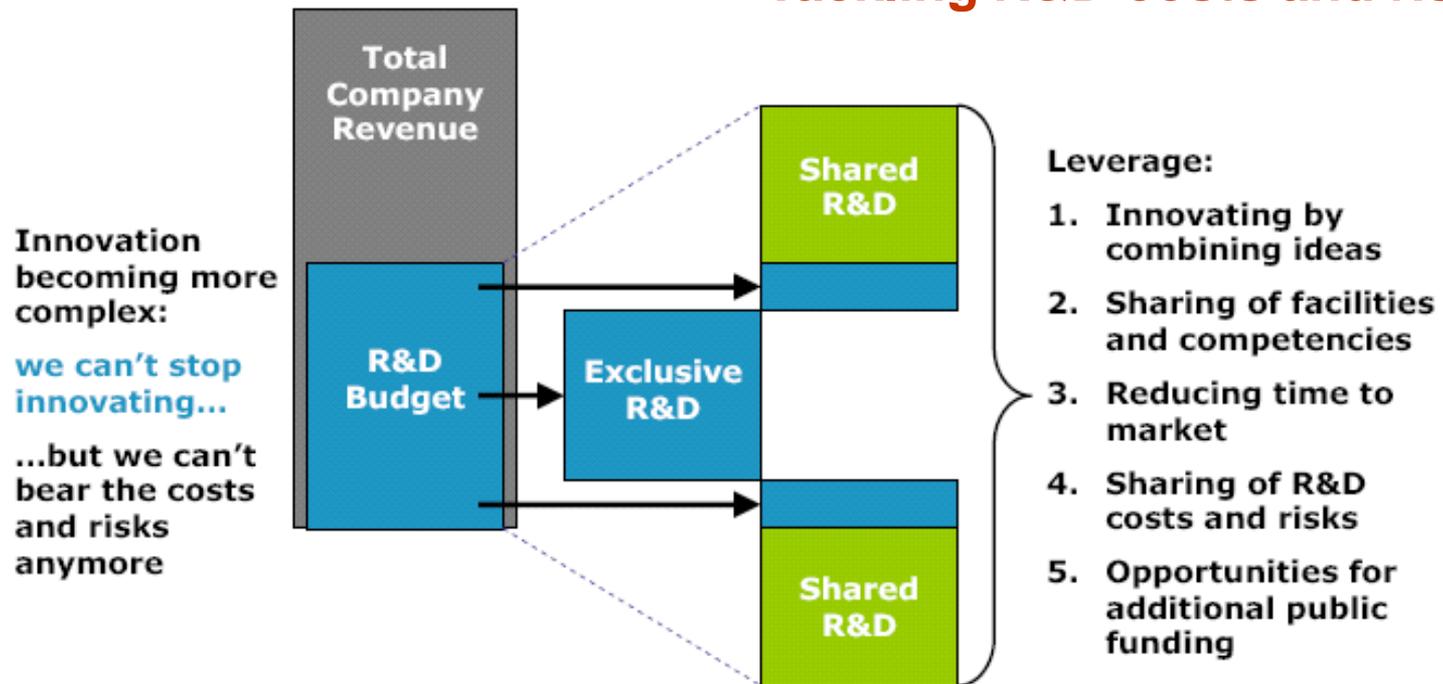
- Access to shared labs and equipment (www.miplaza.com)
- Access to 8,000 m² cleanrooms



Holst/TNO - Open Innovation Center

- Staff of 160 researchers and 70 resident researchers from industry and universities

Tackling R&D costs and risks



Holst/TNO - Open Innovation Center

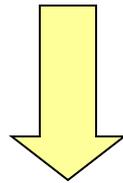
- Global Network of Industrial and Academic Partners

Gate to Market



B2B

B2C



World Leader in Lighting

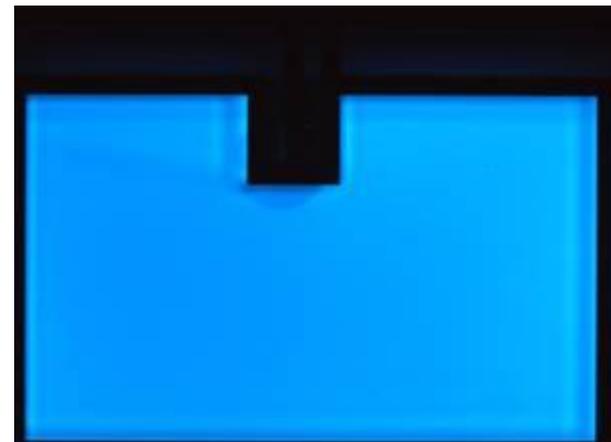


- Did not find such consortium in Basel area...but opened to any suggestion:
 - Partners with testing capabilities (OLEDs, solar cells manufacturers)
 - University/Institutes interested in development of barrier technologies for organic electronic applications.

Current Status Barrier Development

What has been achieved with our partners (Holst and Philips):

- On functional OLEDs, 2 x 2 cm encapsulated with SiN - Huntsman Organic Coating - SiN:
 - No blackspots for at least 500 h at 60°C/90%RH with yield of 86%
 - Translates in 5 years at 20/50 condition.
- Integrated S2S production process under development
- R2R process targeted for 2012



Thank you for your attention

Any question?

