
P3
save energy
keep track
anticipate
lower cost
save time
stay tuned
improve performance
feel secure
Holst Centre
Open Innovation by IMEC and TNO

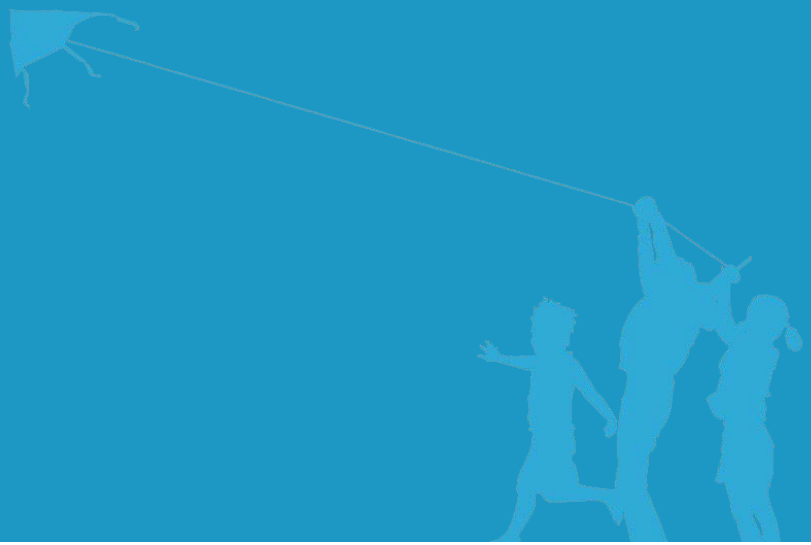
Holst Centre

Open Innovation by IMEC and TNO

Flexible and conformable OLED's

Karel Spee

Holst Centre / TNO



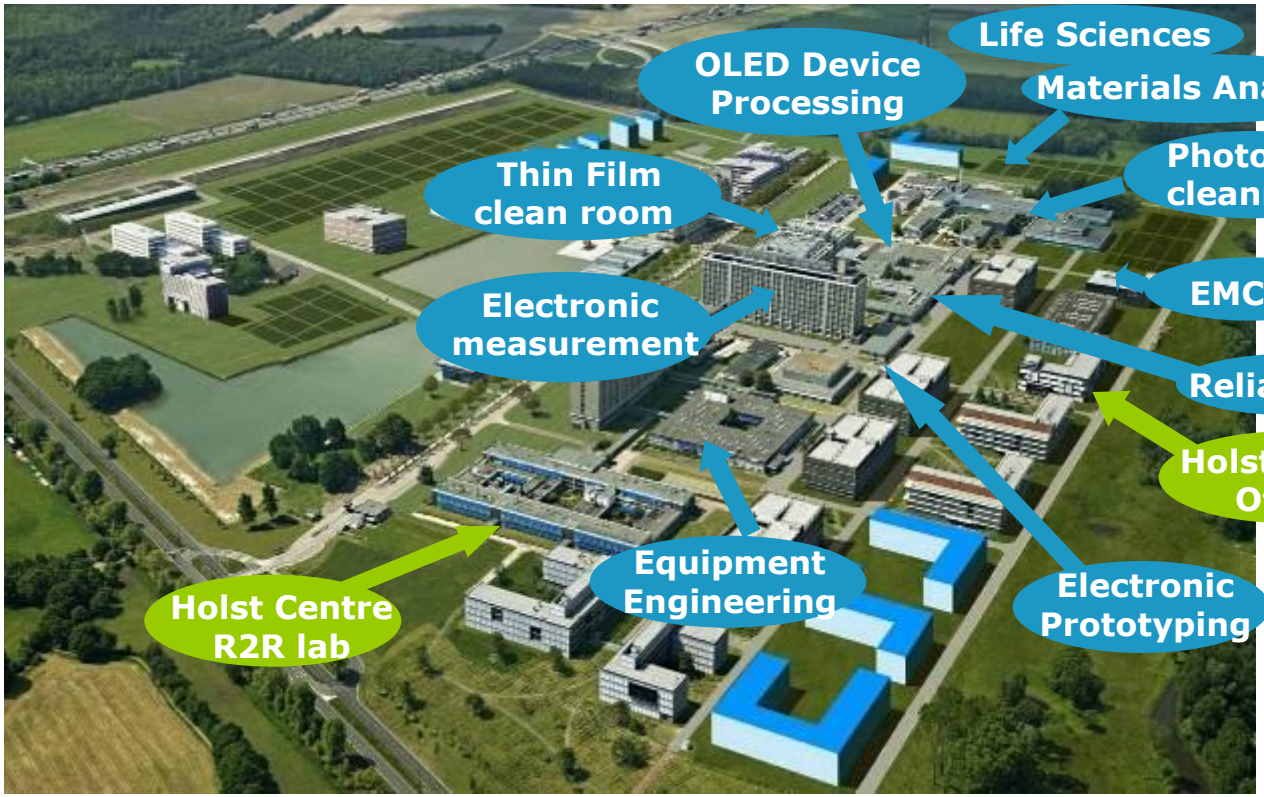
Holst Centre: a solid partner in research

- **Independent, with reputed parents**
  - Founded by imec (1300 fte, Belgium) and TNO (4500 fte, The Netherlands)
  - Established in 2005
- **Critical mass**
  - Own staff 160; 28 nationalities
  - 70 resident researchers from industry and universities
- **Global network**
  - Industrial and academic partners
- **Supported by the Dutch government**
  - Measured by its international excellence, long-term vision and impact on Dutch economy

NL Agency
Ministry of Economic Affairs

SenterNovem

At the hotspot of human-focused innovation

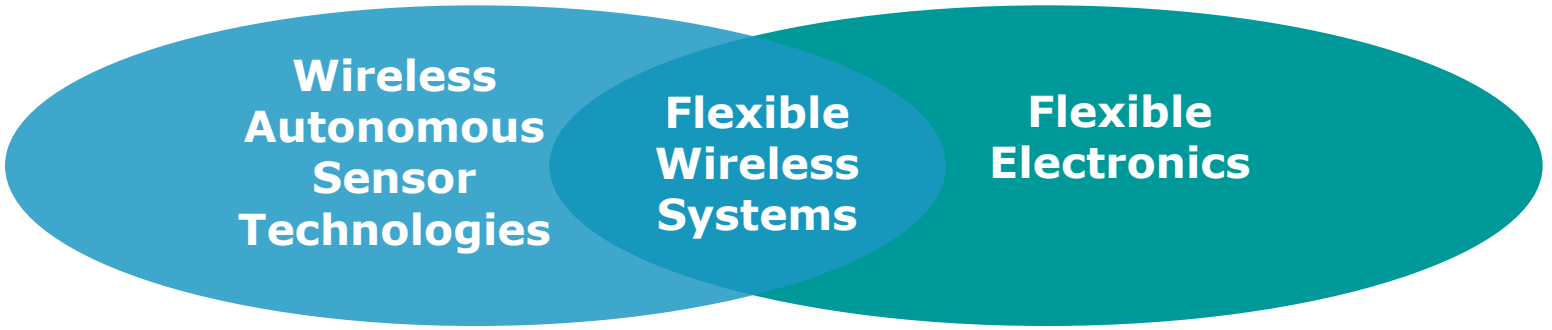


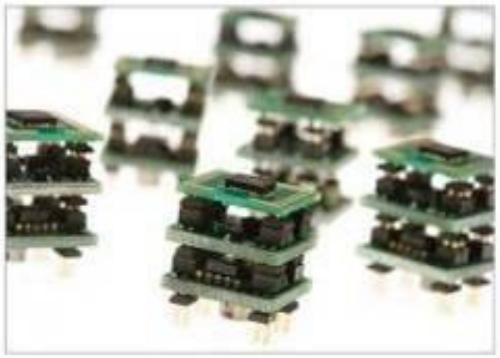
- **High-Tech Campus, initiated by Philips**
- **>90 companies, 7000 researchers**
- **Shared labs (www.miplaza.com); >8000m² cleanrooms**
- **Open Innovation research centres (e.g. Holst Centre)**

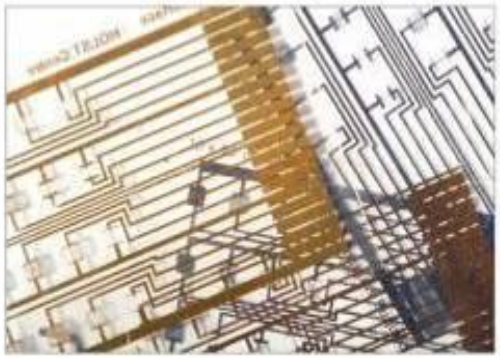
High Tech Campus Eindhoven

Shared research with clear focus

- **Creating generic technologies, time to market 3..10 years**
- **Partnering with industry and universities**
- **Bridging the gap between academia and industry**
- **Results are shared between partners**







Large Area Electronics market applications

Flexible displays

Plastic solar cells

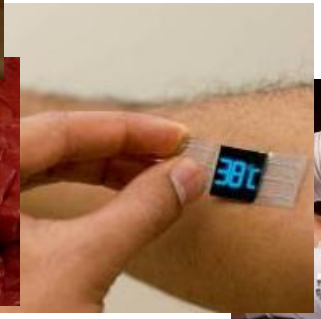
Touch screens

Plastic batteries

Smart packaging

Signage

RFID tags



OLEDs

Sensors

Disposable bio-sensors

Smart bandage

Electronic textiles

Industrial partners from across the value chain

Presentation overview

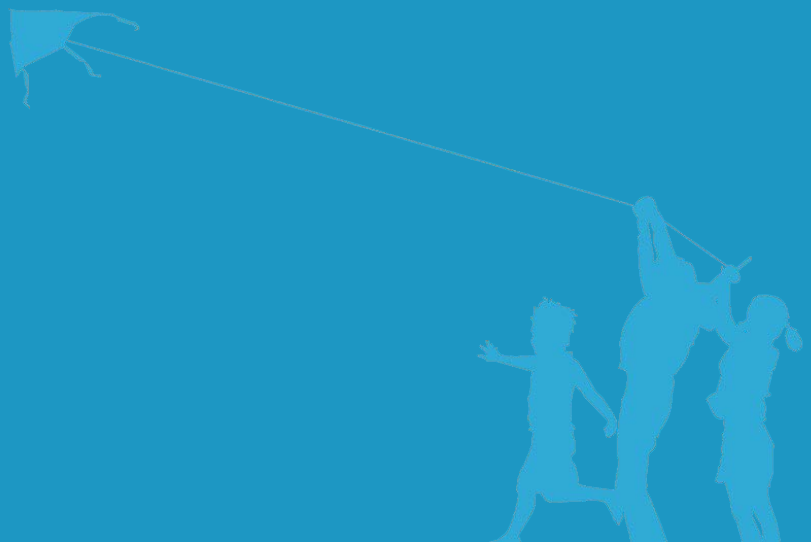
Current OLED applications

OLEDs: what are they, what are the challenges?

Possibilities with flexible OLEDs

Conformable OLEDs

Our Vision



2004: more and more OLED displays enter the market

SGH-E 710

SGH-E 710

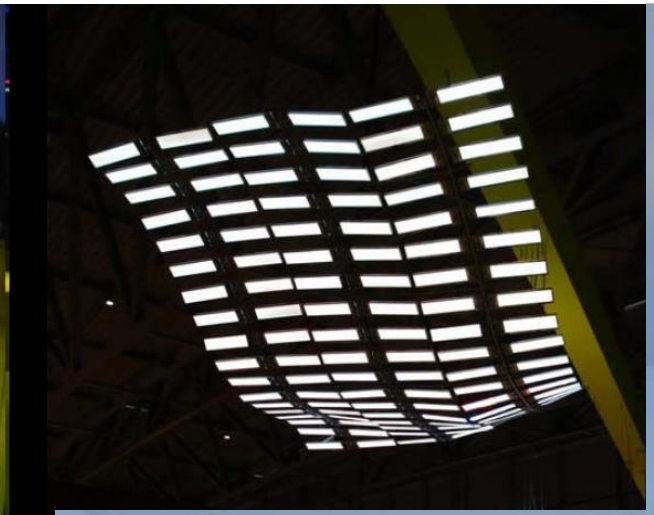
2009-2010: OLED displays in smart phones

Samsung i8910 Omnia HD

Samsung Omnia Pro (June 2009)

2009-2011: first OLED-TVs (will) hit the market

2009: Also OLED lighting makes its debut…



Presentation overview

Current OLED applications

OLEDs: what are they, what are the challenges?

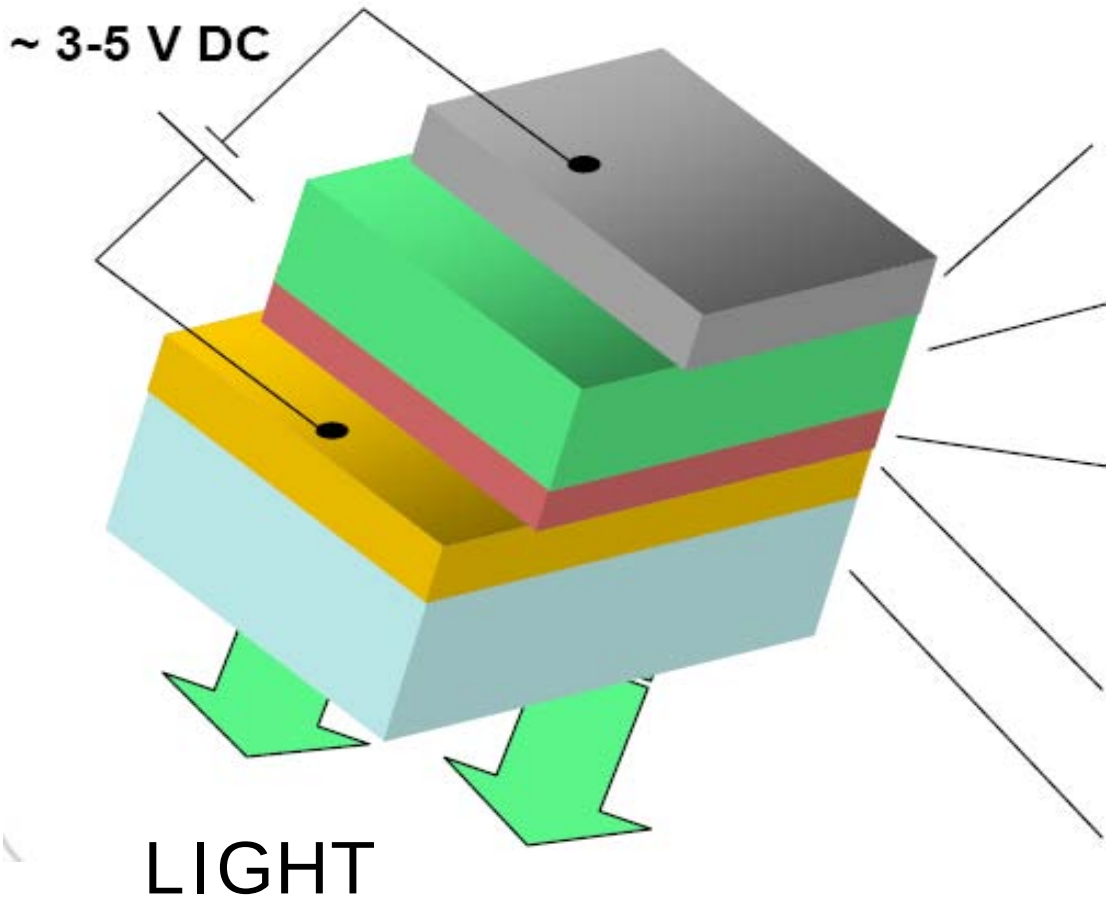
Possibilities with flexible OLEDs

Conformable OLEDs

Our Vision

Anatomy of an OLED device

Total stack < 1 mm!



Cathode (e.g. Ba-Al)

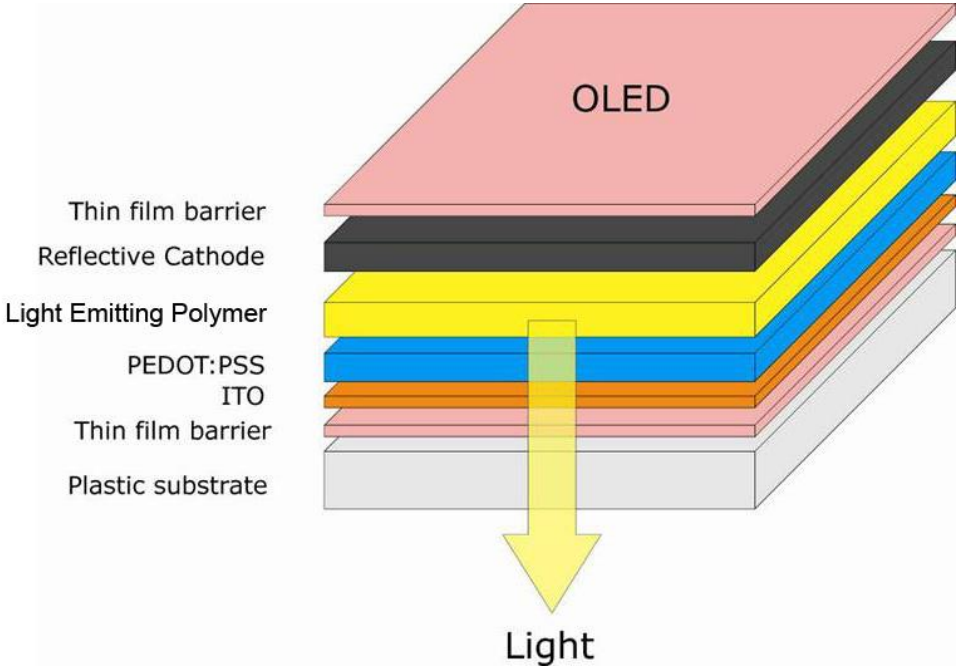
OLED stack (1->20 layers!)

Hole injection layer

Transparent conductive anode

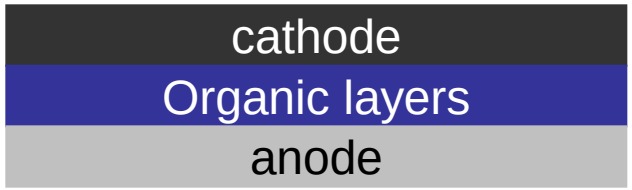
Substrate (e.g. glass, plastic or metal foil

OLED Layout – Polymer based



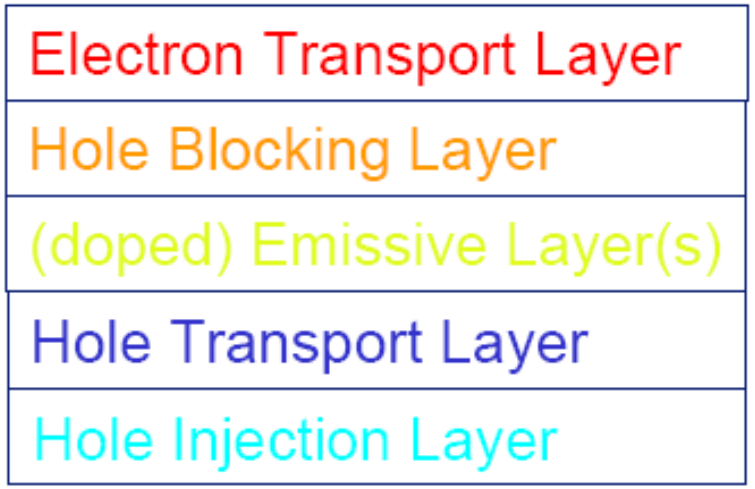
ITO	IndiumTinOxide (typical 90 % In_2O_3 + 10 % SnO_2)
OLED	Organic Licht Emitting Diode
LEP	Light Emitting Polymer
PEDOT:PSS	Organic Conductor - Poly(3,4-EthyleneDiOxyThiophen):Poly(StyreneSulfonat)

OLED Basics



PolyLED

smOLED

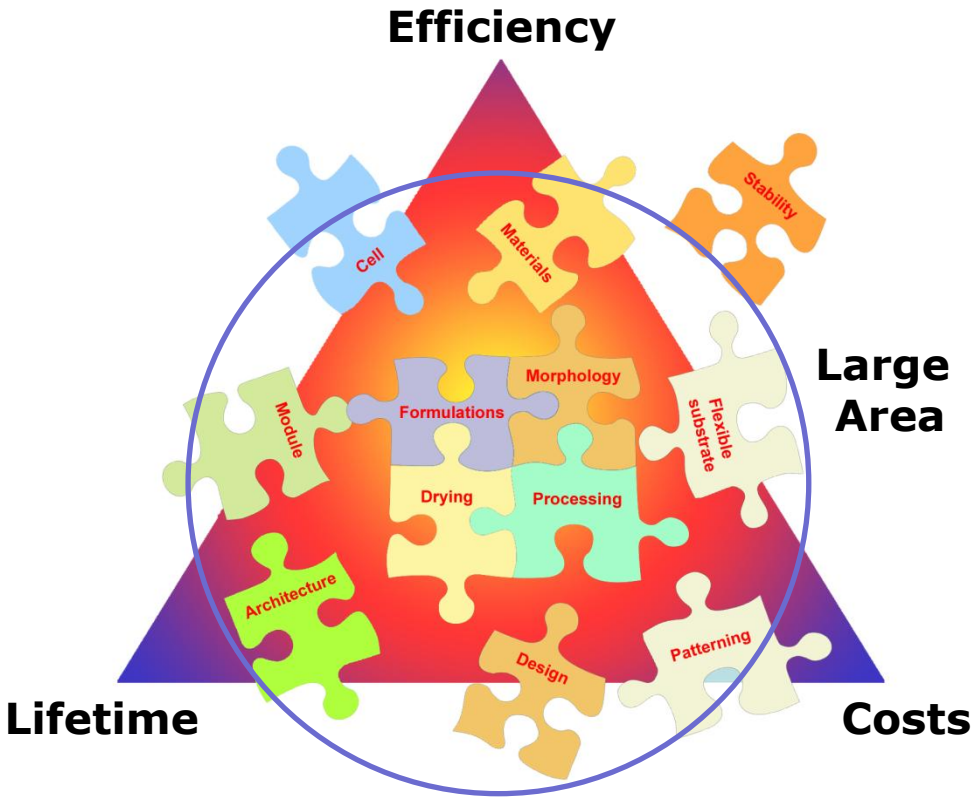


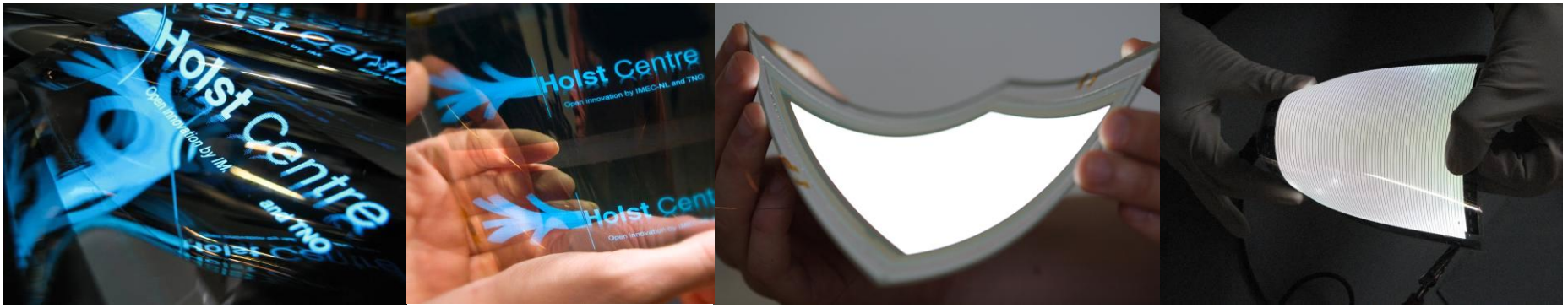
Polymer LED
- simple structure
- solution processable: printing possible
- lower efficiency and lifetime

Small molecule LED
- multilayer structure
- vacuum processing
- high efficiency and lifetime

OLED Challenges

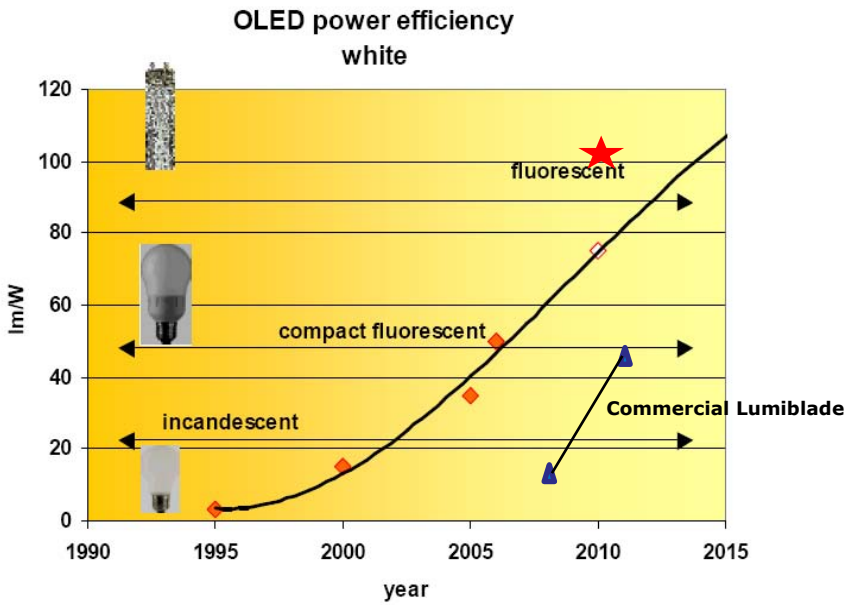
- **Efficiency**
- **Lifetime/reliability**
- **Large area devices**
- **Cost**





OLED Challenge – Efficiency/lifetime

- **Energy-efficient**
- **Long lifetimes**



OLED displays – as little as 1/10th the power wrt LCD

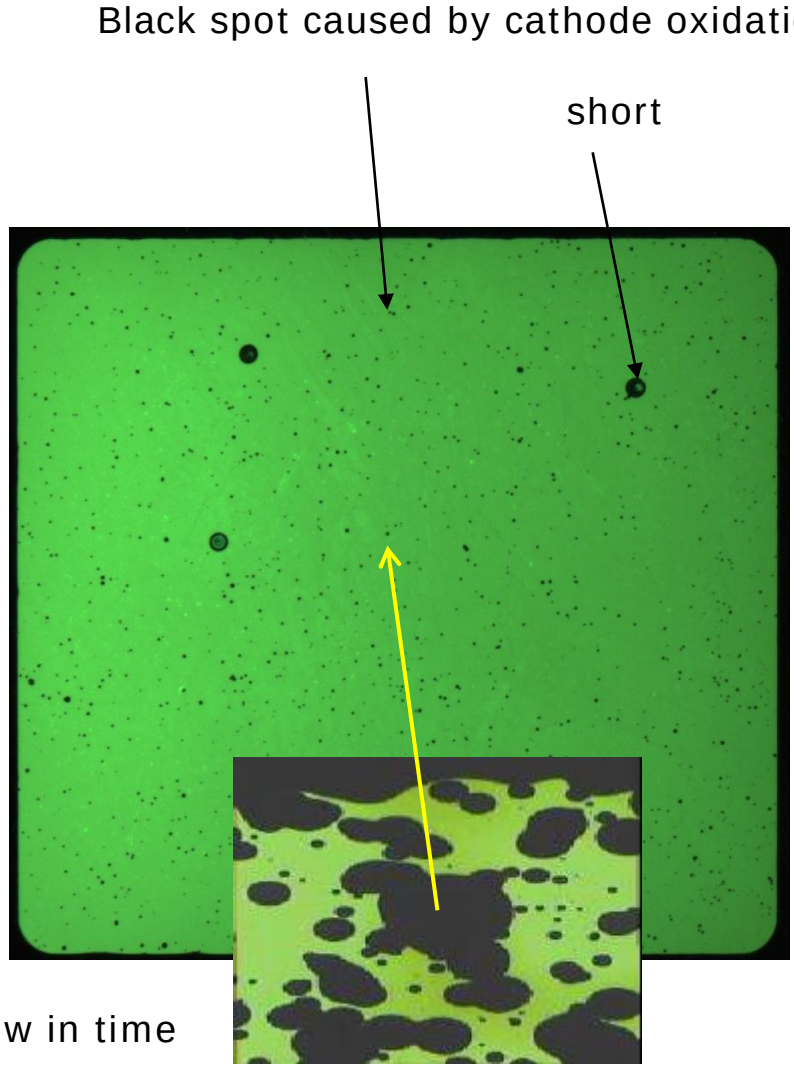
World record efficiency white: 102 lm/W@8000h
World record lifetime white : 100.000h@38lm/W

- **Environment**
  - No hazardous materials

OLED Challenge - Lifetime issues

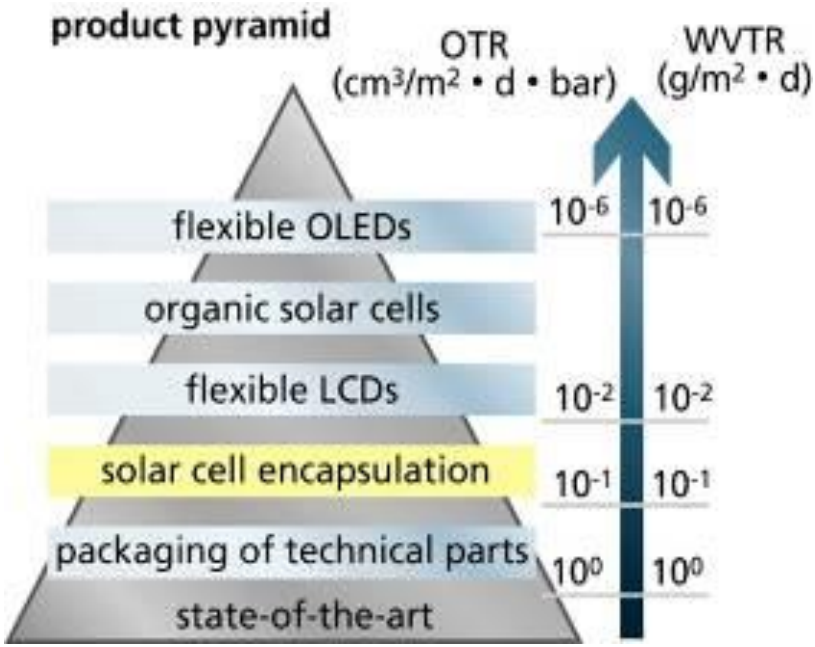
OLEDs degrade over time due to:

- Intrinsic degradation of organic/polymer molecules
  - **More stable and efficient molecules needed**
  - **Prevent oxygen and water from entering the device**
- Short formation
  - **Need for "smart" OLED designs**
- Electrode oxidation
  - **Prevent oxygen and water from entering the device**



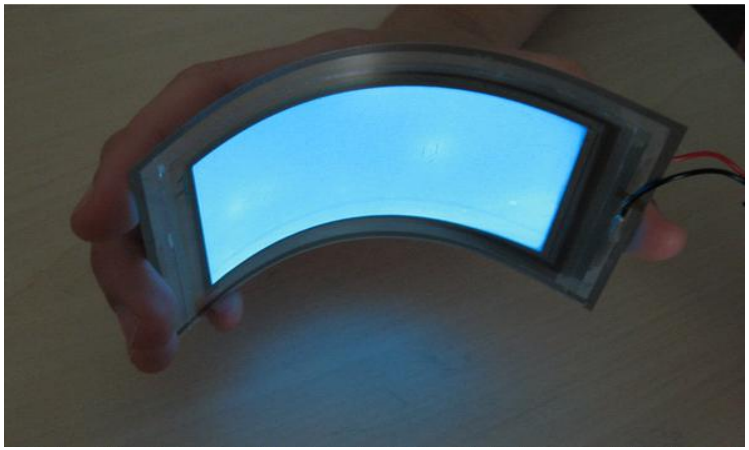
Ultra-good barrier needed

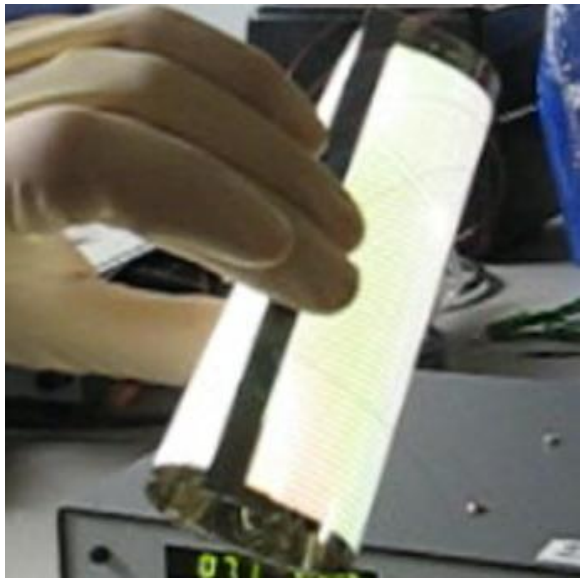
- Currently in production: glass or metal lid
- Future and MUST for flexible OLEDs: thin film barriers
- Barrier in an OLED:
  1,000,000x better than typical potatoes-chip bags (=30 nm Al on PP)



Current barrier performance at Holst centre

- **Multilayer barrier: PECVD SiN-printed organic layer-PECVD SiN 500 h at 60℃/90% RH with yield (=number of OLEDs that remain black spot free) of 97%**
- **Applied in state-of-the-art OLEDs and OPV**
- **Currently transferring technology to R2R (pre-pilot line expected to arrive End 2011)**

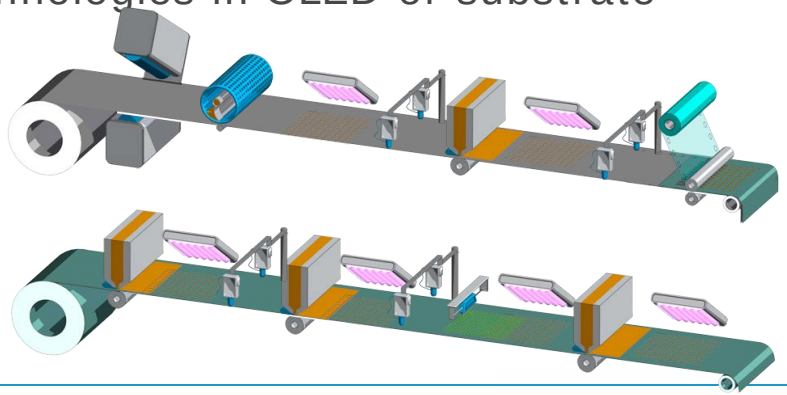




Cost

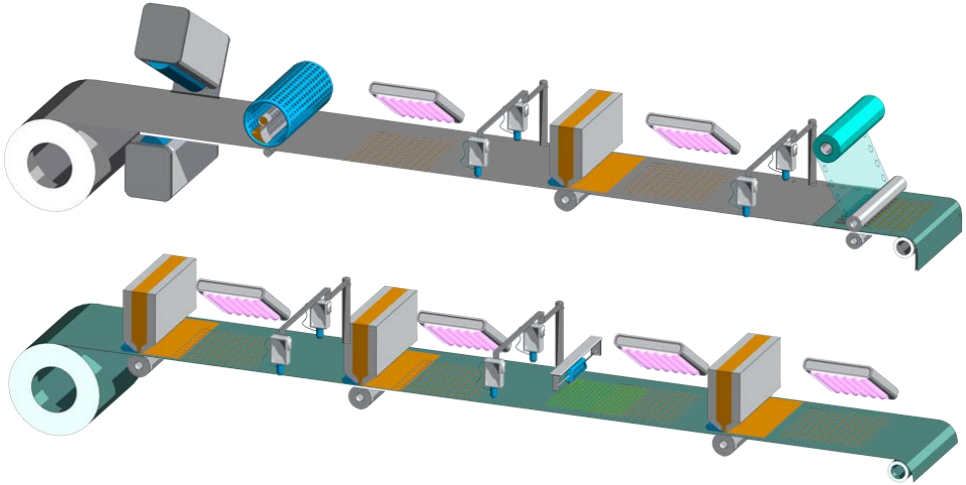
- **Current OLEDs for lighting:**
  - ~35.000 euros/m^2
  - Based on patterning via photo-lithography and vacuum deposition of active layers and metal

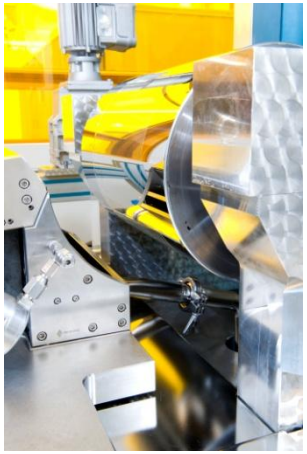
- **Possible solutions for cost down:**
  - Direct patterning through printing of metal and ISO
  - Direct patterning and atmospheric solution processing of active layers of a multilayer of small molecules
  - R2R processing at 5-10 m/min with high yield
  - Replacement of ITO with high conductive polymer
  - Integration of light outcoupling technologies in OLED or substrate (=foil)
  - Thin film barrier
  - Target <= 100 euros/m^2



Large area production by R2R

- **Large area**
- **Cost effective**
- **Development of full printing processes**





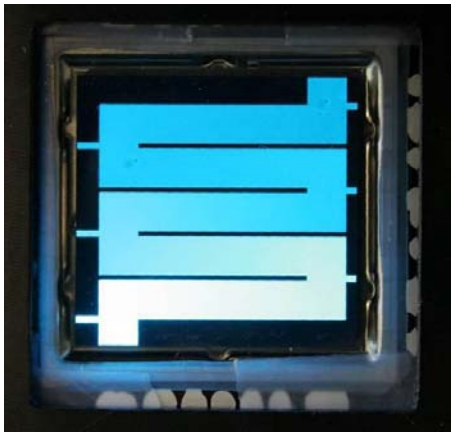
Cost reduction & Area increase

ITO:

- **High sheet resistance on foil ~ 60 ohm/sq**
- **ITO is expensive both in material cost as in production cost**

OLED lamp:

- **Substantial voltage drop from edge to middle of lamp based on ITO only**
- **This results in inhomogeneous light generation**
- **The problem increases with increasing OLED-surface area**



Picture: Zigzag OLED with voltage drop along the ITO anode

Need for high conductive anode!!

Holst Centre develops metal grid + high conductive PEDOT:PSS

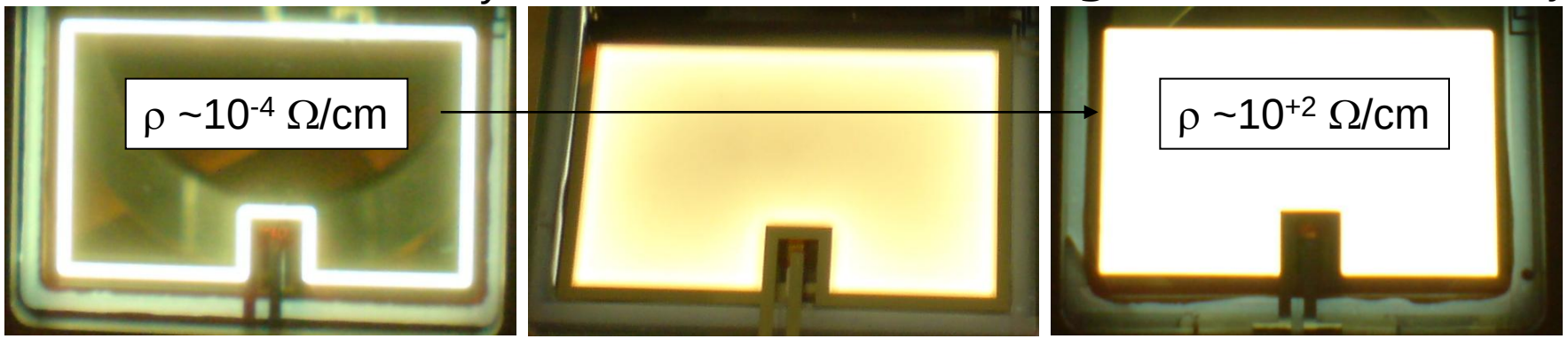
- No costly ITO
- Fully printable (low cost production)

High conductive polymer anode

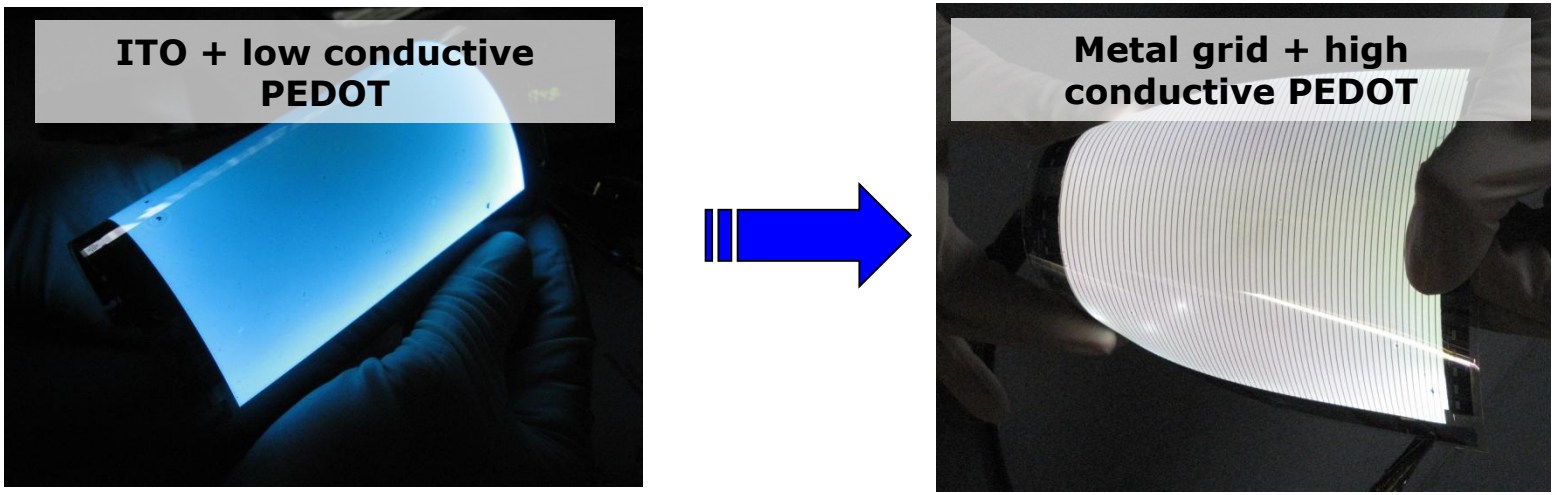
No ITO
Low PEDOT conductivity

5.75 cm²

No ITO
High PEDOT conductivity

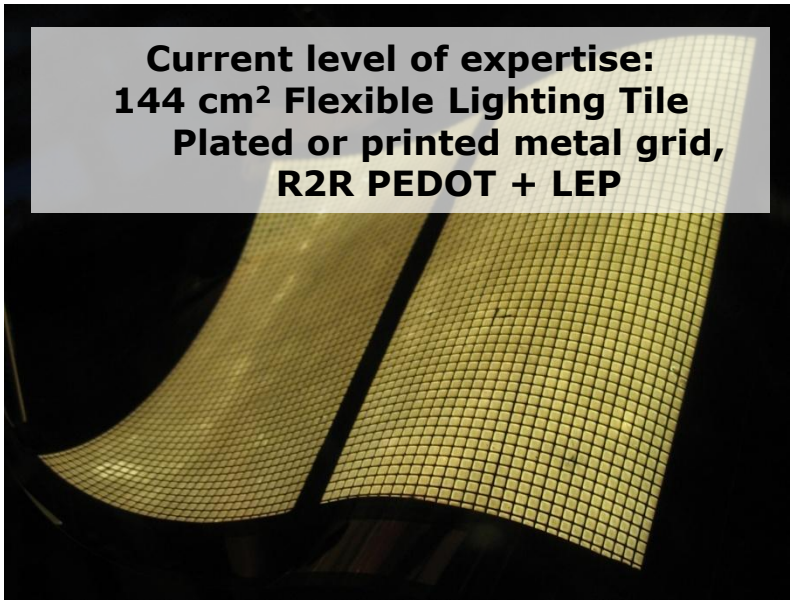


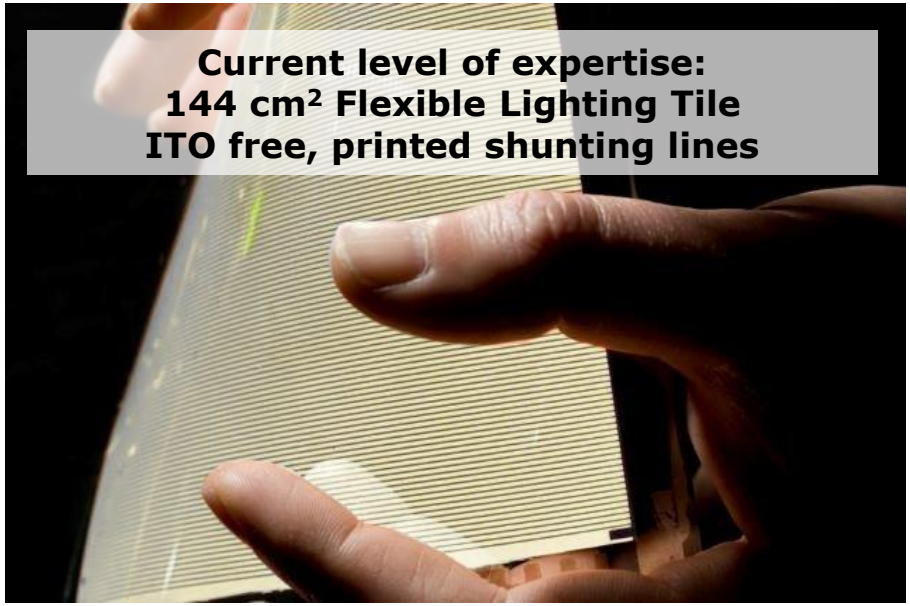
Including grid:



Current status flexible OLEDs

- **Lighting Tile demonstrator:**
  - OLEDs built on flexible *PEN, PET, Al, and SS* foils
  - Processing on temporary glass carrier with DTF adhesive
  - Processing without ITO(!!) and without photolithography
  - Integration of barrier and encapsulation technology
  - Integration of metallic ink printing technology





Presentation overview

Current OLED applications

OLEDs: what are they, what are the challenges?

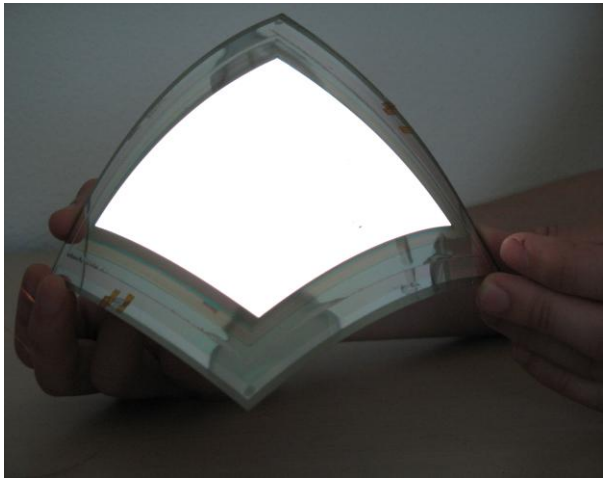
Possibilities with flexible OLEDs

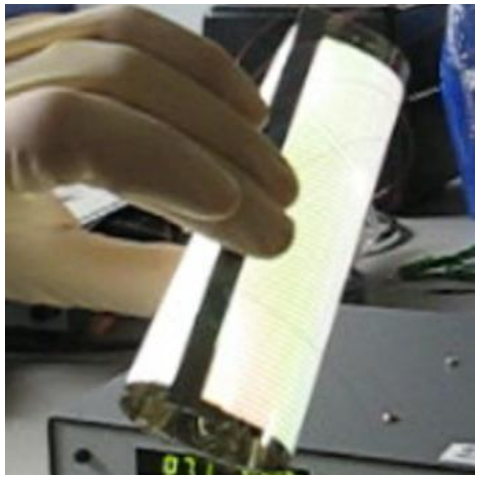
Conformable OLEDs

Our Vision

Why 'OLED Lighting' on foil?

- **Simple, safe and robust**
  - Easy-of-use
  - Unbreakable
  - Low voltage
  - Flexible
  - Thin
  - Area light





New possibilities for 'Solid State Lighting'

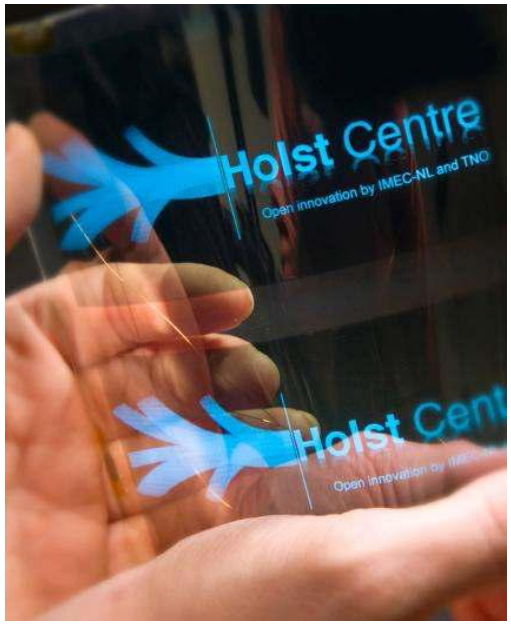
- **Flexibility in light**
  - Wide colour gamut & high CRI
  - Colour control:
    saturated colours, subtle colour effects, cold and hot white
  - Dynamic:
    light intensity, colour variable

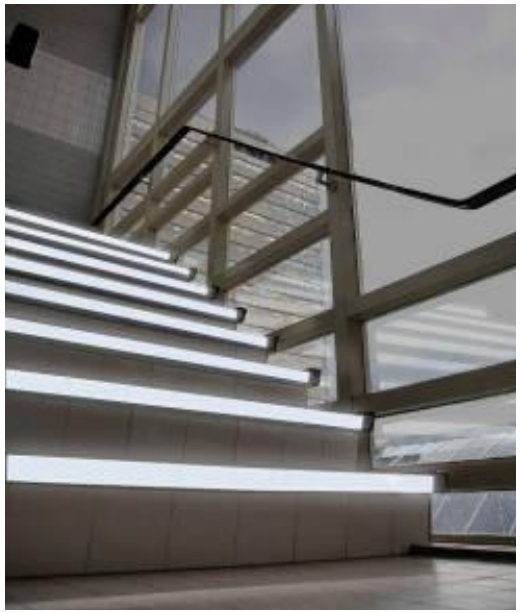
Source: Philips Lumiblade

CFL:
Poor dimming possibilities
Lifetime dependent on switching behavior

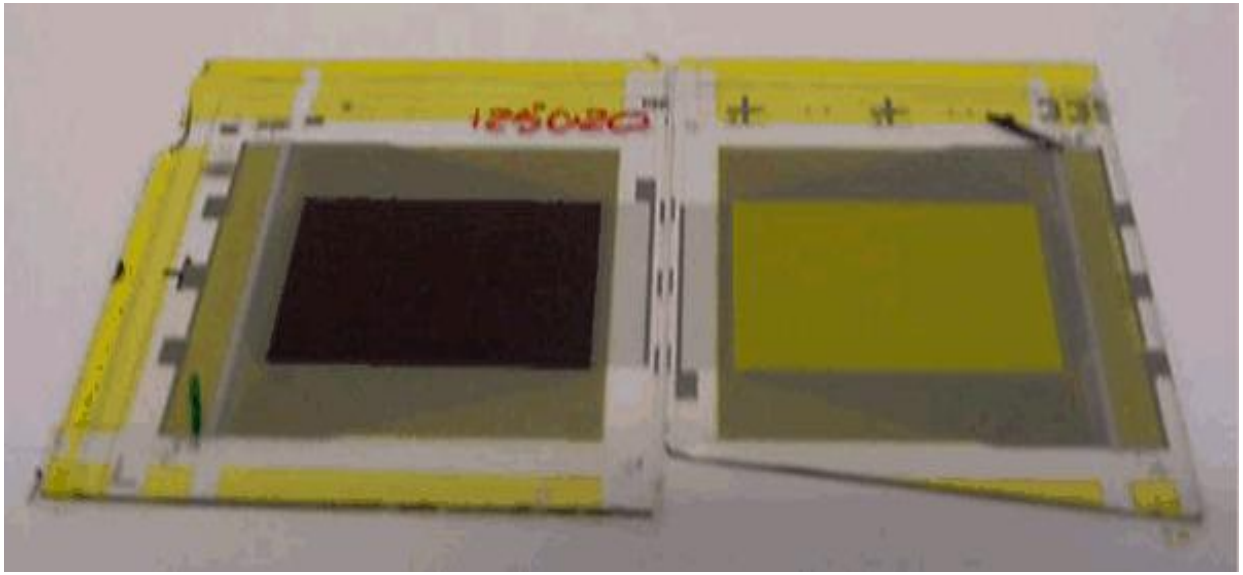
New possibilities for 'Solid State Lighting'

- ✓ **Freedom in design**
  - ✓ Embedding in products
  - ✓ Flexible
  - ✓ Adaptation to environment
  - ✓ Possibility to make transparent devices





Variable Transparency: Black appearance



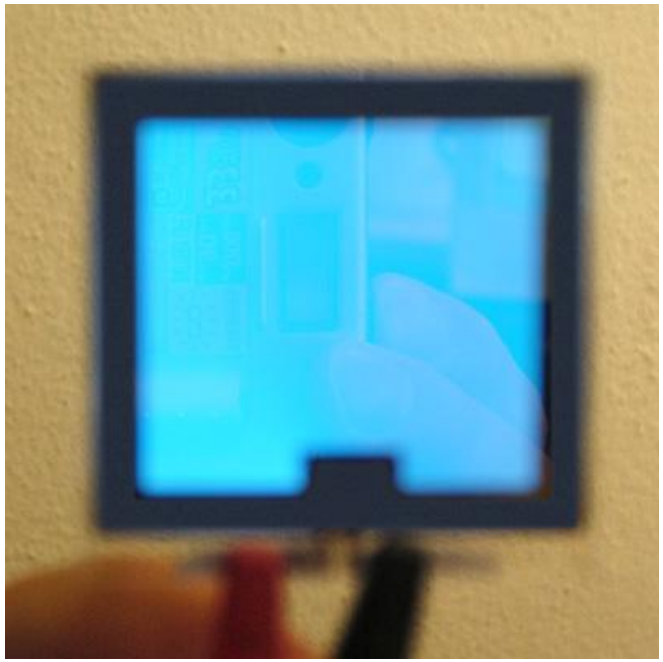
Off state

On state: light generating (yellow in this case)

Variable Transparency: Mirror appearance

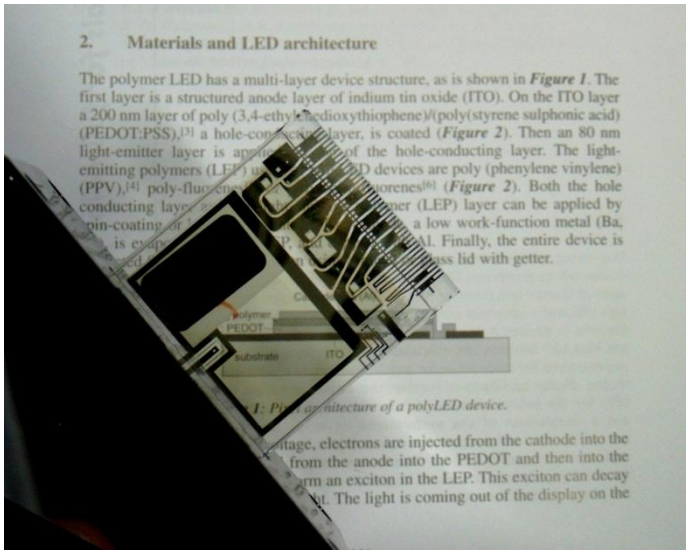
- **light source blends in background: mirror light**

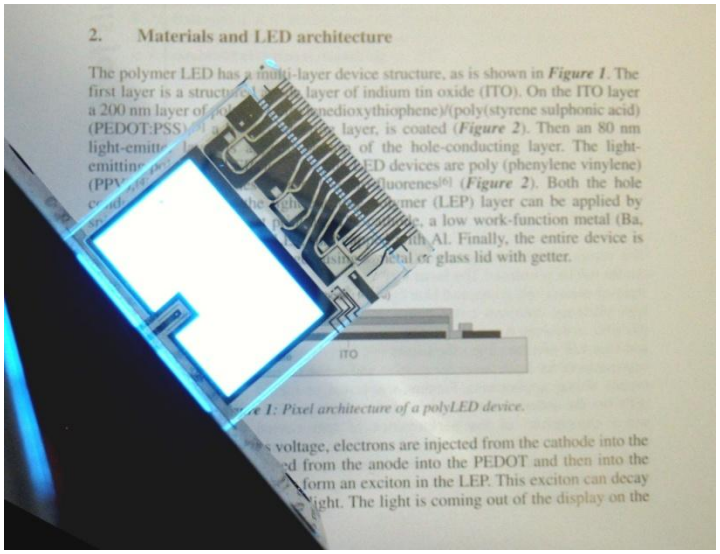
Off state



On state: light generating (blue in this case)

Variable Transparency: Transparent appearance





Off state

On state: light generating (white in this case)

Transparent appearance

Transparent | Semi-transparent | Non-transparent

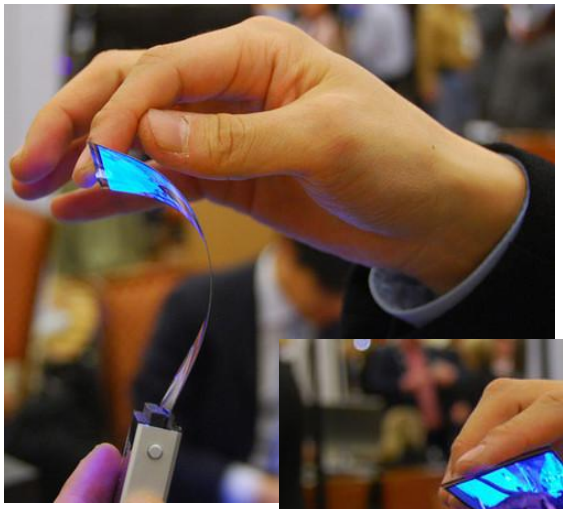
Featuring Cristina Tanase Philips Research

OLED feature on foil - Displays

- **Bendability, flexibility, stretchability, conformability**
- **Market introduction very soon**

http://wwwery.com/10277-samsung-3d-foled-tv-display.html

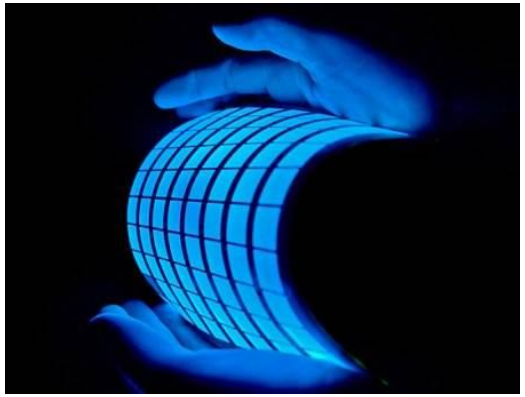
Samsung flexible OLED displays



http://fgadgets.com/future-gadgets/samsung-flexible-and-transparent-amoled-display

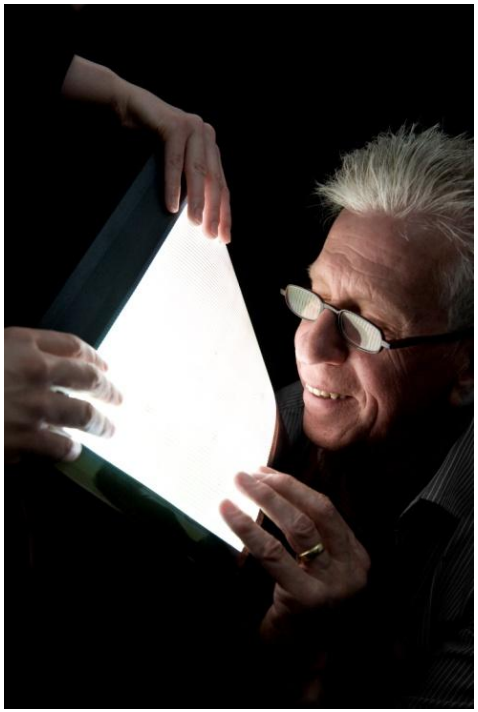
Flexible Lighting

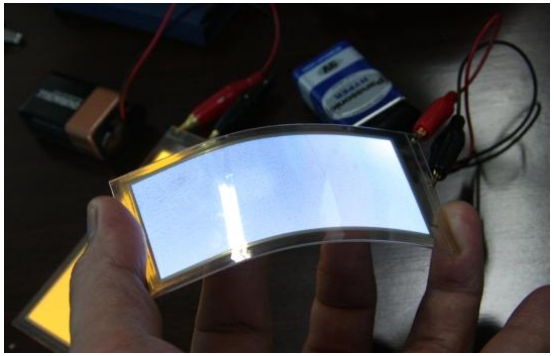
- **Still in research phase**



http://www.displayblog.com/2009/04/18/electronics-and-telecommunications-research-institute-etri-develop-technology-to-improve-amoled/

Holst





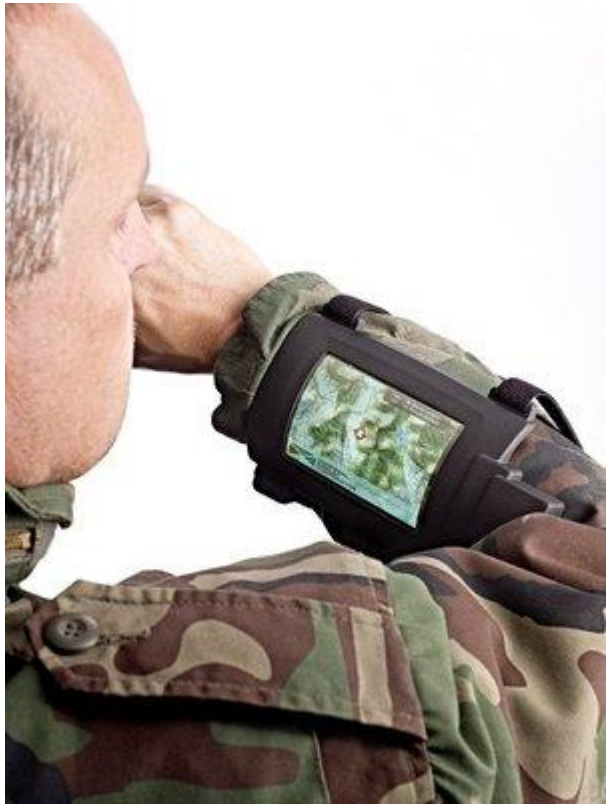
http://us.aving.net/news/view.php?articleId=119491

http://www.archithings.com/ge-scientists-display-first-ever-oled-christmas-tree/2008/12/23

OLED display/lighting around wrist

Holst

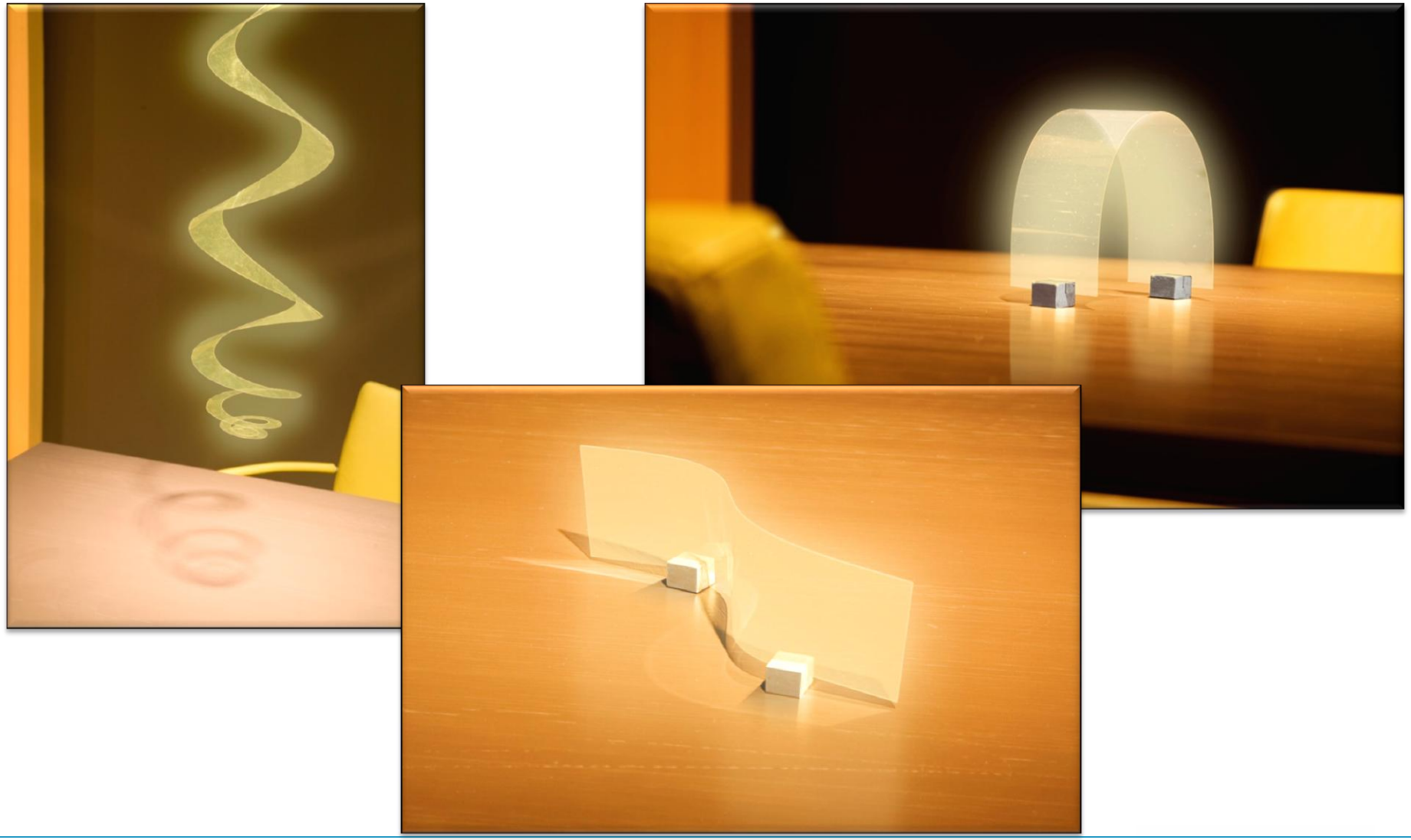
http://www.cypher-sec.org/blog/wp-content/plugins/wp-o-matic/cache/d972a_oled_wrist_2.jpg



Universal Display Company

http://www.oled-info.com/udc-deilvered-8-flexible-wrist-mounted-oled-displays-us-army

Foil based light sources – Holst visions



Smart bandages/blankets

- **Low cost leads to the possibility of disposable products**
- **@ 100 EUR/m² → 1 EUR for 10x10 cm² foil**

- **This leads to the possibility for Smart bandages/blankets for light therapy**
  - It has been known for a long time that light has healing properties, e.g. light treatment for TBC patients
  - But light can also be used for treating seasonal disorders
  - It can be used to heal a large range of conditions (from acne treatment to cancer treatment)

http://getacnehomeremedies.info/images/www.lemedspa.com/images/beforeafters/acne5L.jpg

Example – jaundice treatment of neonatals

- **Old treatment**
  - Static light sources necessitating eye protection of neonatal
  - Jaundice treatment: photochemical conversion and excretion of bilirubine (yellow colour treatment)
- **New possibility**
  - Wearable light source
  - less interfering with care
  - including bonding with parents

Source flickr: 1542122226_5e43a1d008 and 2538039854_e67b67926c

Philips BilitX™
Blue LED based

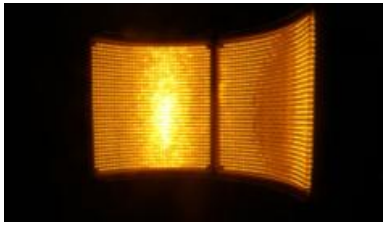
OLEDs in phototherapy

- **From fluorescent → LEDs → conformable OLEDs**

http://www.uvbiotek.com/healthcareProfessionals.asp

http://www.prolightaesthetics.com/page/page/5066261.htm

Source: Ambicare Health Ltd



http://www.shizukany.com/skin-care/facials/gentlewaves.html

Source: Polymertronics

Source:Gentlewaves

Source: MedX Health Corp.

Presentation overview

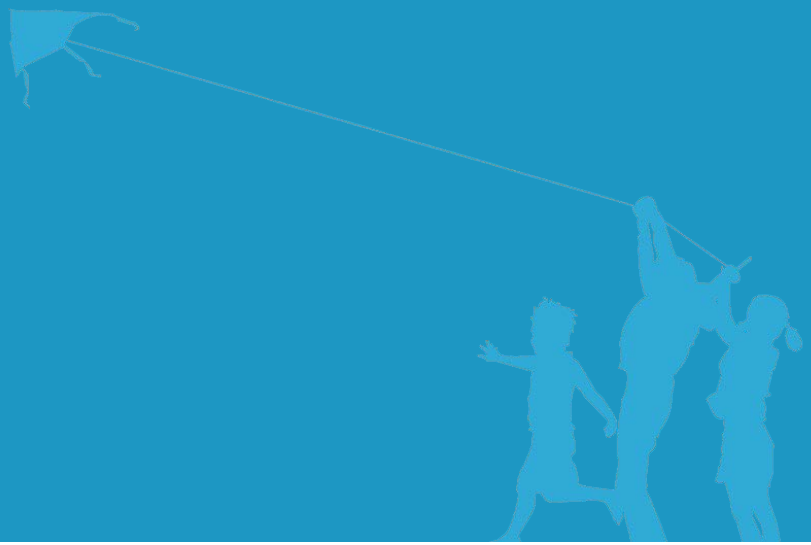
Current OLED applications

OLEDs: what are they, what are the challenges?

Possibilities with flexible OLEDs

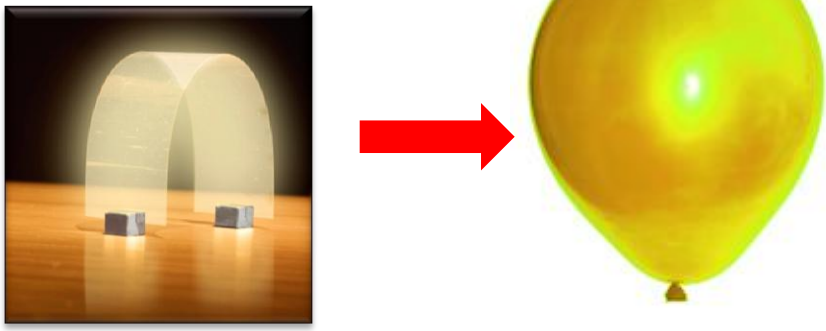
Conformable OLEDs

Our Vision

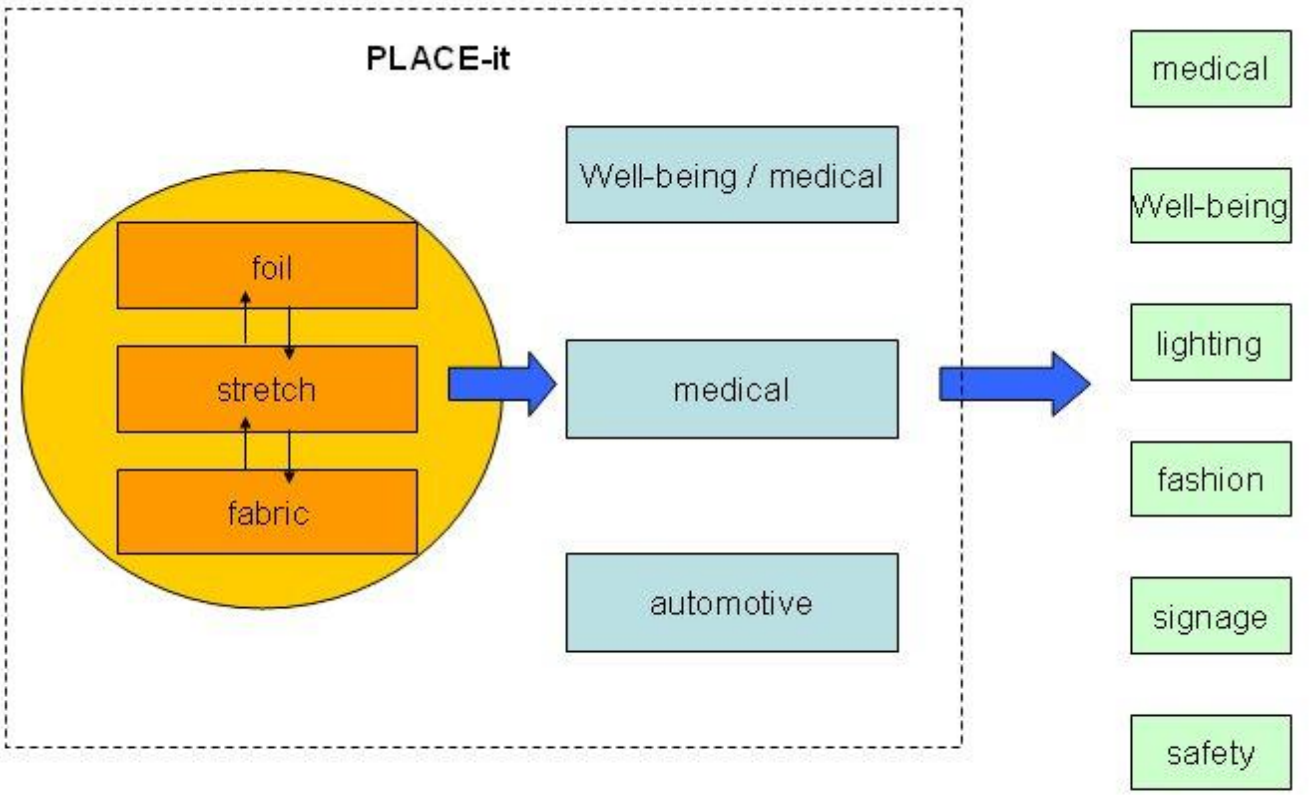


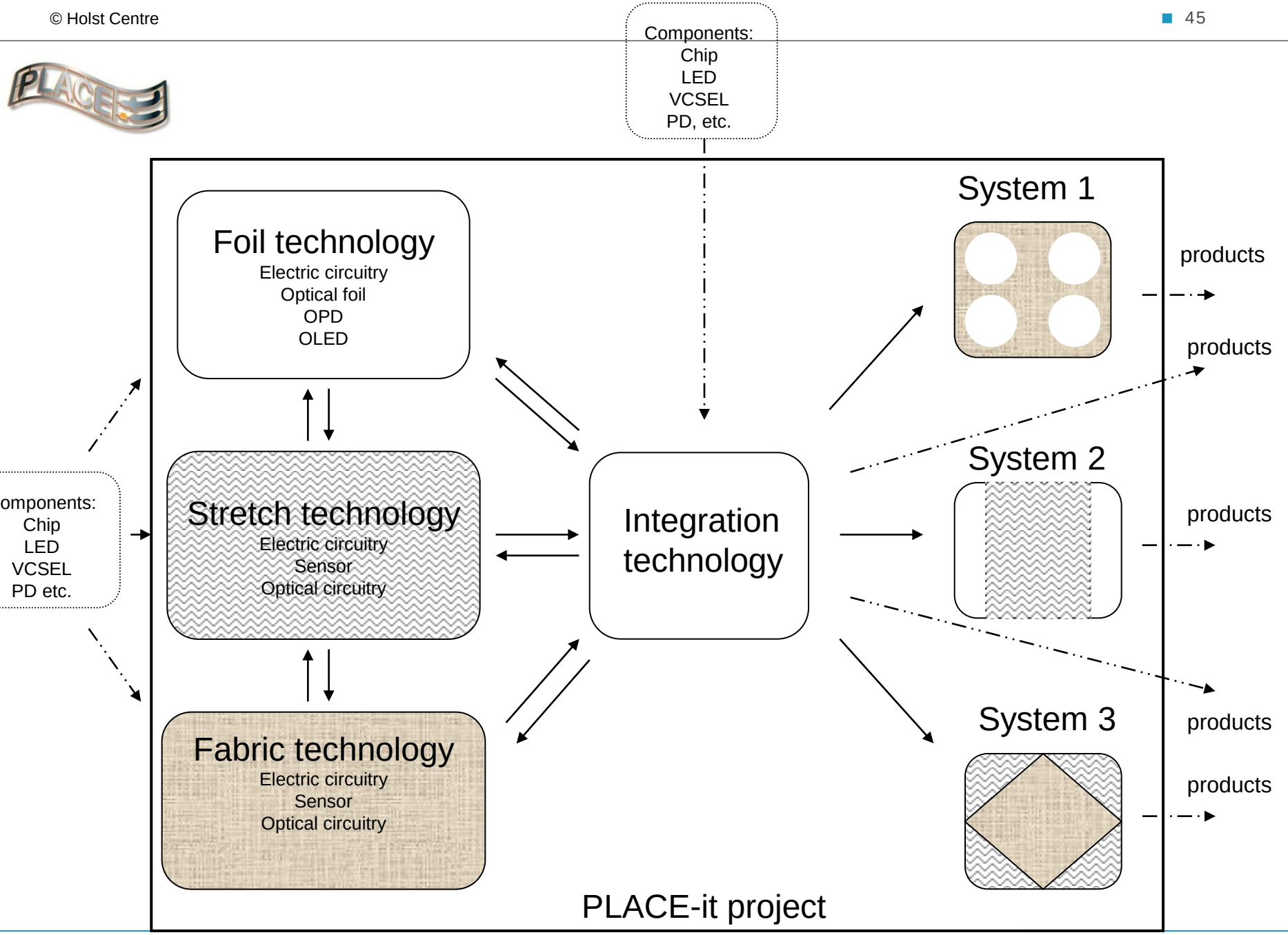
From flexible to conformable

- **Flexibility not sufficient for 3-D surfaces**



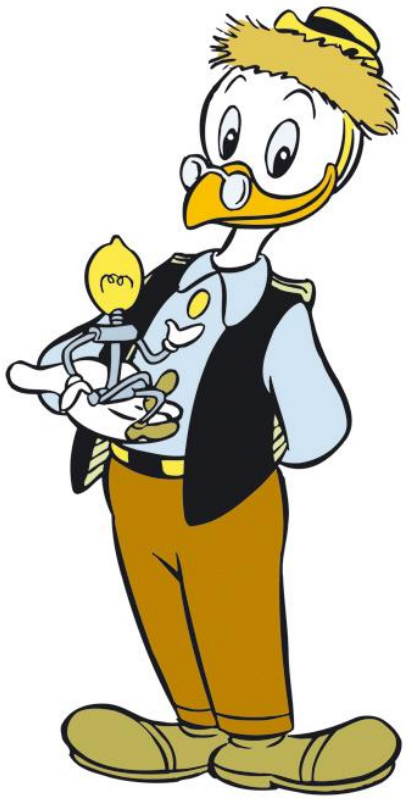
- **Platform for Large Area Conformable Electronics by InTegration**
  FP7 - EU funding


PLACE-it
foil
stretch
fabric
Well-being / medical
medical
automotive
medical
Well-being
lighting
fashion
signage
safety
Technical development (platform)
Project goals / demonstrators
Expectations

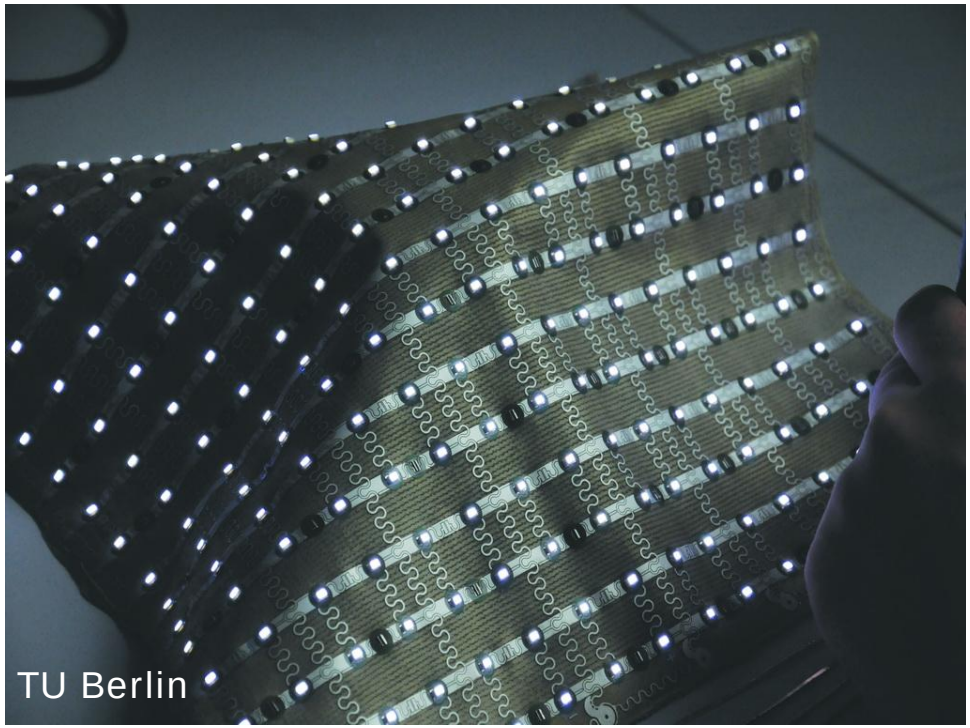

Components:
Chip
LED
VCSEL
PD, etc.
Foil technology
Electric circuitry
Optical foil
OPD
OLED
Components:
Chip
LED
VCSEL
PD etc.
Stretch technology
Electric circuitry
Sensor
Optical circuitry
Integration technology
Fabric technology
Electric circuitry
Sensor
Optical circuitry
System 1
System 2
System 3
products
products
products
products
products
PLACE-it project

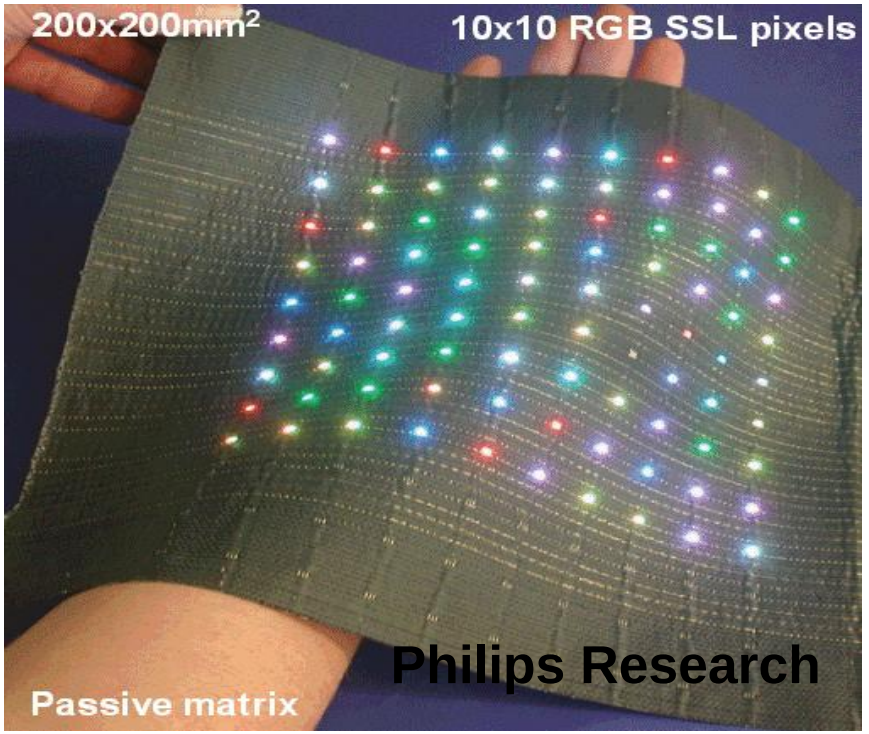
Place-it project: conformable light technology

- **Light from carriers with the following properties:**
  - Thin
  - Large Area
  - Wearable
  - Flexible / elastic
  - Breathing
  - Lightweight



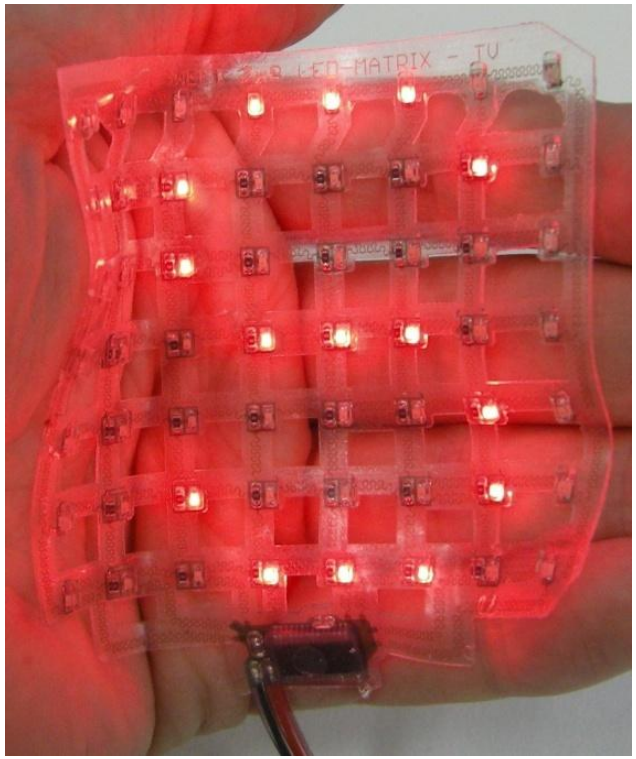
Examples textile: LED technology

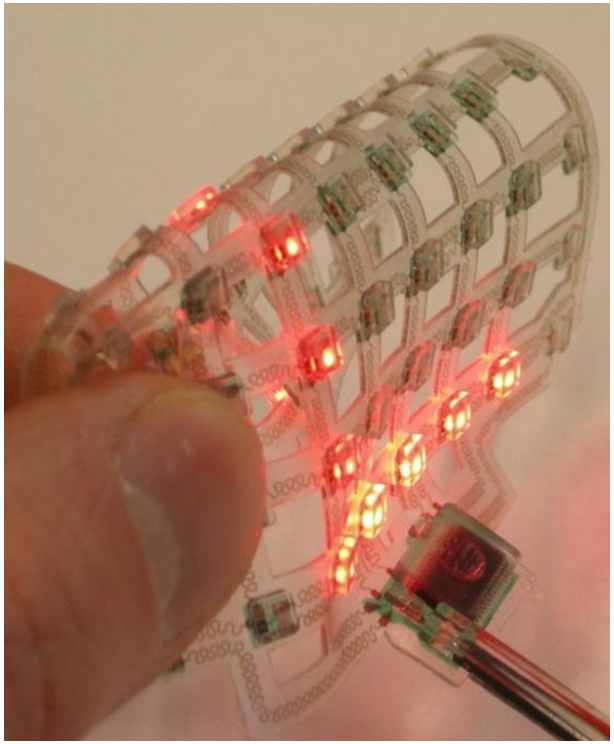




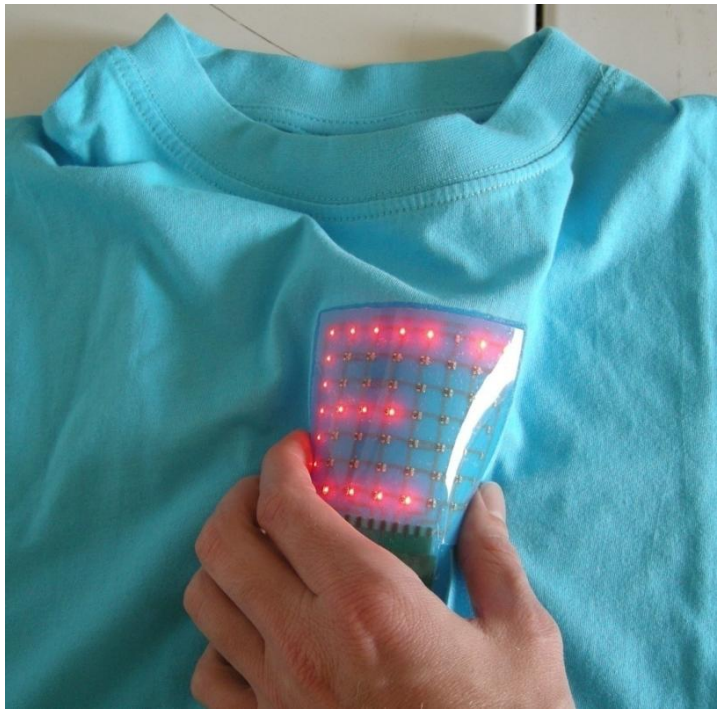
Examples textile: applications

Examples stretchable electronics

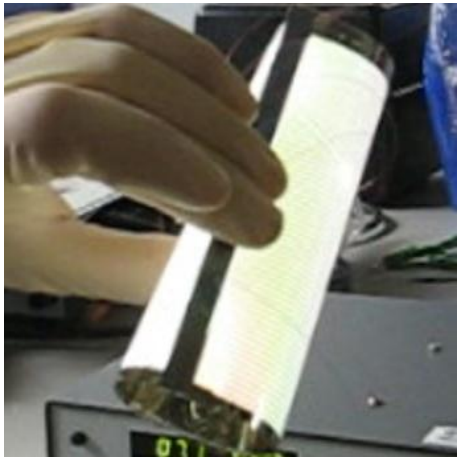


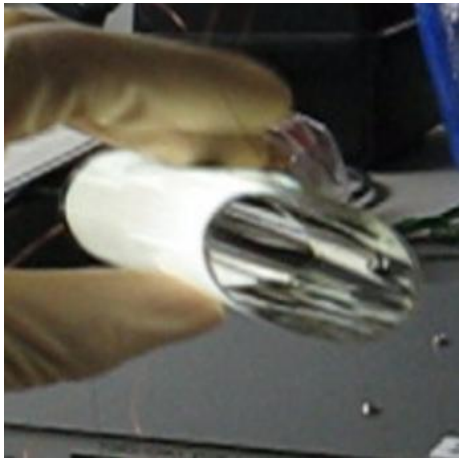


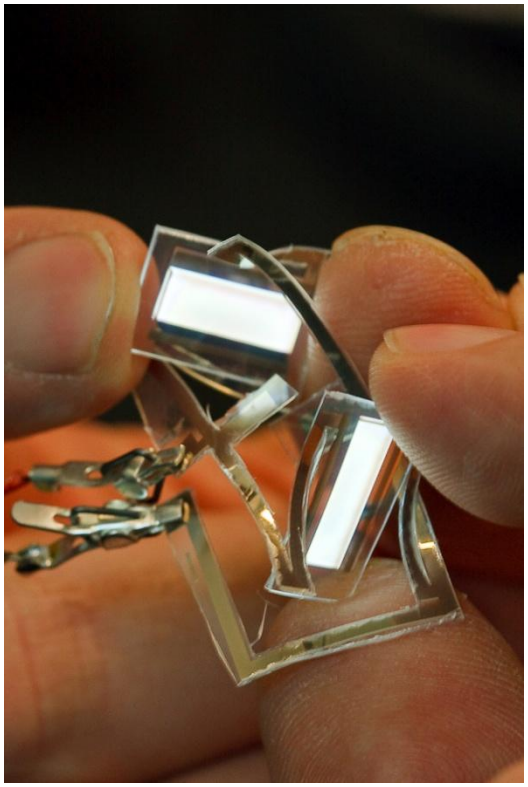
Examples stretchable applications



From bendable OLEDs to transformable







Presentation overview

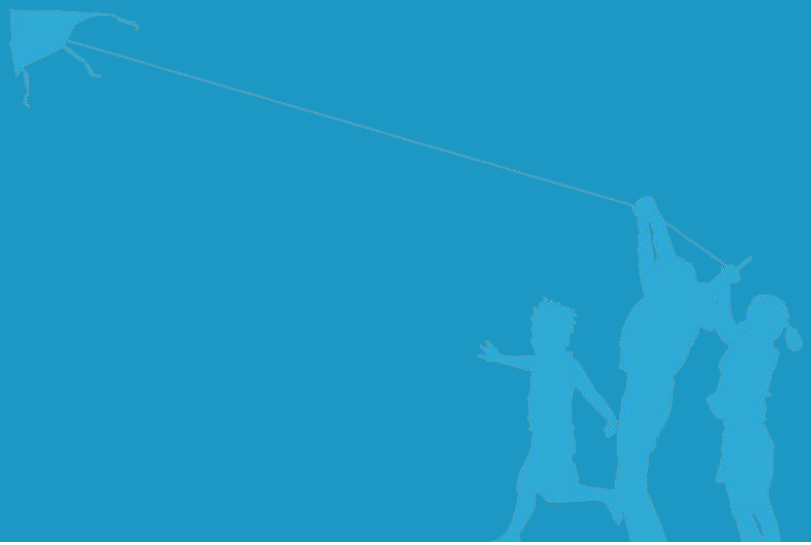
Current OLED applications

OLEDs: what are they, what are the challenges?

Possibilities with flexible OLEDs

Conformable OLEDs

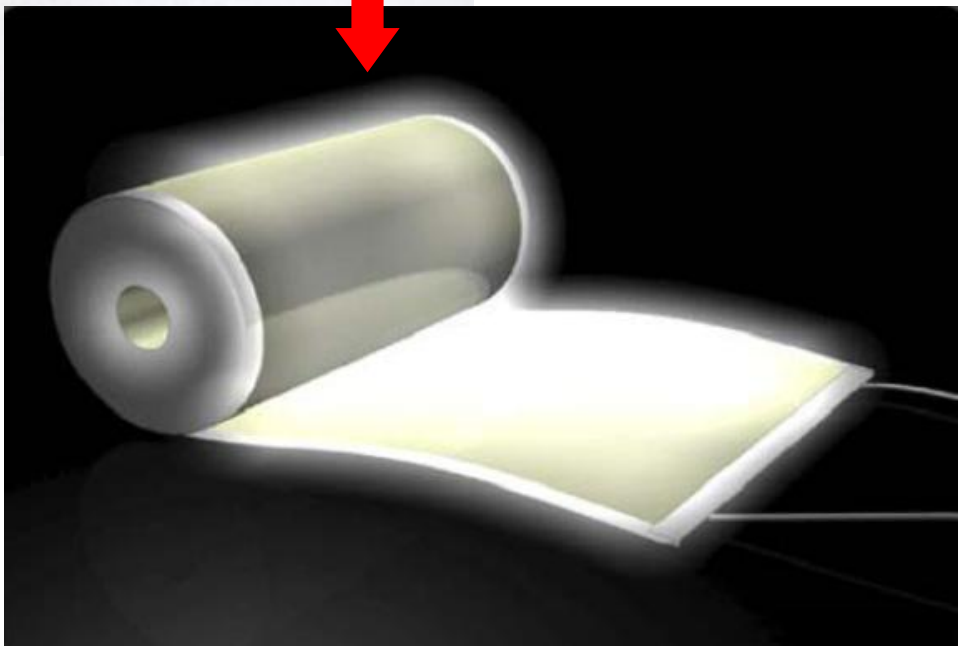
Our Vision



First Flexible OLED used in real life application

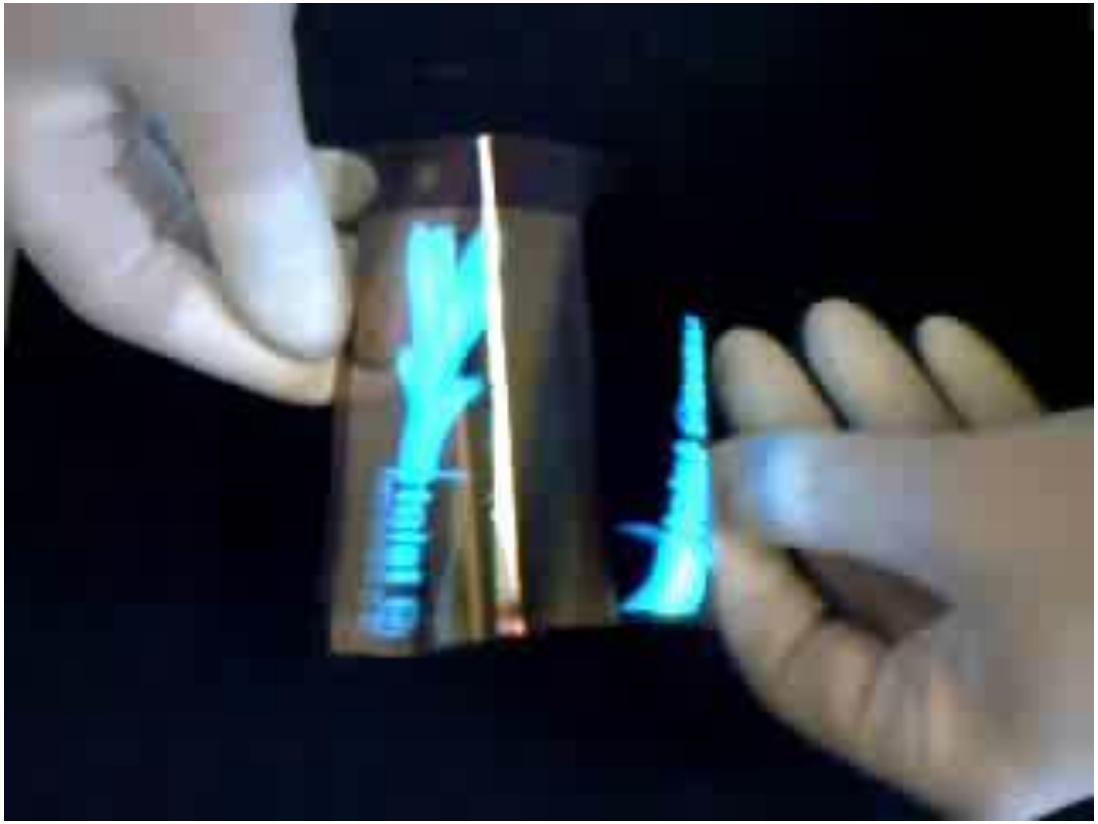
LeMans 2010
Huntsman – Araldite
OLED signage

OLEDs made on the roll



Our vision

Is that in the near future it will be possible to cut-and-paste with lighting foils to make any shape you want….



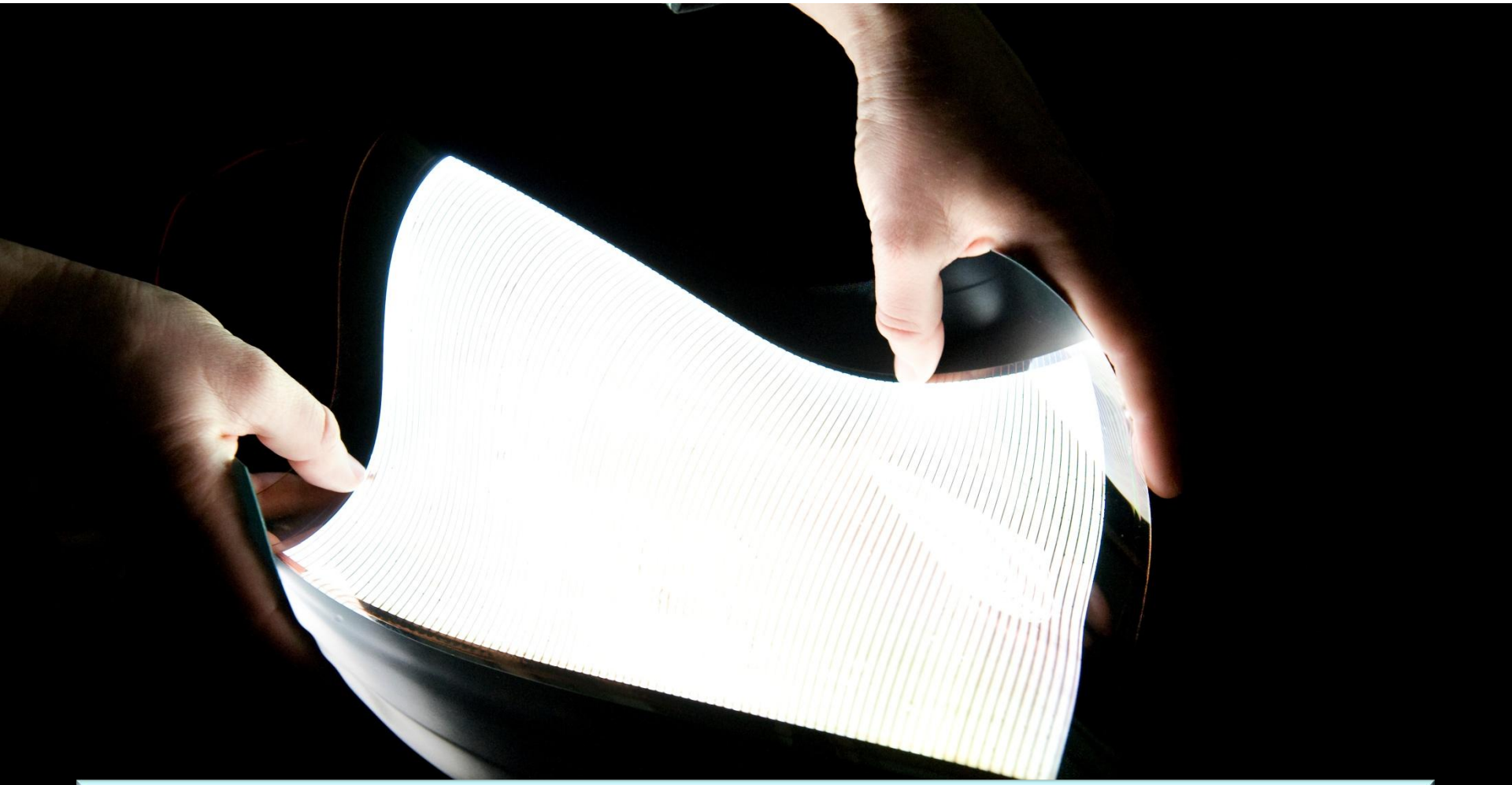
Acknowledgements

OLED research funded and contributed by:

PHILIPS sense and simplicity
BAYER
DuPont Teijin Films
MERCK
HUNTSMAN Enriching lives through innovation
Polymer Vision
SOLVAY
ROTH &RAU
NeoDec solutions to electrodes
Orbotech
AGFA Agfa
Ministerie van Economische Zaken
Fast Light

PLACE-It funded by EU

PHILIPS TNO berlin Freudenberg imec CENTEXBEL titv Das Institut für Spezialtextilien und flexible Materialien GRUPO ANTOLIN iL INNOVATION LAB thinking works RWTH AACHEN UNIVERSITY ohmatex smart textile technology



Thank you for your attention!

karel.spee@tno.nl www.holstcentre.com