Functional Materials & Films for Light Management & OLEDs

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Workshop on Large-Area SSL 30.10.2014, Muttenz BL

Innovation for Success

Content

ROLIC technologies

- Core Technology (Short introduction)
  LCMO (Light Controlled Molecular Orientation) technology
- LCMO Patterned Films for Light management :
  Applications Examples

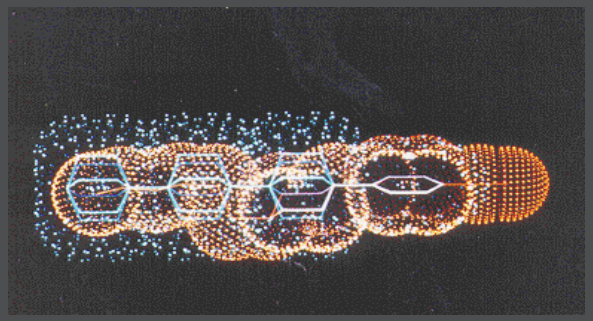
  LCMO- Photo Patterned Retarders
  LCMO- Photo-Patterned Anisotropic Topologies
- Summary

Technology Competence: LCMO Technology

Light-induced spatial alignment of molecules to create complex structured anisotropic optical elements on microscopic and macroscopic scale.

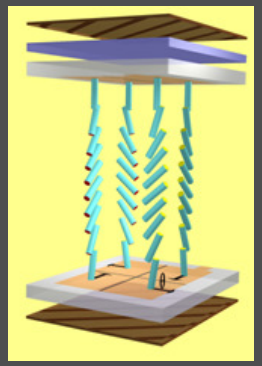
Interdisciplinary Research and Development at Rolic
From Functional Molecules to Devices (Displays, Optical thin-films, Organic Electronics, ...)

Single molecule with specific functions (e.g. liquid crystal for optics and light control):



Molecular design, simulation, synthesis

Ensemble of molecules; amplification properties of single molecules via long range interactions



Creation of advanced structured optical elements to manage and control light properties: polarization, color, transmission, reflection, scattering, emission, …)

Final Device based on specific optical, electro-optical or electrical effect with simple mass-production processing:

- Sheet-to-Sheet: up to ca. 10 m2
- Roll-to-roll : up to ca. 100 m/min

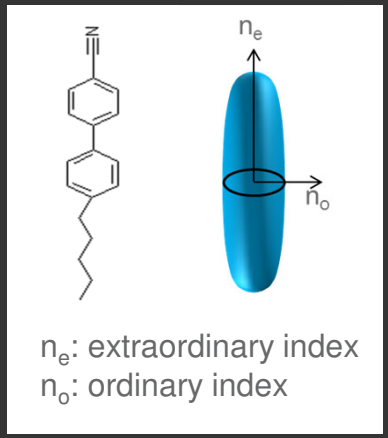
Technology as well as the associated specific materials and processing

Core Competence: Alignment of organic molecules

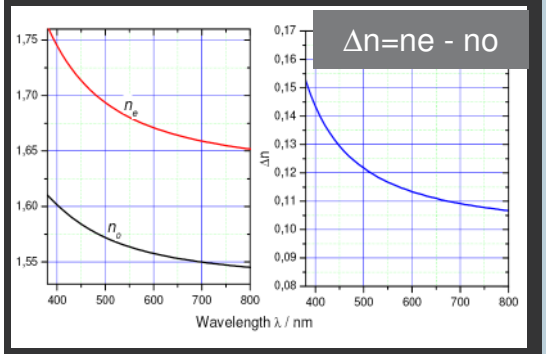
ROLIC technologies

Liquid crystals, LC

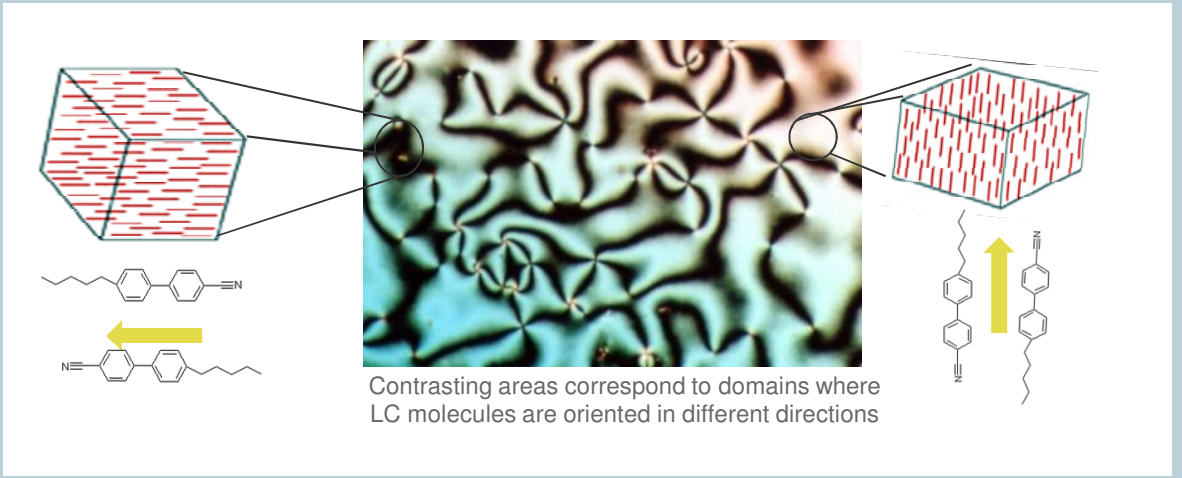
- Anisotropic molecules
- Berifringent: ne ≠ no



n_e: extraordinary index
n_o: ordinary index



Nematic phase (self-organisation with local orientational order)

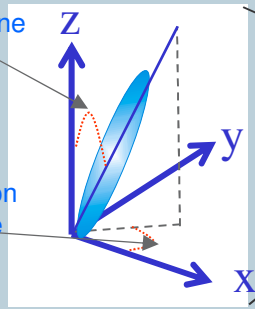


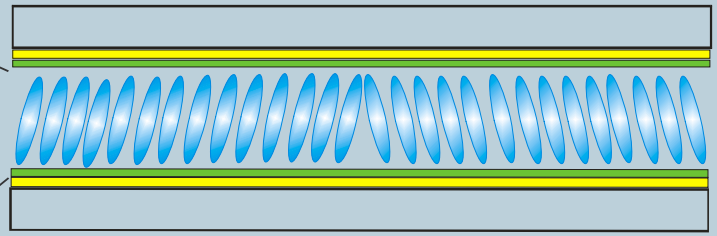
Contrasting areas correspond to domains where LC molecules are oriented in different directions

Alignment of the LC molecules is a key technology to make LCDs

Tilt angle direction out of the display plane

LC alignment direction in the display plane





Areas or pixels with homogeneous alignment from few microns up to several m2

LCMO - Light Controlled Molecular Orientation

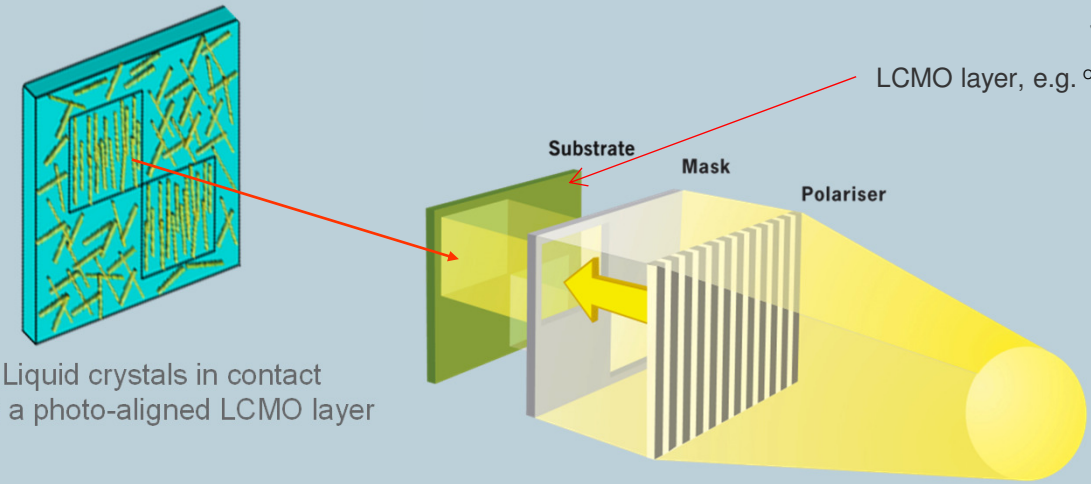
Surface modification of photosensitive materials, on the molecular level, by Linearly Polarized UV (LPUV) light

ROLIC technologies

Linear polarized light transfers information (e.g. from a photo mask) into a light sensitive polymeric layer, which will become X-linked in the exposed areas.

The exposed areas exhibit an anisotropic surface texture, unexposed areas remain isotropic.

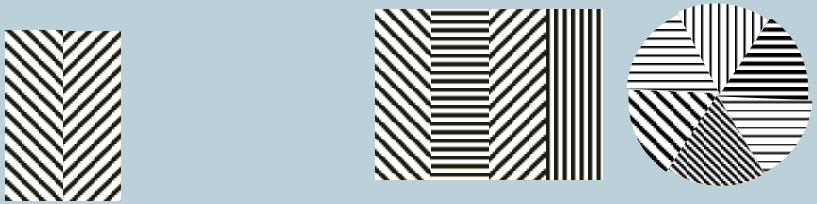
Molecules (e.g. liquid crystals, semiconductor molecules) can be aligned (or organized) according to the surface texture.



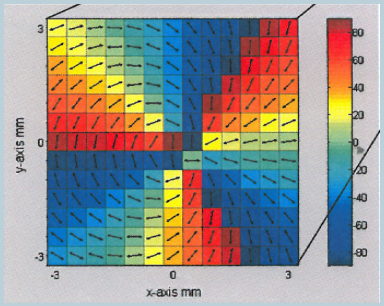
Liquid crystals in contact with a photo-aligned LCMO layer

Micro-patterning of optical anistropic effect

FPR type **or** **Any other type**



(2 alignment directions) **Multi-alignment directions**



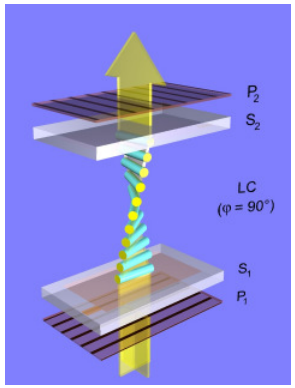
Continuous profile

Main Liquid Crystal Display (LCD) Types

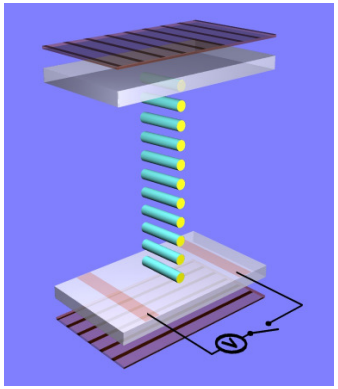
TN-LCD

IPS-LCD

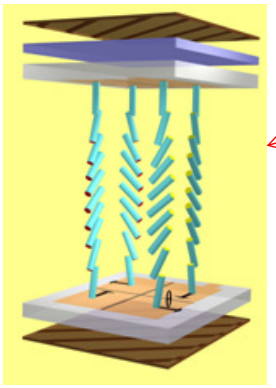
MVA-LCD



Twisted Nematic



In Plane Switching



Multi-domain Vertical Alignment

Bright & low energy consumption TV (Production start 2008)

Alignment of the LC molecules is a key technology to make LCDs

TN effect invented in 1970, Hoffman La Roche (Swiss pharmaceuticals group); M. Schadt, W. Helfrich, *Appl. Phys. Lett.* **18**, 127 (1971).

LCMO - Optical Retarders

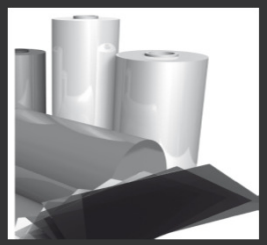
Control of bulk alignment:

(1) Molecular design of LCMO polymer layers

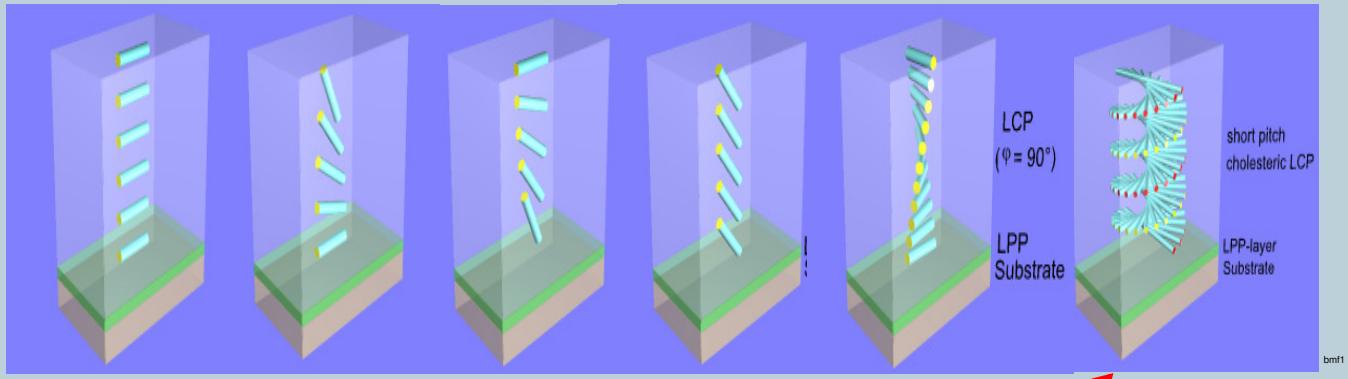
(2) Molecular design of LCP

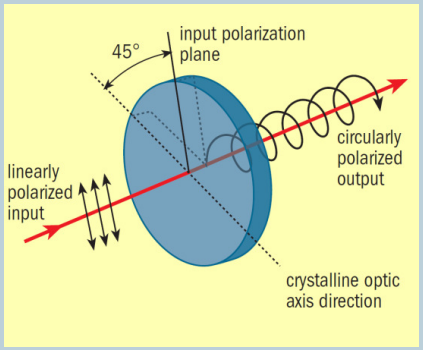
(3) Process parameters

(4) Interaction of LCP with Interfaces (LCMO layer, air)

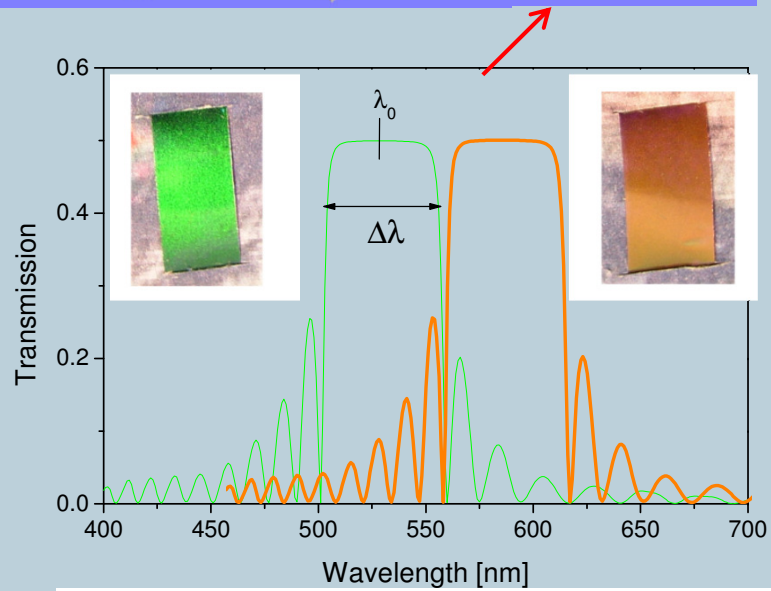


Examples of LCMO Aligned Single-Layer Optical Films





Quarter wave plate



Angle dependent Reflective Color Filter

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Business Areas & typical Applications

Innovative Swiss nano-tech company applying light controlled molecular orientation (LCMO) for the industries:

Displays

– LCD - VA
- IPS
- ...

Optical Thin Films

(High-Resolution Anisotropic Patterns)

– (3D) Retarder (WVF)
– Security Elements
– Polarisers, Filters,
– Brightness enhancement
– ....

Organic Electronics

- Barrier (OPV, OLED,...)
- Light extraction
- Functional Foils
- ...

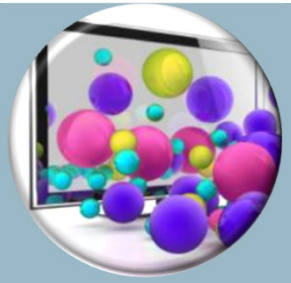
LCMO – Optical Films

Optically anisotropic Films to manage and control light properties (polarization, Color, transmission, reflection, scattering, emission, …)

LIC technologies

Typical Applications

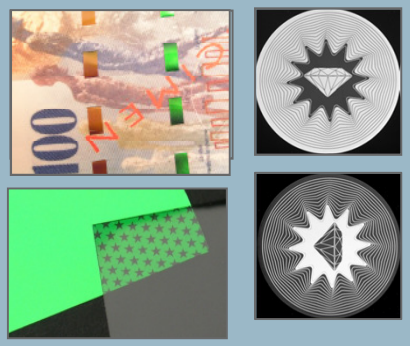
- Patterned retarders (**e.g. LCMO-3D**)
- Wide-view films for any type of LCD
- Information storage (optical security element)
- Dichroic polarizers, color filters
- polarising filters, polarimeters, ...
- Polarisation converters (beam shaping)
- Brightness enhancement Films
- Circular Polarisers
- Anti-reflective, directional reflectors & diffusers
- Diffractive thin films & waveplates
- etc.



Retarders (ex. 3D)

Wide Viewing Films

Optical Security

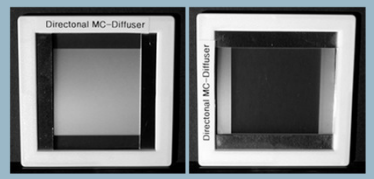


Polarisers, Filters,…

Interference Color Filters

Brightness enhancement

Directional- Diffusers

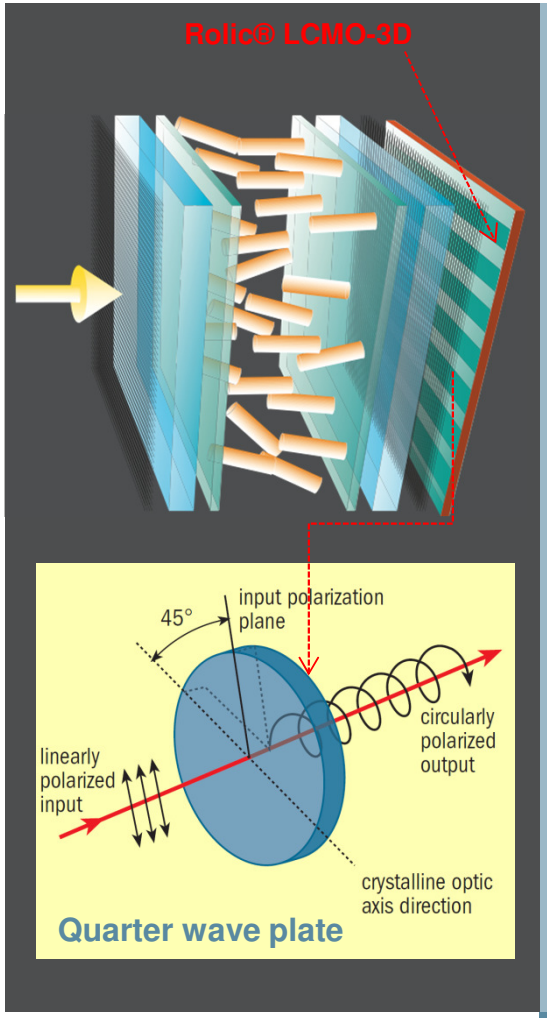


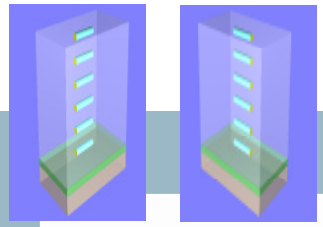
Directional- reflectors

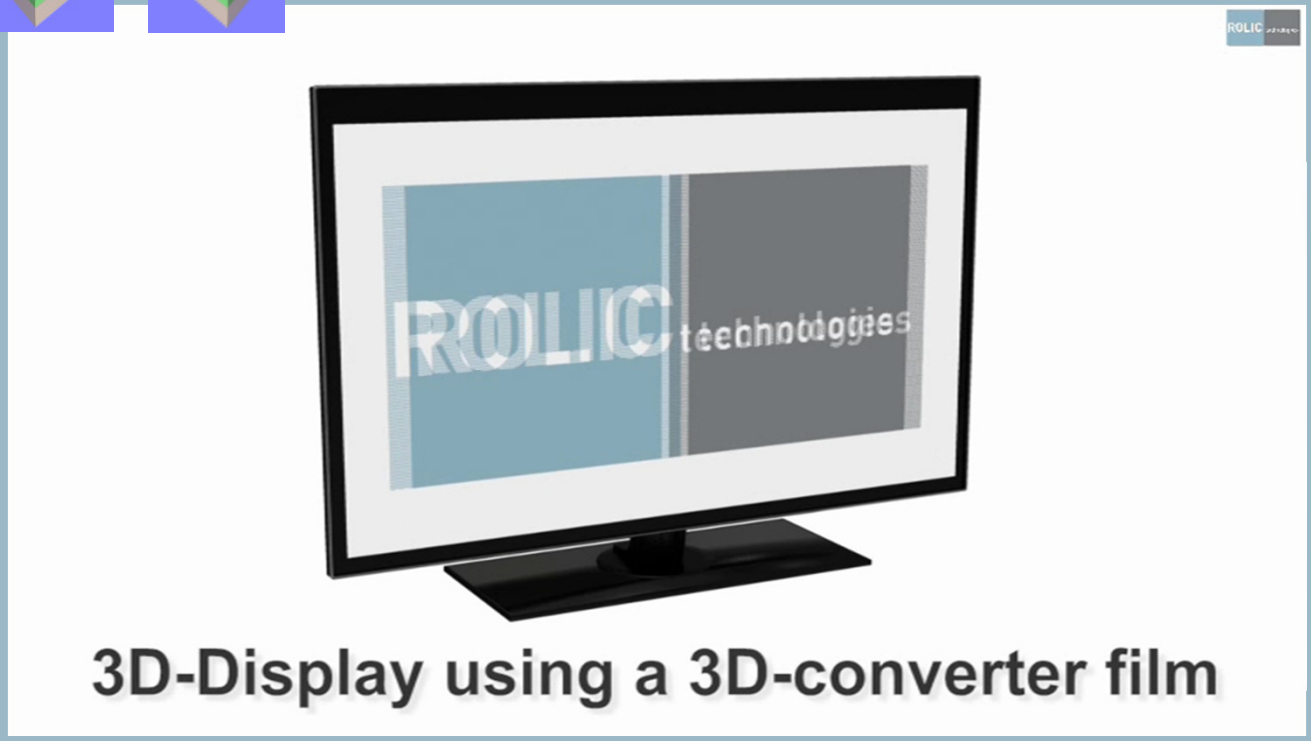
low power consumption (no back-light)

LCMO Industrial Applications

LCMO 3D in mass production

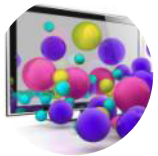






LCMO – Optical Film Production

Example of Roll-to-roll processing of patterned retarders for 3D: Rolic® LCMO-3D



ROLIC technologies

L1

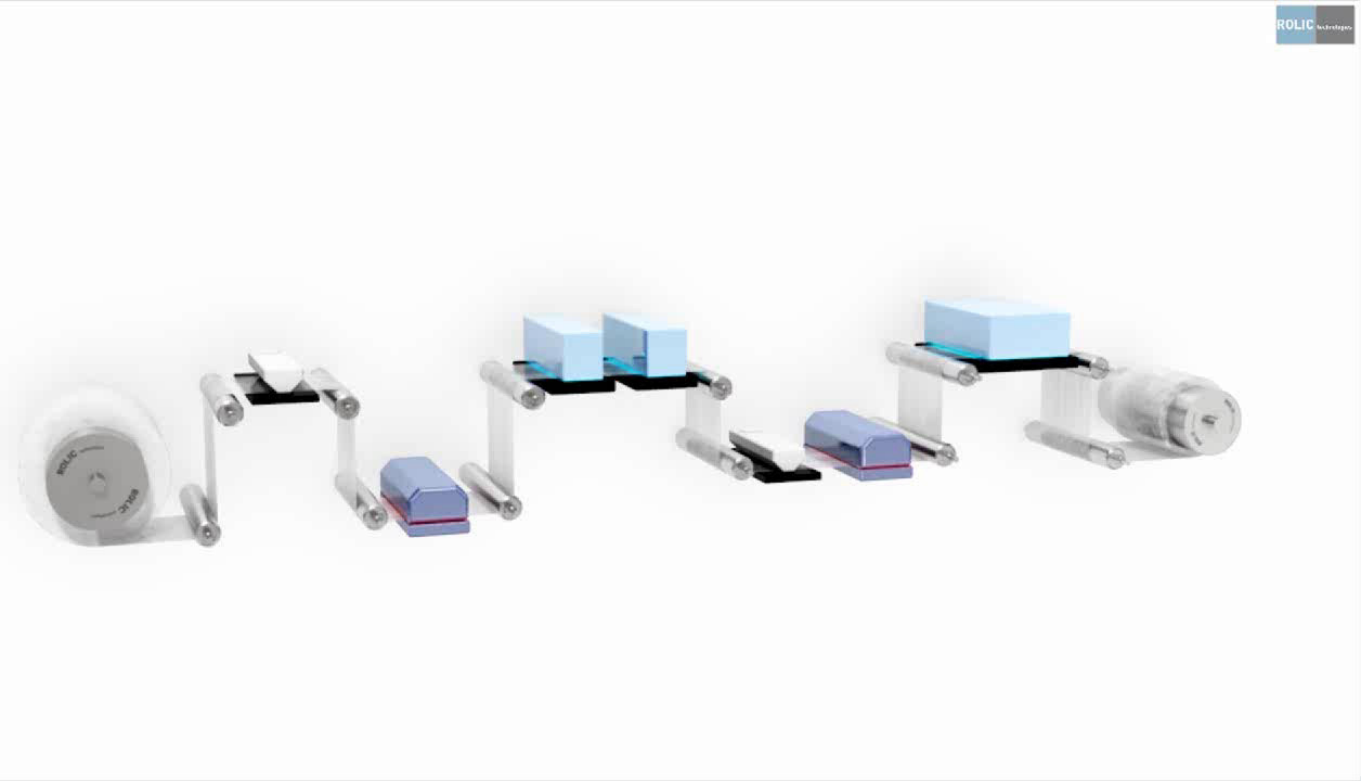
Optical films

– High Production Speed

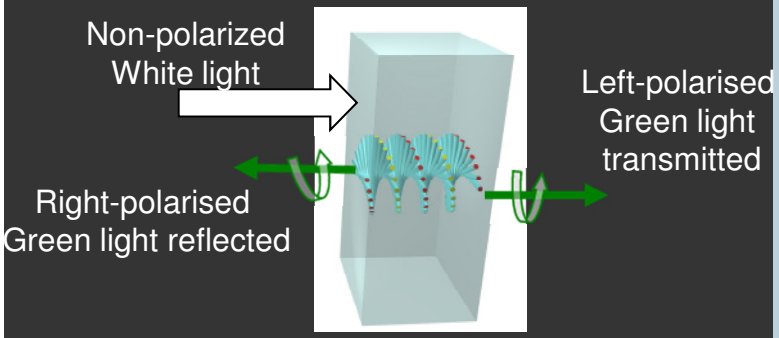
– High Stability

– Low cost

Incorporation of specific patterns with LCMO

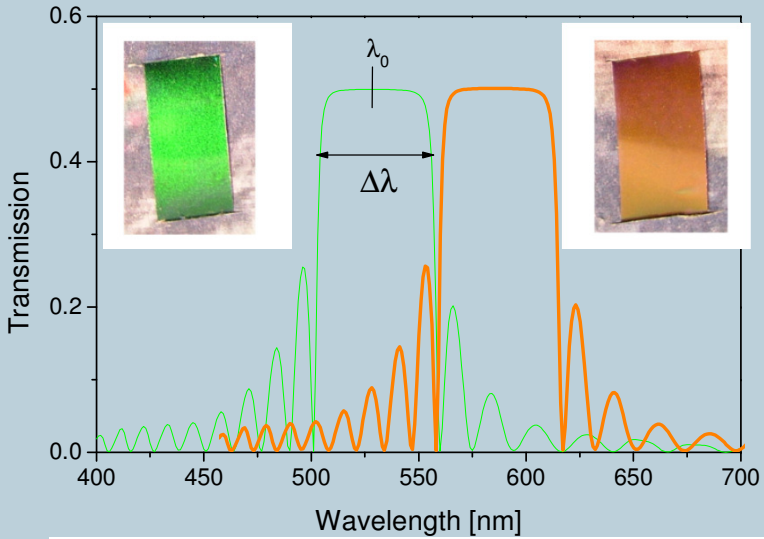


Cholesteric Filter (Color Shift)

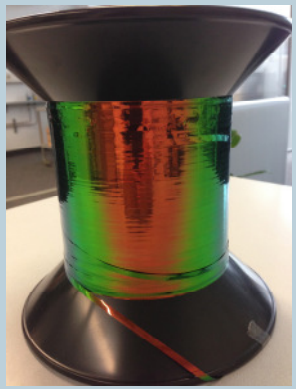


Properties:

- easily adjustable selective wavelength band
- non-absorbing, light stable
- Circular polarisation within $\Delta\lambda$; light outside $\Delta\lambda$ not affected
- combination of color filter and polarizer
- feasibility of polarization recovery
- compact due to stackable thin film design



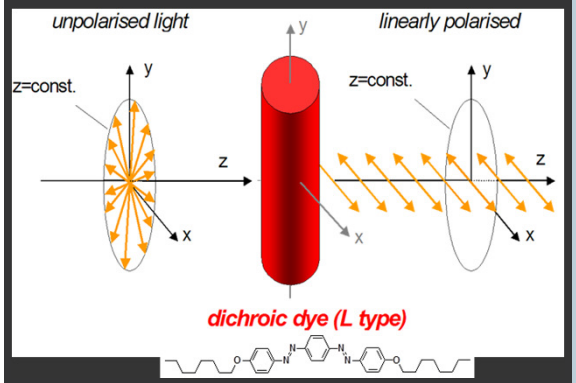
Angle dependent Reflective Color Filter



Proto-type of one industrial Product:
Security Threads for Banknotes

LCMO – Printable Polariser

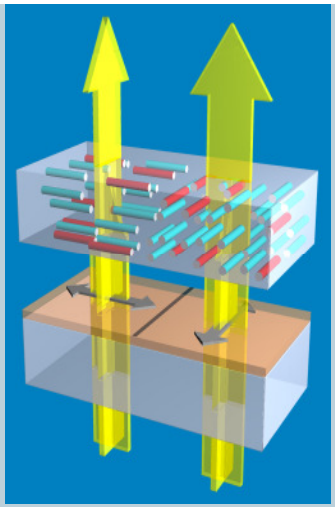
Linear Dichoic-LCP (Guest Host) Polarizer



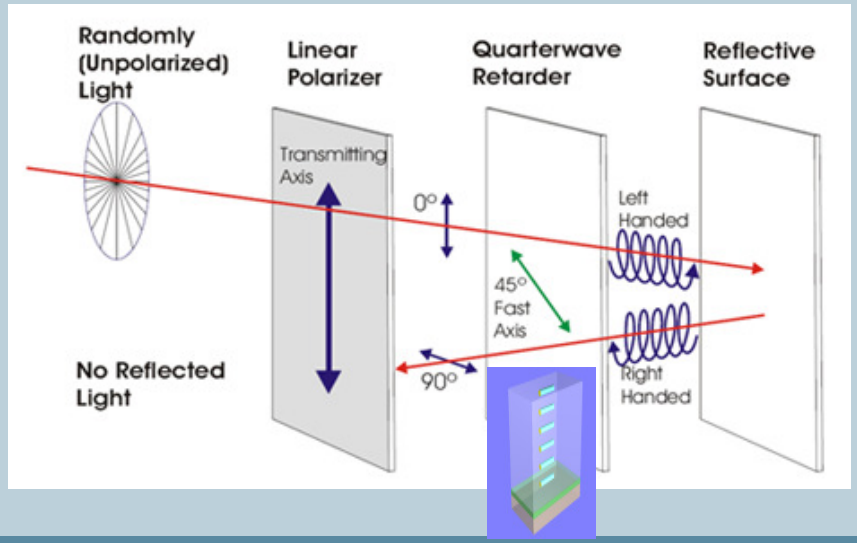
Some Applications:

- **Polarized sun glasses**

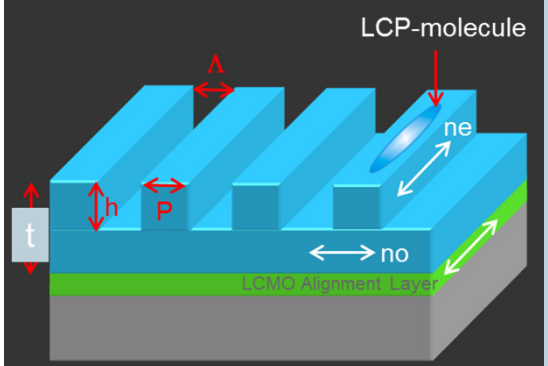
- **Glare reduction (OLEDs, LCD, …)**
- **3D-devices**
- **Coatable, ultra thin Polarizers**
- **Imaging (camera, …)**
- **optical data storage (Security, …)**
- **light brightness modulation (ex. Aircraft windows)**



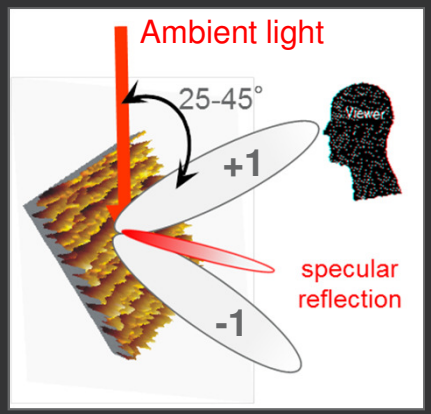
- Full range Color (Patterned) Polarizer



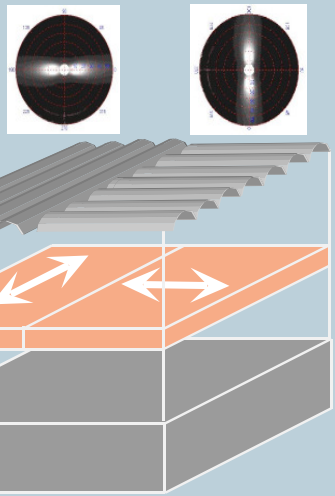
LCMO – Photo-Patterned Anisotropic Topologies



Working principle: Grating like

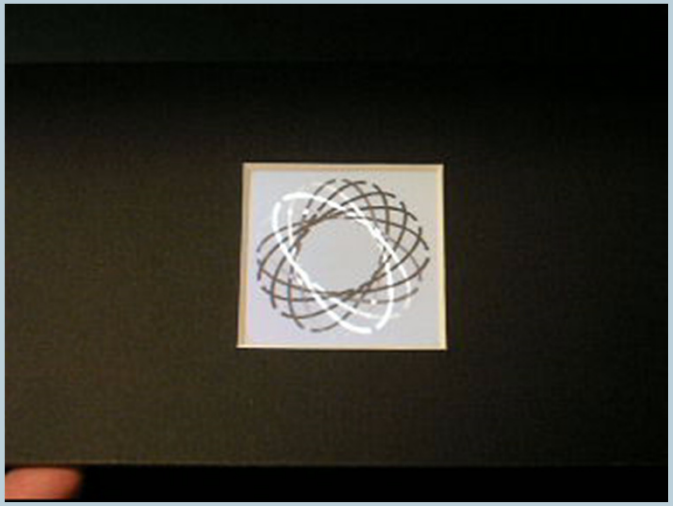


- Example 1(2 perpendicular scattering directions)



- Example 2:

dynamic Features (ellipses with 8 scattering directions)



Innovation for Success

LCMO – Biaxial Anisotropic Topologies

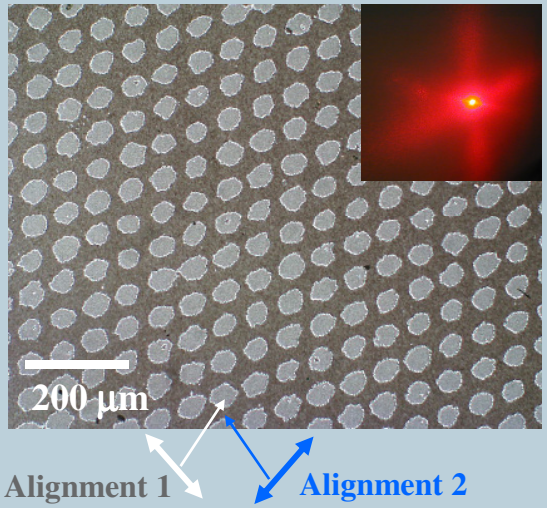
Light Outcoupling OLEDs (Patterned micro-grooves)

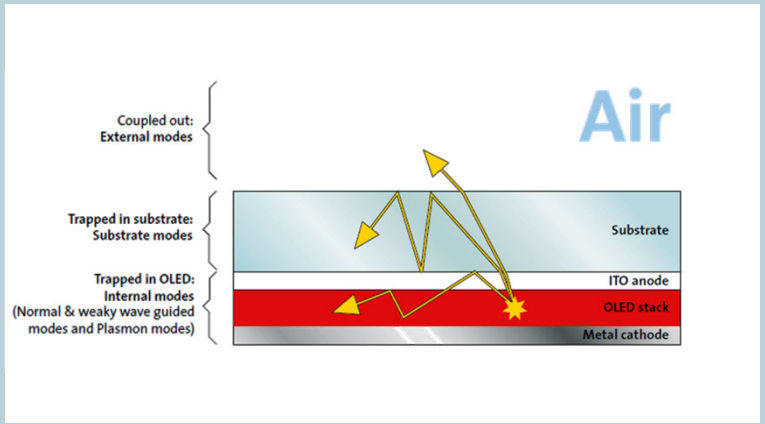
ROLIC technologies

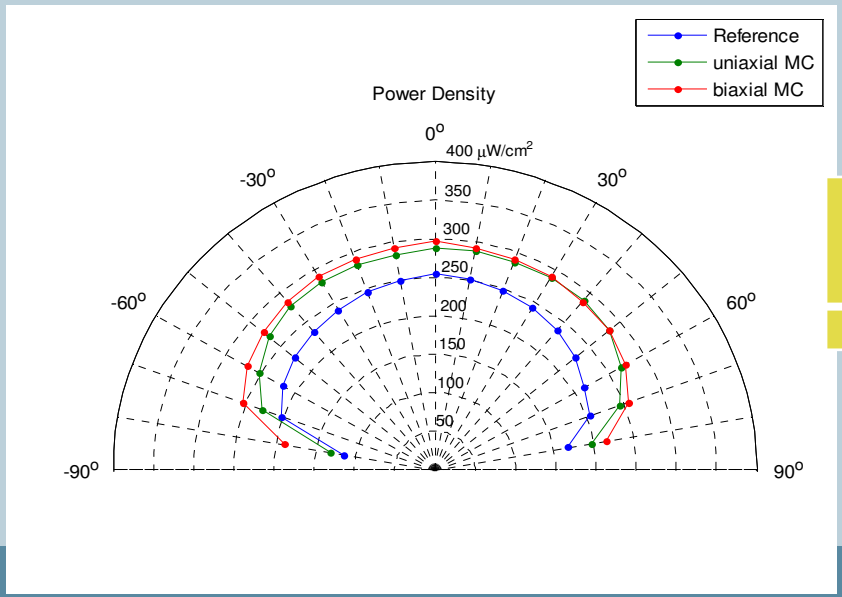
Low efficacy of OLEDs in converting electrical energy into light

Light is wave-guided in the layers due to total internal reflections

- Substrate mode: light trapped in the glass plate (~25% losses)
- Organic mode: light trapped in the organic stack (~50% losses)







Light-enhancement device	Light intensity improvement (%)
Biaxial (Rolic)	24%

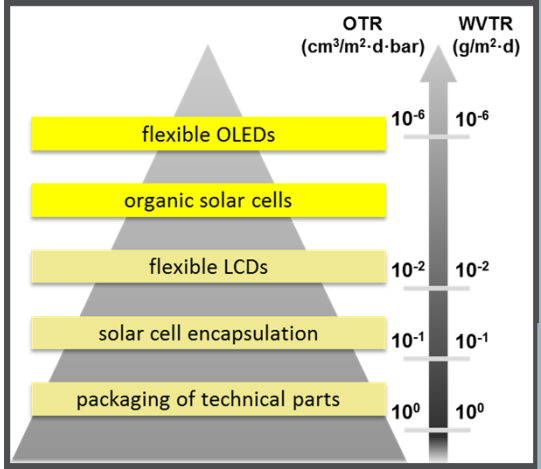
LCMO applied for Organic Electronics

- ROLIC is developing key materials and turn–key solutions for assembly of rigid and flexible devices in the area of organic electronics
- ROLIC is currently targeting applications like OLED for lighting and display, organic Photovoltaics and printed sensors
- Focus is the development of materials for use as:
  - encapsulation
  - light outcoupling
  - functional foils
- Cooperation with market leaders to develop customized industrial solutions for mass production
- Partnership with HOLST Centre, Eindhoven

OLEDs: Ultra-High Barriers needed

ROLIC technologies

Organic Electronics (OE)

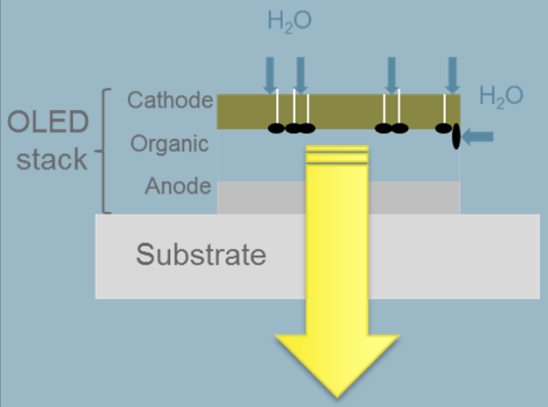


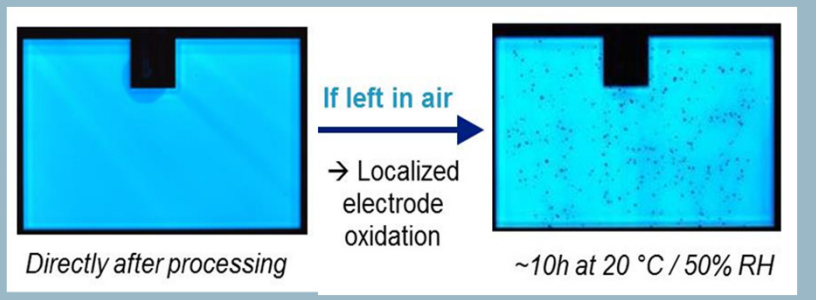
•Barrier in OLEDs: 1,000,000 x better than typical potato-chips bag

ROLIC's motivation: water protection

Problem: water destroying parts of OLED cathode

- Black spots visible, product appearance not accepted by customer

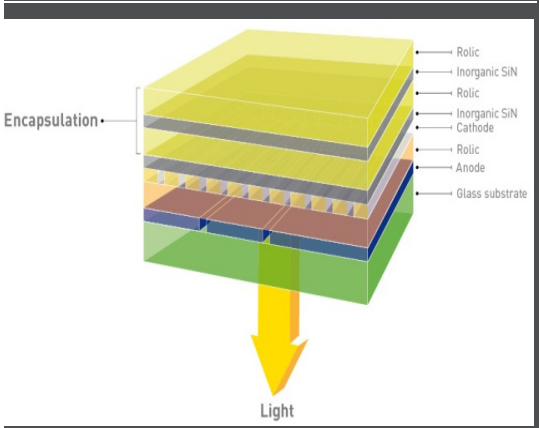


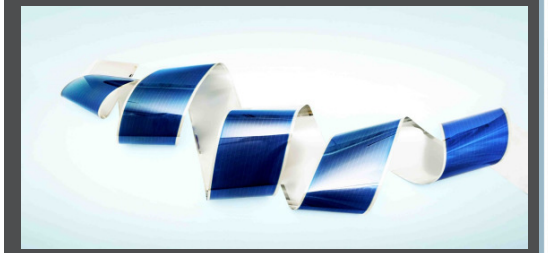


Thin film barrier technology for flexible devices: OPV

ROLIC technologies

Rolic‘s encapsulation technology:

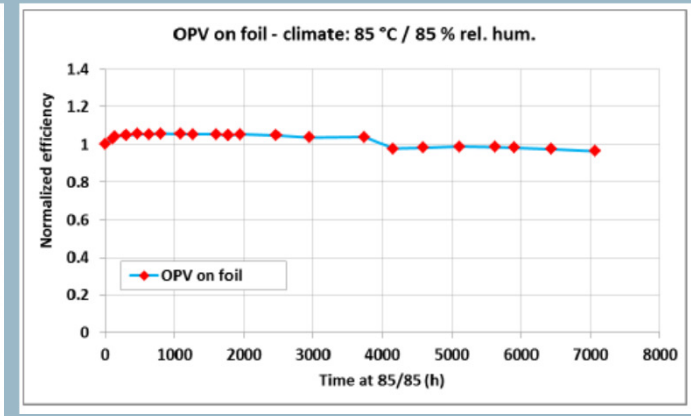




Organic Photovoltaic

Upscaling S2S barrier concept to R2R barrier foil production

- State-of-art pre-pilot R2R inline (SiN-organic-SiN) barrier production tool, installed Q3-2012
- Deposition for films of up to 40 cm width @ 0.5 - 4m / min
- Attractive for cost-effective high-volume manufacturing of large-area and flexible devices



No significant degradation for **7000h at 85/85**: Lifetime of OPV on barrier foil **> 60 years**

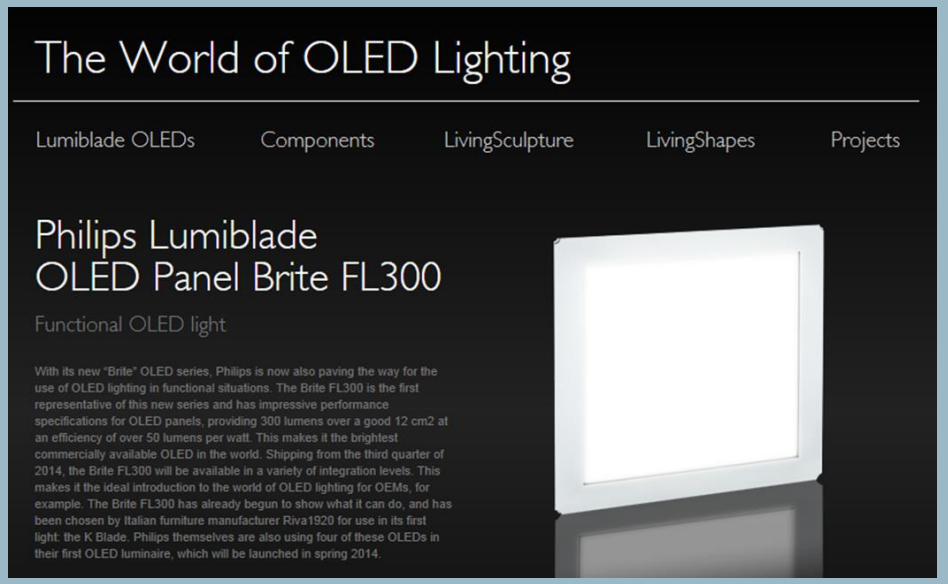
Thin film barrier technology for OLEDs

Commercially available Products

OLED Lighting:

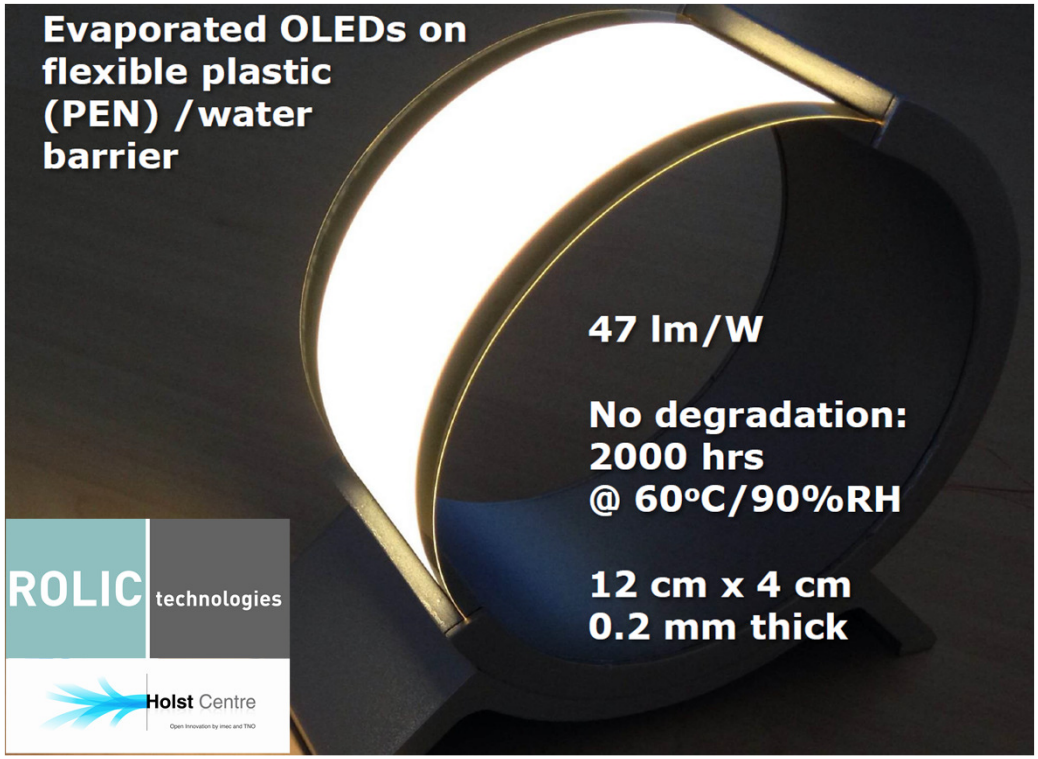
Pics copyright Philips GmbH

Lumiblade OLED Panel Brite FL300 delivers more light output and lower cost than prior products



Lumen : 300 lm
Lumen efficacy: > 50 lm/W
Luminance : 9000 cd/m2

OLEDs: Next steps



- Flexible OLEDs between two barriers (top and bottom): black spot free for 2000 hrs at 60oC/90%RH (still ongoing)
- Exposure to **250ºC for 1 to 3 hours**: no degradation
- **10 000 rolls at 20 mm diameter**: no visible barrier degradation
- Optically transparent

Summary

Light controlled molecular orientation – LCMO

I) Rolic® LCMO is the fundamental photo alignment technology for the today's advanced displays and optical devices. It has been successfully applied in mass production of :

☺ Advanced Optical Films for light management
☺ Advanced new generation large LCD-TV panels

II) Rolic® Functional Materials and Foils for OLEDs and OPV have been successfully applied in production / pre-pilot phase.

III) Rolic® LCMO will significantly evolve for the development of the next generation displays, optical, photonic and electronic devices