Functional Materials & Films for Light Management & OLEDs

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Workshop on Large-Area SSL 30.10.2014, Muttenz BL

Innovation for Success
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):

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

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

Molecular design, simulation, synthesis

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

Technology as well as the associated specific materials and processing
Core Competence: Alignment of organic molecules

Liquid crystals, LC
- Anisotropic molecules
- Birefringent: $n_e \neq n_o$

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

Nematic phase (self-organisation with local orientational order)

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

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

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

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

- Angle dependent Reflective Color Filter
- Quarter wave plate

Transmission vs. Wavelength [nm]
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
- ...

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

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

Polarisers, Filters,…

Optical Security

Brightness enhancement

Directional- Diffusers

Directional- reflectors

low power consumption (no back-light)

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LCMO Industrial Applications
LCMO 3D in mass production

3D-Display using a 3D-converter film

Quarter wave plate

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

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

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)
LCMO – Photo-Patterned Anisotropic Topologies

- Example 1: 2 perpendicular scattering directions
- Example 2: dynamic Features (ellipses with 8 scattering directions)

Working principle: Grating like

Ambient light

25-45°

specular reflection

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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)

Biaxial (Rolic) 24%
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

Organic Electronics (OE)

ROLIC’s motivation: water protection

Problem: water destroying parts of OLED cathode

• Black spots visible, product appearance not accepted by customer

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

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Thin film barrier technology for flexible devices: OPV

Rolic’s encapsulation technology:

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:

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 60°C/90%RH (still ongoing)
- Exposure to 250°C for 1 to 3 hours: no degradation
- 10 000 rolls at 20 mm diameter: no visible barrier degradation
- Optically transparent
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.