LayTec: Company Overview and TF-Displays

Address: Seesener Str. 10 - 13 · 10709 Berlin · Germany
Contact: info@laytec.de · mail@laytec.de
Tel.: +49 (0)30 89 00 55-0 · Fax: +49 (0)30 89 00 55-180
Outline

- Applications
- System setup
- TF-Display
  - a-Si functional layers
  - OLED
- Summary
- About LayTec
## Markets, Methods, Measured parameters

<table>
<thead>
<tr>
<th>Market</th>
<th>Methods</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED LASER</td>
<td>Reflectance, deflectometry, pyrometry</td>
<td>Layer thickness, growth rates, composition film</td>
</tr>
<tr>
<td>PV</td>
<td>Reflectance, PL, EVA crosslink</td>
<td>Layer thickness, conductivity, composition, surface roughness</td>
</tr>
<tr>
<td>Display</td>
<td>Reflectance, transmittance, EddY current</td>
<td>Layer thickness, sheet resistance</td>
</tr>
<tr>
<td>LED LASER</td>
<td>Layer thickness, PL</td>
<td></td>
</tr>
</tbody>
</table>
Display

- Layer thickness/sheet resistance measurement of ARC and functional layers
- Multilayer structures (SiOx, SiNx, a-Si, LTPS, IGZO)
- Feedback control
- 100-1000Hz measurement rate
Outline

- Applications
- **System setup**
- TF-Display
  - a-Si functional layers
  - OLED
- Summary
- About LayTec
In-line control

In-line optical spectroscopy during thin-film processes in multi-chamber systems
Main components of LayTec metrology systems

Optics heads
- Small
- Versatile
- Vacuum

Controller
- Robust 24/7
- Low maint.
- HQ Optics

Computer
- Display, Storage

Equipment
- All interfaces
- Feedback
Outline
- About LayTec
- Applications
- System setup
- TF-Display
  - a-Si functional layers
  - OLED
- Summary
- About LayTec
LayTec maintains own database of optical properties

- Accurate results by adapted dispersion
- Performance equal to lab systems

Every process is correlated with specific optical properties. LayTec’s thin-film dispersions are parametrized and can be adopted.
Reflectance fit of in-line produced a-Si layer

Reflectance spectra can be fitted more accurately using LayTec dispersion > thickness resolution: 1 nm (typically)
a-Si thickness on two substrates A and B

a-Si layer determined by off-line ellipsometer is thicker due to smaller refraction index. Same thickness fluctuations are resolved by both measurements.
In-line in-out repeatability test

a-Si can be resolved on nanometer scale!
Stack 50nm a-Si / 100nm SiO_x / 50nm SiN_x

SiO_x and SiN_x thicknesses for nominal stack 45nm a-Si / 130nm SiO_x / 50nm SiN_x can be resolved after proper optical adjustment.

LayTec offers nanometer accurate in-line monitoring of a-Si, SiN_x, and SiO_x layers for 100% production control.
Sheet resistance measurements (EddY)

- Quality assurance of low and high conductive thin-films
- Sheet resistivity monitoring from 0.01 – 50 Ohm/square by use of calibrations
- Other specifications on request
Characteristics of EddY

- Contact-free and real-time
- Customized systems considering design requirements of application
- Single-point or multi-point measurement at up to 16 positions
- Suitable for vacuum application on demand
- Production flow up to 100 mm/s
OLEDs: Principles of in-line spectral reflectance

- White light is irradiated to the sample
- Reflected light is detected spectrally resolved
- Most robust geometry: normal incidence
- Applicable to non-transparent substrates
- Other geometries possible on request
In-line spectral reflectance after each deposition step

- Yields layer thickness directly
- Yields spectral optical properties (for optical coatings)
- Straight forward if \( nd > l \)
- Requires more sophisticated analysis for \( nd < l \)

**Challenge: Large variety of organic materials, intermediate layers, polarization effects.**
Full OLED structure on glass

- All OLED layers clearly resolved
- Signal-to-noise ratio is excellent
- Quantitative analysis of thickness (all layers) by using n,k data base

All functional layers (HTL, EBL, EM, HBL and ETL) give a characteristic spectrum.
In-line measurement on glass of complex OLED structure

<table>
<thead>
<tr>
<th></th>
<th>$d_{\text{refl}} / \text{nm}$</th>
<th>$d_{\text{prof}} / \text{nm}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTL</td>
<td>143 ± 1</td>
<td>150 ± 5</td>
</tr>
<tr>
<td>+ EBL</td>
<td>7 ± 1</td>
<td>10 ± 5</td>
</tr>
<tr>
<td>+ EM</td>
<td>30 ± 1</td>
<td>24 ± 5</td>
</tr>
<tr>
<td>+ HBL</td>
<td>9 ± 1</td>
<td>10 ± 5</td>
</tr>
<tr>
<td>+ ETL</td>
<td>37 ± 1</td>
<td>39 ± 5</td>
</tr>
</tbody>
</table>

Organic layers of few nanometers can be resolved.
## In-line measurement on flexible substrate

<table>
<thead>
<tr>
<th>Layer</th>
<th>Soll</th>
<th>Foil, in-situ</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTL</td>
<td>60 nm</td>
<td>51 ± 3 nm</td>
</tr>
<tr>
<td>EBL</td>
<td>10 nm</td>
<td>5 ± 2 nm</td>
</tr>
<tr>
<td>EML</td>
<td>20 nm</td>
<td>20 ± 3 nm</td>
</tr>
<tr>
<td>HBL</td>
<td>10 nm</td>
<td>6 ± 2 nm</td>
</tr>
<tr>
<td>ETL</td>
<td>30 nm</td>
<td>28 ± 3 nm</td>
</tr>
</tbody>
</table>
Measurement set-up for NET18 on NPD in roll-to-roll process

- In-line Measurement at the center of the foil
- Pos4 = NPD
- Pos5 = NPD+NET18

Sequential measurement at pos4 and pos5 resolves double-layer structure.
Layer thickness of NET18 on NPD

- Step #3 and #4 no deposition
- Step #5 to #6 deposition of nominally 50nm NET18
- Drift in thickness can be resolved
- Thickness-resolution down to 10nm

LayTec can measure very thin OLED layers with high accuracy. Feasibility study necessary for new materials.
Outline

- About LayTec
- Applications
- System setup
- TF-Display
  - a-Si functional layers
  - OLED
- Summary
- About LayTec
LayTec competence in displays

- LayTec offers sophisticated in-line and in-situ optical metrology tools that yield long-term stable results
- Thicknesses of typical anorganic and organic functional layer stacks can be measured in-line and in real-time
- Measurement accuracy comparable to lab equipment
- Access to thickness homogeneity, composition, as well as electronic properties such as conductivity and mobility
Outline

- About LayTec
- Applications
- System setup
- TF-Display
  - a-Si functional layers
  - OLED
- Summary
- About LayTec
Layer by layer

- 1999 foundation of LayTec
- Optical in-situ & in-line metrology solutions for thin film applications
- World market leader of in-situ metrology for LED and LASER production equipment
- Worldwide more than 1600 metrology systems

All LayTec products are certified quality “Made in Germany”.
Knowledge is key

www.laytec.de