Full automated polarimeter
Fullauto StrainEye
LSM–9100W/WS

Luceo Co., Ltd.
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- Company profile/Products
- Polarization
  (what is Polarization/ Cross-parallel nicol/Retardation ?)
- Measurement method
- About LSM-9100W/WS
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Company profile

- In 1966, when liquid crystals did not exist, we took notice of polarizing plates, an optical element, and began our in-house R&D, production and sales.

- Using proprietary technologies, we manufacture our own brand of polarizing plate, optical element of wave plate, optical unit and optical inspection equipment, and sell it to domestic as well as around the world.
Product

- polarizing plates
  - wave plates

Polariscopes
Polarization

Light oscillates only in a specific direction

Controlling light creates a new technology.
LUCEO offers optical related products.
Cross nicol · Parallel nicol

Cross nicol
(Polarized transmission axis Cross)

Parallel nicol
(Polarized transmission axis Parallel)
Linear polarized light - Circularly polarized light

**Linear polarized light**
- Natural light
- Linear polarized light
- Polarizer
- Transmission axis
- Linear polarized light
- Absorption axis

**Circularly polarized light**
- Vibration direction of incident light
- Optical axis direction of quarter-wave plate
- Linear polarized light
- Quarter wave plate
- Circularly polarized light
Retardation/principal axis direction

The upper figure shows the process of generating the phase difference of birefringence. The axis with the highest or lowest refractive index is called the direction of the principal axis. Also, the axis with the lowest refractive index is called the fast axis because the light travels fast, and the axis with the highest refractive index is called the slow axis. Here, the relationship between the birefringence phase difference (retardation) that occurs when passing through the birefringent material, the thickness $d$ of the material, and the birefringence of the material is expressed by the following equation.

$$ \Delta = \frac{2\pi}{\lambda} (n_x - n_y)d $$
Measurement method

Capture images at different angles of the rotating analyzer and calculate strain from changes in brightness.

Unpolarized light

Rotating polarizing plate

Sample

Rotating polarizing plate

Cross nicol / Parallel nicol

“RGB linear polarization method”

- Use RGB LED (460/525/630 nm) as light sources
- 3 wavelengths images are taken at the same time.
**Measurement method**

- Light intensity data at any point \( \sim \) Fourier analysis

**Graphical Representation**

- From the angle of the polarizing plate at the darkest position, the direction of the principal axis \( \phi \) is caught according to sine wave approximation.

**Mathematical Expression**

- Calculate the retardation “Re” from the amplitude “a”

**Diagram Description**

- Base on image processing by every pixel, result of every point in the field of view will be obtained.

- Variation in measurement results can be reduced by using both cross nicols and parallel nicols.
Fullauto StrainEye LSM-9100W/WS

LSM-9100W

LSM-9100WS
Fullauto StrainEye LSM–9100W/WS

• LSM–9100W / WS is a device that non-destructively measures the internal stress of plastic products with large strain (internal stress) non-destructively in the retardation range of 0 to 3,000 nm.

• LSM-9100 Product family
  
  **LSM-9000W** Suitable of bigger samples (φ 150mm)
  
  **LSM-9100WS** 6x zoom lens for measurements on smaller samples
# Fullauto StrainEye LSM-9100W/WS

<table>
<thead>
<tr>
<th>Contents</th>
<th>LSM-9100W</th>
<th>LSM-9100WS</th>
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<tr>
<td>Outer</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<tr>
<td>Outer dimension (Body)</td>
<td>W300×D353×H540mm</td>
<td>W300×D353×H580mm</td>
</tr>
<tr>
<td>Weight (Body)</td>
<td>22kg</td>
<td>24kg</td>
</tr>
<tr>
<td>Sample Available Height</td>
<td>0～160mm</td>
<td>0～115mm</td>
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<td>Inspection method</td>
<td>RGB linear polarization method</td>
<td>←</td>
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<tr>
<td>Set wavelength</td>
<td>420～680nm</td>
<td>←</td>
</tr>
<tr>
<td>Retardation Range</td>
<td>0～3000nm</td>
<td>←</td>
</tr>
<tr>
<td>Repeat Accuracy</td>
<td>Single wavelength σ&lt;1nm</td>
<td>←</td>
</tr>
<tr>
<td></td>
<td>Three wavelength σ&lt;3nm</td>
<td>←</td>
</tr>
<tr>
<td>Measurement area</td>
<td>Φ150mm</td>
<td>60 × 60mm ～ 10 × 10mm</td>
</tr>
</tbody>
</table>
• In glass and plastic products, internal residual stress remains in the form of strain when they are heated and formed in the manufacturing process.

• Products with strain have poor optical properties and are fragile.

• A polarimeter is an instrument that observes/measures the strain quantitatively.

(Sensitive Color method)
### Difference with other measurement principles

<table>
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<tr>
<th>Classification</th>
<th>Sensitive color</th>
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<th>Rotating analyzer</th>
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<tr>
<td></td>
<td>Visually</td>
<td>Semi-automatic one-point measurement</td>
<td>Automatic two-dimensional measurement</td>
<td>Automatic two-dimensional measurement</td>
</tr>
<tr>
<td>Items</td>
<td>LSM-4300LE</td>
<td>LSM-7000LE</td>
<td>LSM-9000LE/S</td>
<td>LSM-9100W/WS</td>
</tr>
<tr>
<td>Measurement item</td>
<td>Retardation Determination of compression and tension</td>
<td>Retardation principal axis direction</td>
<td>Retardation principal axis direction</td>
<td>Retardation principal axis direction</td>
</tr>
<tr>
<td>Retardation measurement resolution</td>
<td>10nm</td>
<td>1.5nm</td>
<td>1nm</td>
<td>3nm</td>
</tr>
<tr>
<td>merit</td>
<td>Determined visually from color</td>
<td>Quantitative measurement</td>
<td>High precision measurement of small strain</td>
<td>Measures large strain up to 3000 nm</td>
</tr>
<tr>
<td>Demerit</td>
<td>Requires comparison with standard</td>
<td>It takes time to measure. Not 2D measurement.</td>
<td>Unable to measure strain of 130 nm or more</td>
<td>Lower measurement accuracy in low strain (about 0 to 5 nm)</td>
</tr>
<tr>
<td>Measurement example</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Application 1  LSM-9100W smartphone cover

Max 1250nm

Live image

histogram

1D graph

Retardation map

Retardation 3D map
Application2  LSM-9100W  Plastic disc compression

Max 3068 nm

Retardation map

Retardation 3D map
Application 4  
LSM-9100W/WS  
Beam bending  

Max 3090 nm
### Application 5: LSM-9100WS CD Case

<table>
<thead>
<tr>
<th>Field of View (mm)</th>
<th>Retardation Map</th>
<th>Retardation (nm) (Arrow Position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td><img src="image1" alt="Retardation Map" /></td>
<td><img src="image2" alt="Retardation Data" /></td>
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<tr>
<td>25</td>
<td><img src="image3" alt="Retardation Map" /></td>
<td><img src="image4" alt="Retardation Data" /></td>
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<tr>
<td>10</td>
<td><img src="image5" alt="Retardation Map" /></td>
<td><img src="image6" alt="Retardation Data" /></td>
</tr>
</tbody>
</table>

Max Retardation: 2086 nm
<table>
<thead>
<tr>
<th>Field of view (mm)</th>
<th>Retardation map</th>
<th>Retardation (nm) (arrow position)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td><img src="image1.png" alt="Image" /></td>
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Application 6  LSM-9100WS  Plastic bracket compression  Max 3378 nm
Application 7  LSM-9001LE/S Glass

Max10nm

LSM-9001LE lens

Max100nm

LSM-9001S Lamp bulb