Waver-Level Optics and Optical Inline Monitoring

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Fraunhofer IOF
Data and facts

- Located in Jena
- Founded in 1992
- ~ 7000 m² floor space
  (~ 1000 m² clean room)
- 206 Employees
  + 70 Students
- Budget 2013: 23,9 mill. €
  (48 % industry projects)
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Business Fields

- Optical Components & Systems
- Precision Engineering Components & Systems
- Functional Optical Surface & Layers
- Laser Technology
- Photonic Sensors & Measuring Systems
The Fraunhofer IOF charts the entire process chain, from the system design to the manufacture of prototype systems.
- Waver-Level Optics
- Optical Inline Monitoring
- other Topics
Microoptical Systems / Waver-Level Optics - Application

requirements:
- small z-height
- low mass
- low cost

1.8 billion devices shipped in 2012*

Natural & artificial imaging principles

State-of-the-art cameras
- Miniaturization limited (noise, diffraction, technology)

Ultra-thin imaging systems
- Further miniaturization
Technology comparison

<table>
<thead>
<tr>
<th>Single aperture</th>
<th>Multiaperture</th>
</tr>
</thead>
<tbody>
<tr>
<td>conventional</td>
<td>optical</td>
</tr>
<tr>
<td>miniaturized</td>
<td>electronic</td>
</tr>
<tr>
<td>reduction of pixel pitch</td>
<td>segmentation of field of view</td>
</tr>
<tr>
<td></td>
<td>stitching of image segments</td>
</tr>
<tr>
<td></td>
<td>no stitching of image segments</td>
</tr>
</tbody>
</table>

**alternative imaging principle**

objective

imager

microscope
camera
Electronic Cluster Eye – eCLEY

- array of miniature cameras
- each transmits partial image of a different part of FOV
- image processing to reconstruct final image from image segments
- electronic image stitching
- unique patented approach
  - low optics z-height
  - easier wafer-level fabrication & assembly


granted patents – many others pending:
US20110228142, JP5379241, KR101284414
US20110098208
Electronic Cluster Eye – eCLEY Fabrication
Electronic Cluster Eye – eCLEY 720p Demonstrator

- **optics z-height < 2mm**
- large DoF (4mm - ∞)
- depth imaging
- Software focusing/refocusing

DoF: Depth of field (proportional to depth of focus)

- Waver-Level Optics
- **Optical Inline Monitoring**
- other Topics
Optical Inline Monitoring

- 3D measurement system for inline monitoring and quality control of circuit boards / solder paste

- Principle of 3D measurement: Active triangulation (projection of stripe patterns) and search for corresponding points
Optical Inline Monitoring

- 3D measurement system for inline monitoring and quality control of circuit boards / solder paste
- 3D measurement accuracy (thickness) < 3 μm
- Detectable thickness of solder paste 500 μm
- Lateral resolution 10 – 20 μm
- Measurement speed up to 90 cm² / sec
Optical Inline Monitoring
Optical Inline Monitoring

- Measurement examples

400 μm
Optical Inline Monitoring

- Measurement examples
  (structure height ~ 200 μm)
- Waver-Level Optics
- Optical Inline Monitoring
- other Topics
Research Focus – Metrological wafer stages

- metrology stage for e-beam lithography
  - low CTE materials
  - for 6” ...12” wafer
  - light weight, non-magnetic...
  - flatness < \( \lambda / 20 \) @633nm
  - orthogonal < 1arcsec
  - pyramidal < 10arcsec

Stage principle

- Mask stage
- Interferometer
- Objective lens system
- Wafer stage
- Wafer
Fraunhofer IOF
Research Focus – Electrostatic Chucks

- low CTE materials
- high flatness
- light weight design
- high stiffness & force

12” wafer chuck for e-beam Lithography

6” mask chuck for EUV Lithography
Research Focus – Vacuum Chucks

- low CTE material (Zerodur)
- for 6” & 12” Si- wafer
- light weight design (recesses)
- high stiffness
Collector mirror for EUV lithography

Reflection data of collector mirrors in the wavelength range 2.4 to 3.14 nm