Challenges in development, assembly and testing of Lidar Sensors
Our Mission (1/3): *We develop and implement optical systems beyond the limits of standard solutions.*

- We combine camera, illumination and evaluation algorithm specific for your application
- We offer knowledge of a wide range of optical measurement technology

CIS – cuevette inspection system

3D geometry verification
Our Mission (2/3): We offer a comprehensive system knowledge, short project launch times and a high degree of innovation.

- Physical understanding and analysis of your application
- Creative solutions resulting from our interdisciplinary experience

Improving windshield inspection with simple shaping optics

defence laser for LIDAR testing systems
Our Mission (3/3): We offer complete solutions from a single source.

- Design, development and prototyping of various optical systems
- Testing and characterisation based on ISO standards
- Turn-key systems with CE conformity
- Coordination and project management for complete system or inspection module

Distortion measurement for AR-glasses

Inspection optics for LIDAR sensors
Ensuring the *reliability* is challenging

### High quality LIDAR

<table>
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<th>Sensor design</th>
<th>receiving inspection</th>
<th>Sensor assembly</th>
<th>End of line test</th>
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- **Sensor design**: susceptibility to manufacturing tolerances
- Quality of each *single component* counts
- Precise alignment required during *sensor assembly*
- **End of line test** critical to meet strict requirements
**Optic design**

**Lidar Receiver**

- Development and challenges depending on the concept (Flash vs. Scanning)
- Receiver
  - Horizontal field of view up to 150°
  - Cross-talk with light path of sender
  - Fast optical systems F/# < 1,0
- General challenges:
  - Costs of components
  - Limited space
  - Automotive temperature range -40°...+95°C
  - Lots of vibrations
  - Quality standards (→ Quality control)

Source: H. Gross, Handbook of optical systems
**Component inspection**

**Example: Rotating mirror**

**Part: Rotation mirror**

- **Critical specifications**
  - Parallelism of the two mirrors
  - Angle of the mirrors to the reference surface

- **Requirements for system**
  - Angular measurement with accuracy < 0.001°

Mirror test system by DIOPTIC
Component inspection
Example: Protection window

Component: Protection window

- Challenges
  - Form errors cause angular errors of the lidar
  - Testing to angular range of 360°

- Solutions
  - 3D-imaging (shape measurement)
  - Wavefront sensor

Setup measurement of angle deflection

Horizontal deflection (mrad)
Alignment and assembly

- **Tight Tolerances: sender**
  - Emission angle of the Lasers
  - Divergence of the laser
  - Decentralization, focal length of lenses
  - Angle and position tolerances

- **Tight Tolerances: receiver**
  - Aberrations
  - Location, angle of image sensor
  - Location APDs
  - Orientation rotation mirror

- **Concatenation of tolerances often requires monitored or active alignment**

**Diagram:**
- **Passive assembly**
  - Pick and Place
- **Monitored Adjustment**
  - Support by camera or angle measuring system
- **Active adjustment**
  - Laser / sensor is active
Alignment and assembly
Emitter assembly

Challenges
- Multiple optical components must be aligned

Tasks
- Conception
- Measurement of
  - Position and angle of optical components
  - Emission angle of Laser
  - Focus position of Laser
  - Reference points
- Positioning and alignment
- Fixation by UV adhesive
**Alignment and assembly**

**Reciever assembly**

**Issue**
- Cheap lenses typically have a tilted image plane due to tolerance
- 6 degrees of freedom

**System**
- Detection of reference markers for angular alignment
- Alignment of the sensor behind lens to correct tilting of the image plane

**Benefit DIOPTIC**
- Benefit from our knowledge in lens design and building high end inspection systems
**Inspection systems**

**Alignment of send and receive path**

**Challenges**

- Synchronization
- Lighting of APDs
- Aperture of the lens must be very large

![Lidar with Laser and APDs](image1)

**Huge aperture objective design by DIOPTIC**
Inspection systems

Conoscopy

Conoscopy

- greek: konos = cone, skopeo = to inspect
  → Inspection of angle fields

Challenges / Special features

- The entrance pupil is in front of the lens (all light emitted needs to be collected)
- Large aperture
- Calibration of distortion (“Object in infinity” → Use of DOEs)

Huge aperture objective design by DIOPTIC:
150 mm diameter
365 mm length
9 lenses
**Inspection systems**

**Eye safety**

- According to DIN EN 60825-1, the permissible irradiance and duration on the retina is specified.

- Irradiance depends on:
  - Laser power
  - Pulse pattern
  - Beam parameters (divergence, diameter, focus position, beam quality)
  - Scanning speed
  - Accommodation of the eye
  - Pupil size (according to standard 7 mm)

> *Inspection system must cover large number of configurations*
Our services for lidar systems

Development
- Consulting
- Optic design
- Prototyping

Assembly systems
- Conception
- Monitored alignment
- Active alignment

Inspection systems
- Component inspection
- End-of-line systems
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