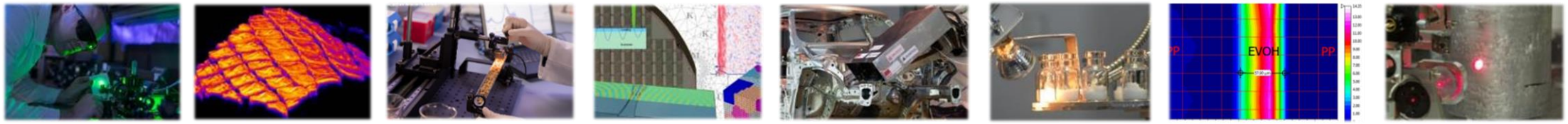
FLOIM

In-mould measurement for mechatronic compensation of positioning errors in injection over-moulding

RECENDT
RESEARCH CENTER NON DESTRUCTIVE TESTING

Fraunhofer
IWU

Member of UAR INNOVATION NETWORK



RECENDT - REsearch CEnter for Non-Destructive Testing

Science Park @ Johannes Kepler University
Linz, Austria

- Founded in 2009
- ~40 researchers
- Funded research
  (national, H2020, HEU, ITN, …)
- Contract research

upper austria

Member of UAR INNOVATION NETWORK

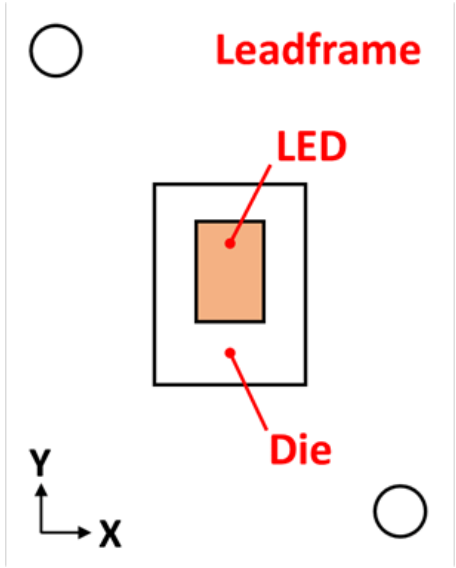
6 Research Groups:

• Infrared & Raman Spectroscopy • Optical Coherence Tomography • Terahertz Technology	**Optics**
• Laser-Ultrasound • Photoacoustics • Physical & Computational Acoustics	**Acoustics**

FLOIM

Fraunhofer IWU

Motivation



Initial situation and motivation

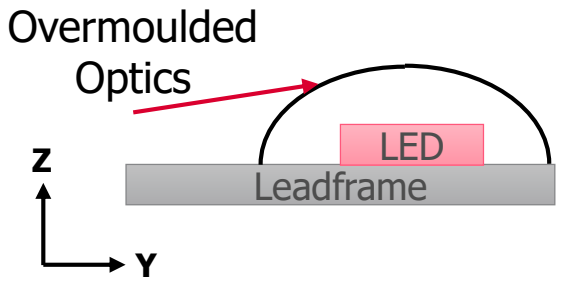
Geometric tolerances

Compensation and Alignment

Reproducible optical characteristics

Higher productivity

Miniaturization and function integration



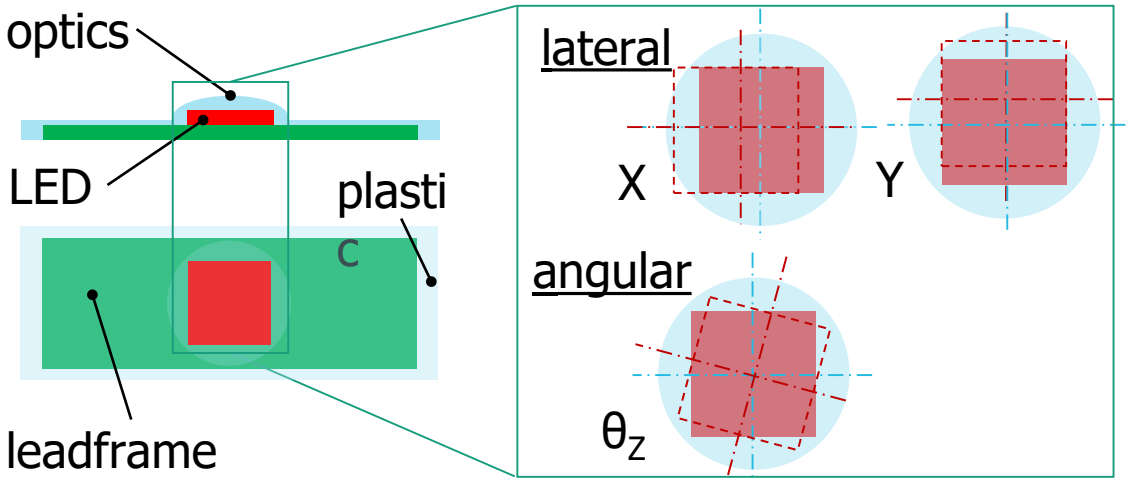
In-mould compensation system: Requirements

Initial situation and requirements

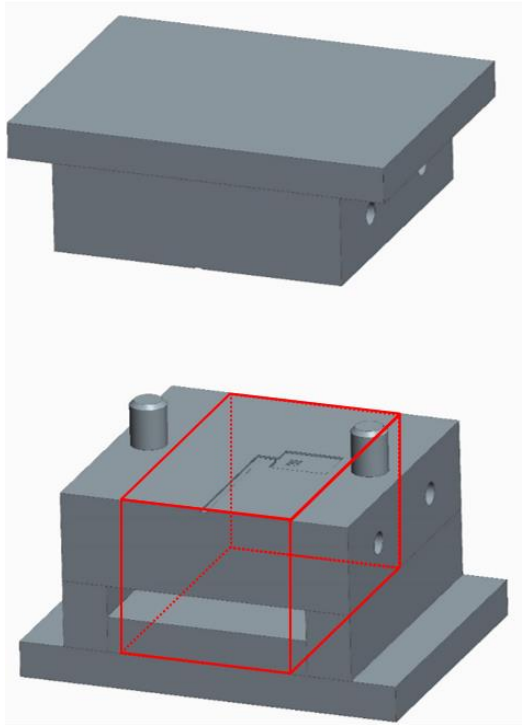
Requirement	Value
Max. translatory travel in both axes	min. 200 µm
Max. rotatory actuating angle	min. 0,5°
translational positioning accuracy	min. 0,1 µm
rotatory positioning accuracy	min. 0,006°

Requirements

Movement axes: $XY\theta_Z$



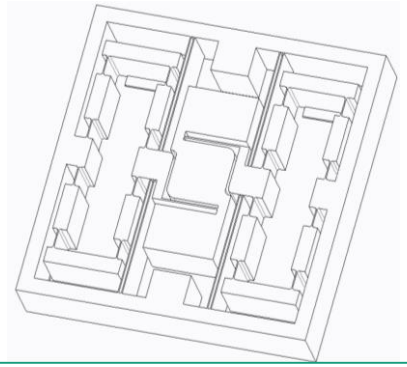
Installation Space

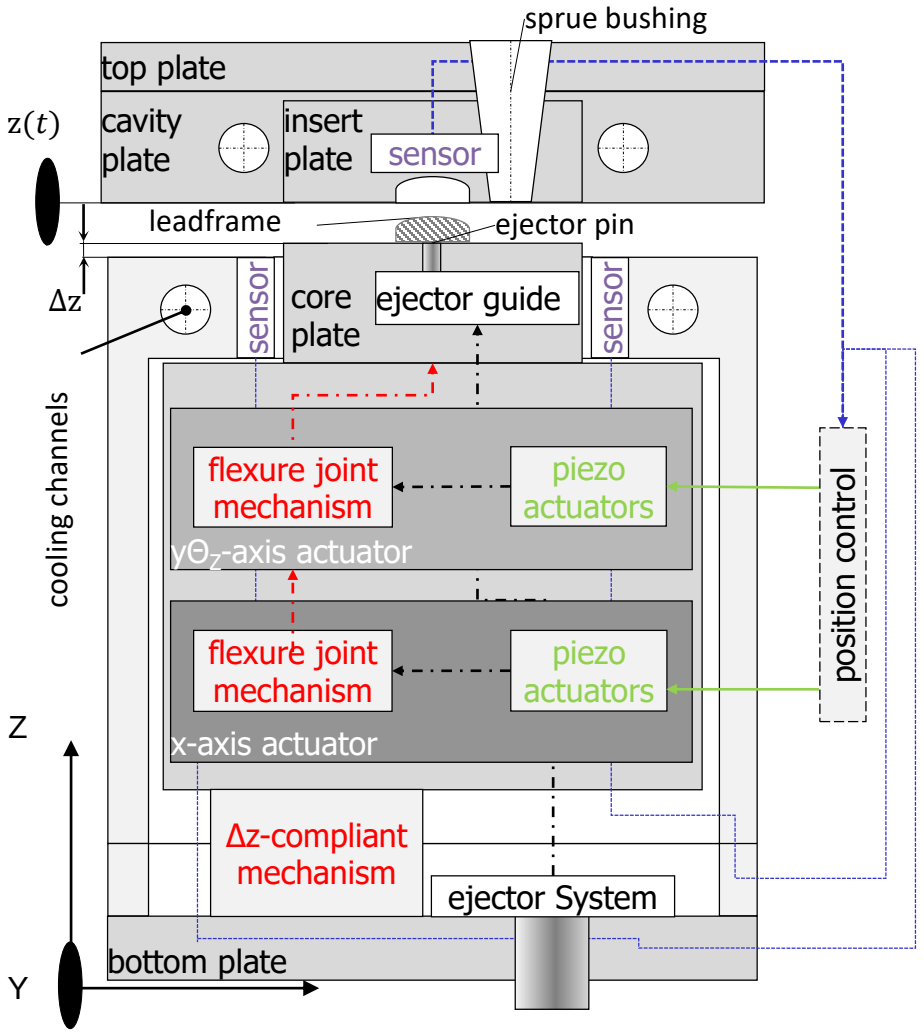


In-mould compensation system: Concept

Movement generated by piezo actuators

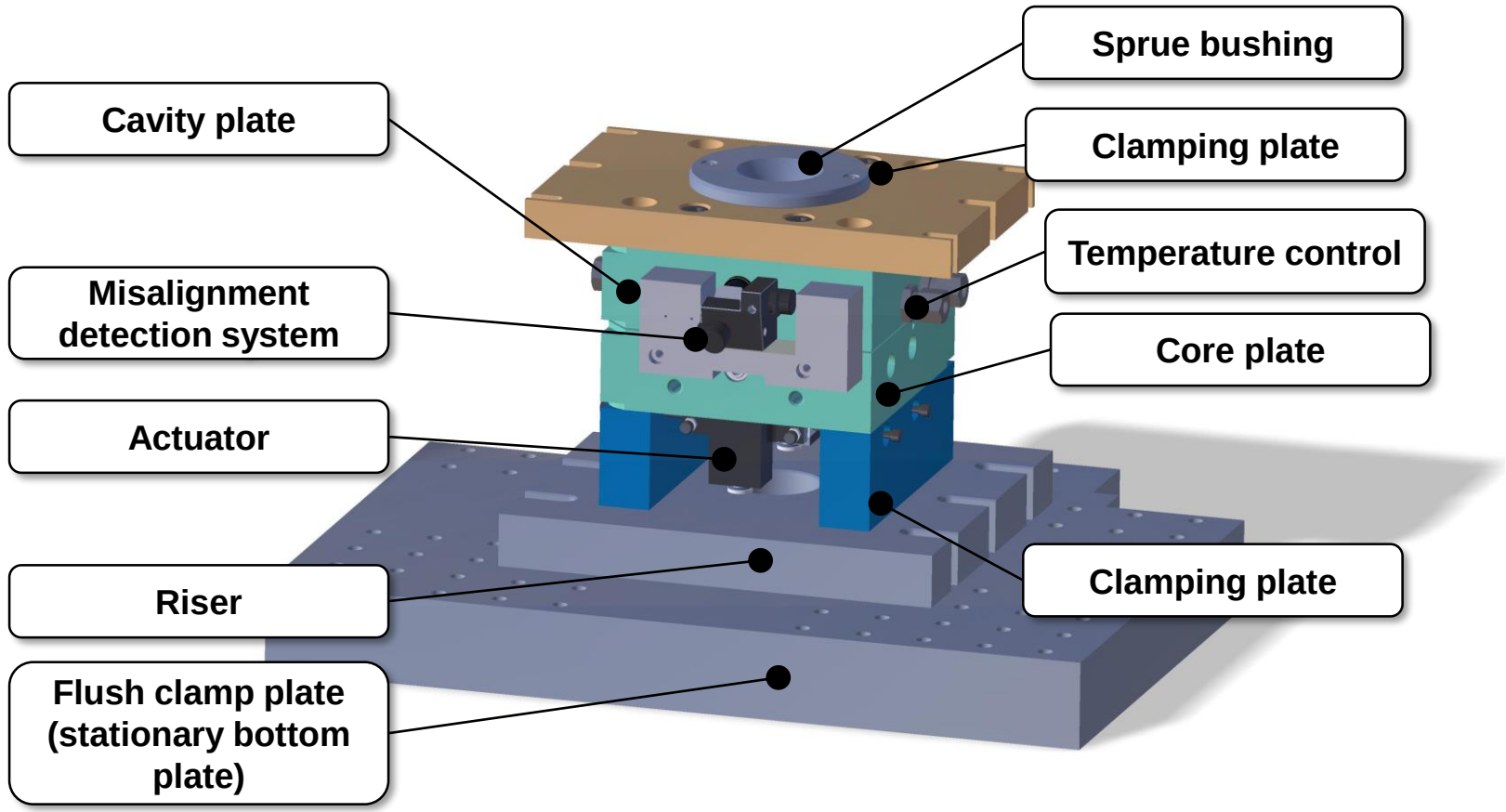
Movement transmitted by flexure joint mechanisms





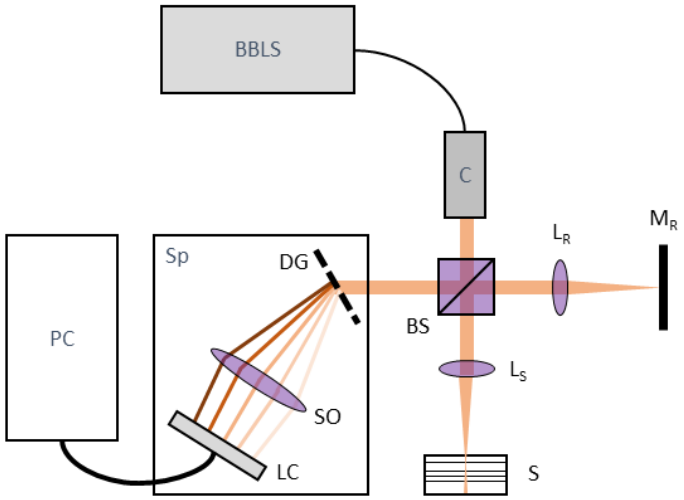
In-mould compensation system: mould integration

- Micro-Injection mould
  - Vertical two-plate mould
  - Standard-components
- High precision 3-DOF
  - Integrated piezo-actuators
  - High precision flexure joint mechanisms
- Measuring systems:
  - 3 capacitive sensors on cavity plate

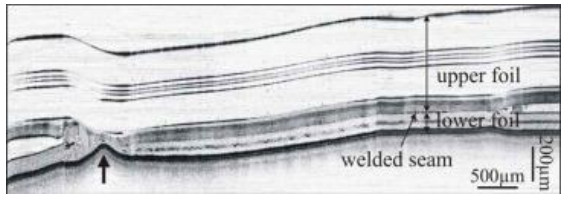


156x156x200 mm (l×w×h)

Optical coherence tomography



Structural OCT



Internal structural composition

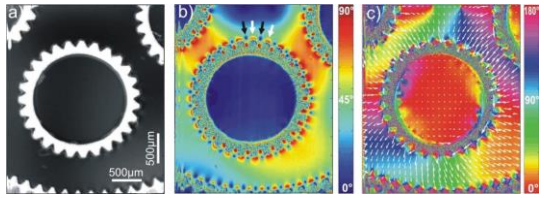
Intensity-based OCT

Information on:

- Structural composition / interfaces
- Defects (e.g. micro-cracks)
- Delamination or inclusions

Functional OCT

e.g. Polarization- Sensitives OCT



Reflectivity Retardation optical Axis

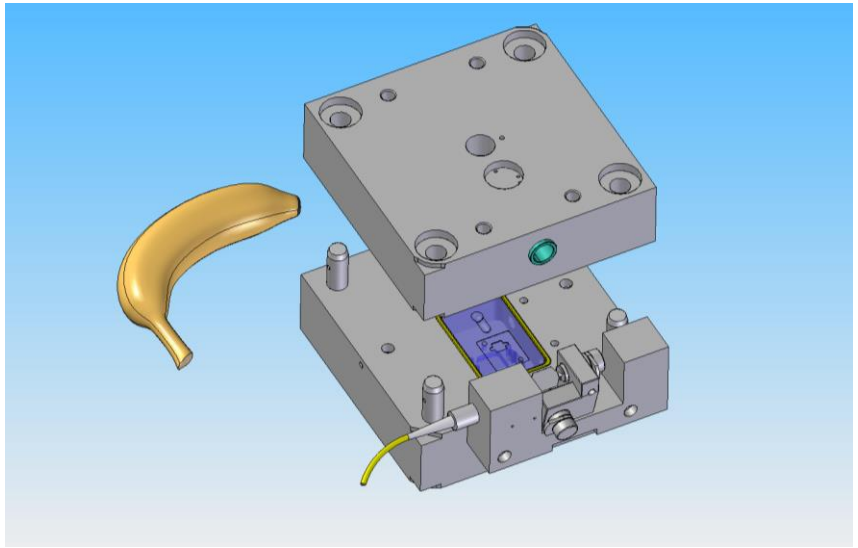
Phase-based OCT

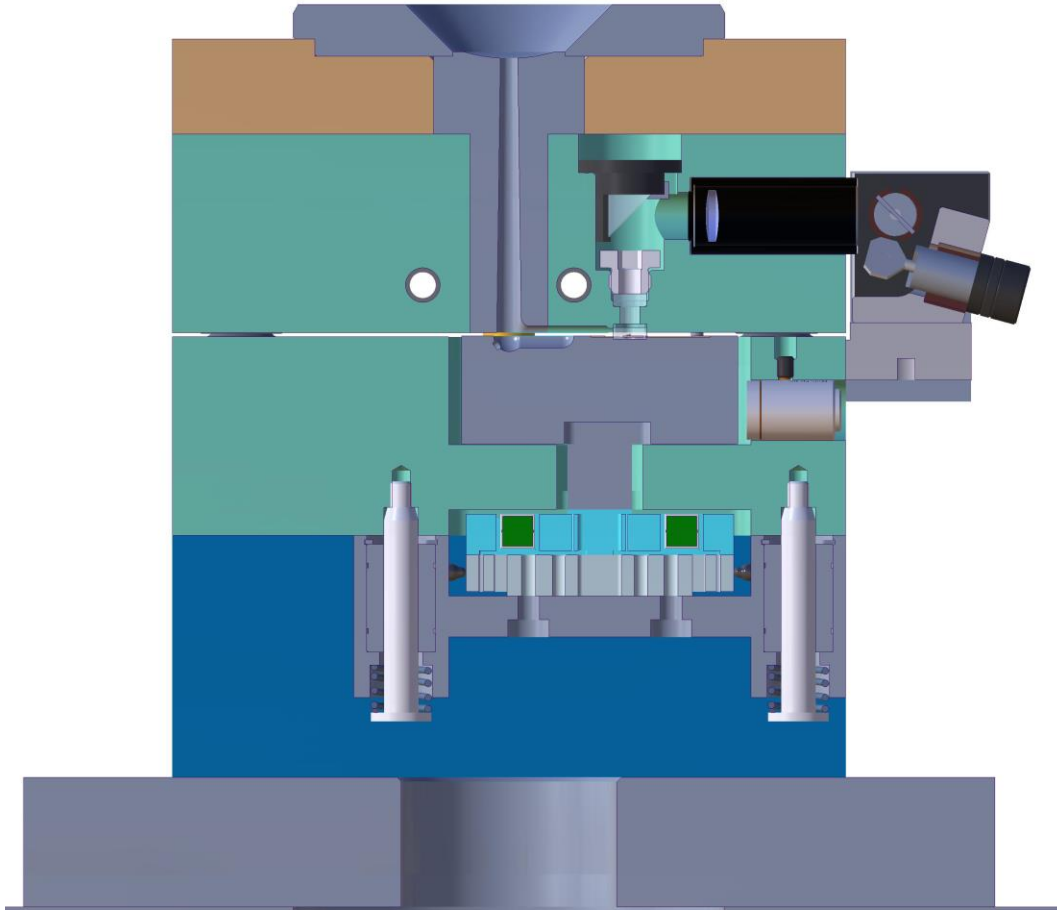
Information on:

- Optical Anisotropies
- Internal stresses in polymers
- Local reflective index changes

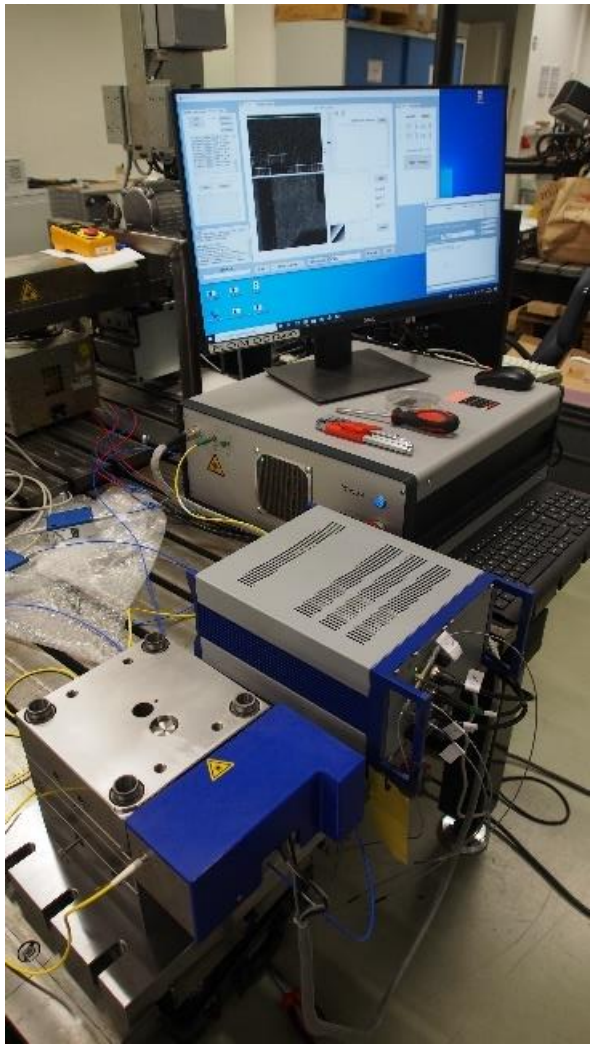
In mould process monitoring: design

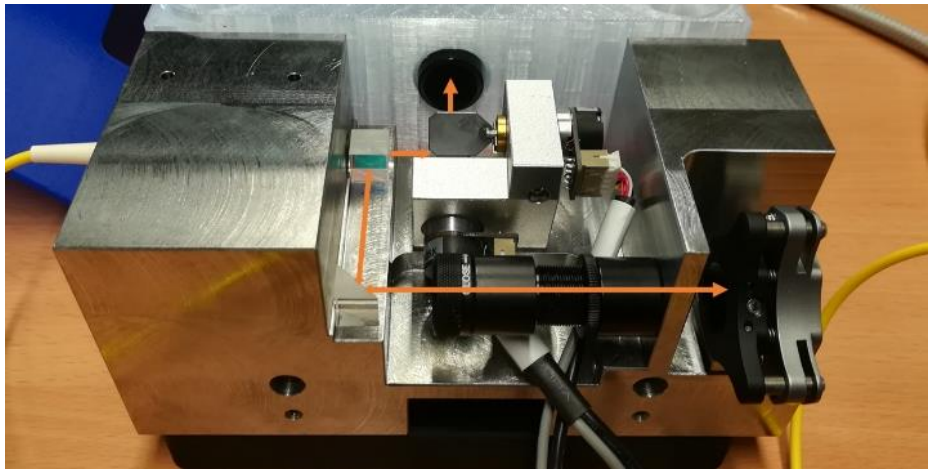
Specification	
Axial resolution, Δz (µm)	10
Lateral resolution, Δx (µm)	< 20
Depth scan area (mm)	4.2
Lateral scan area (mm × mm)	6×6
B-scan rate (Hz)	80

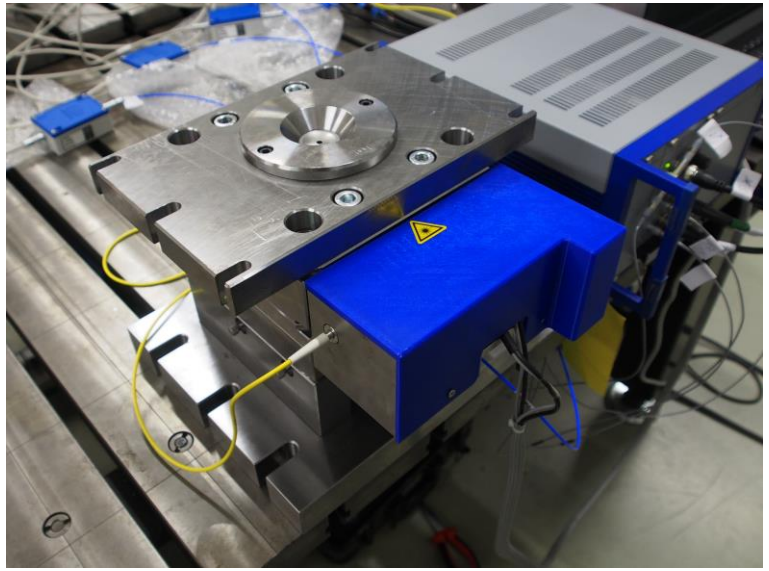




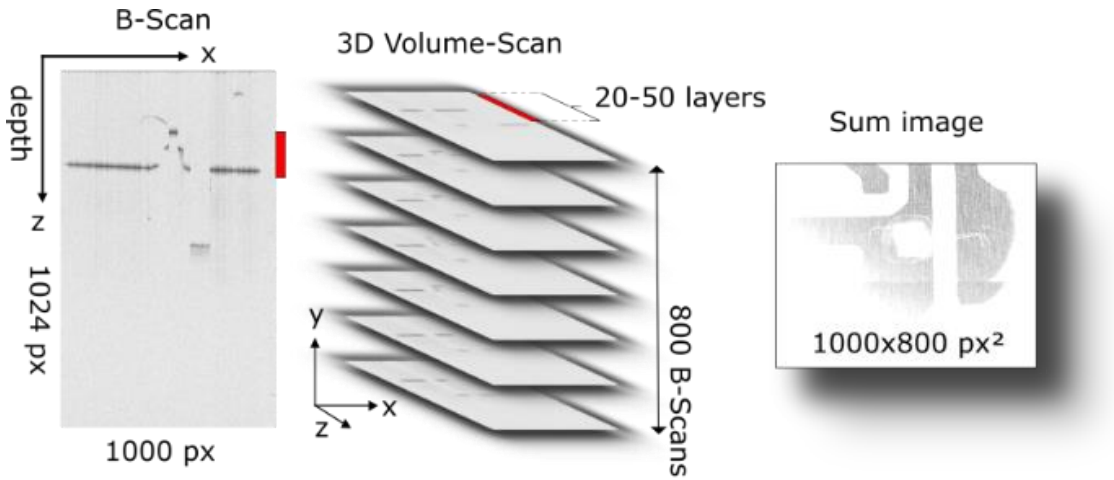
In mould process monitoring: design

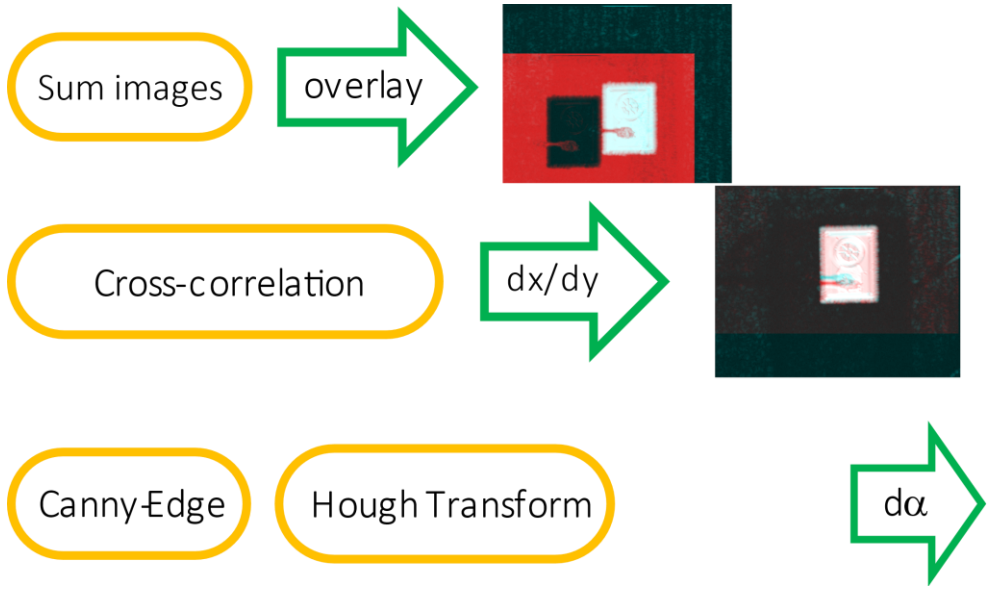




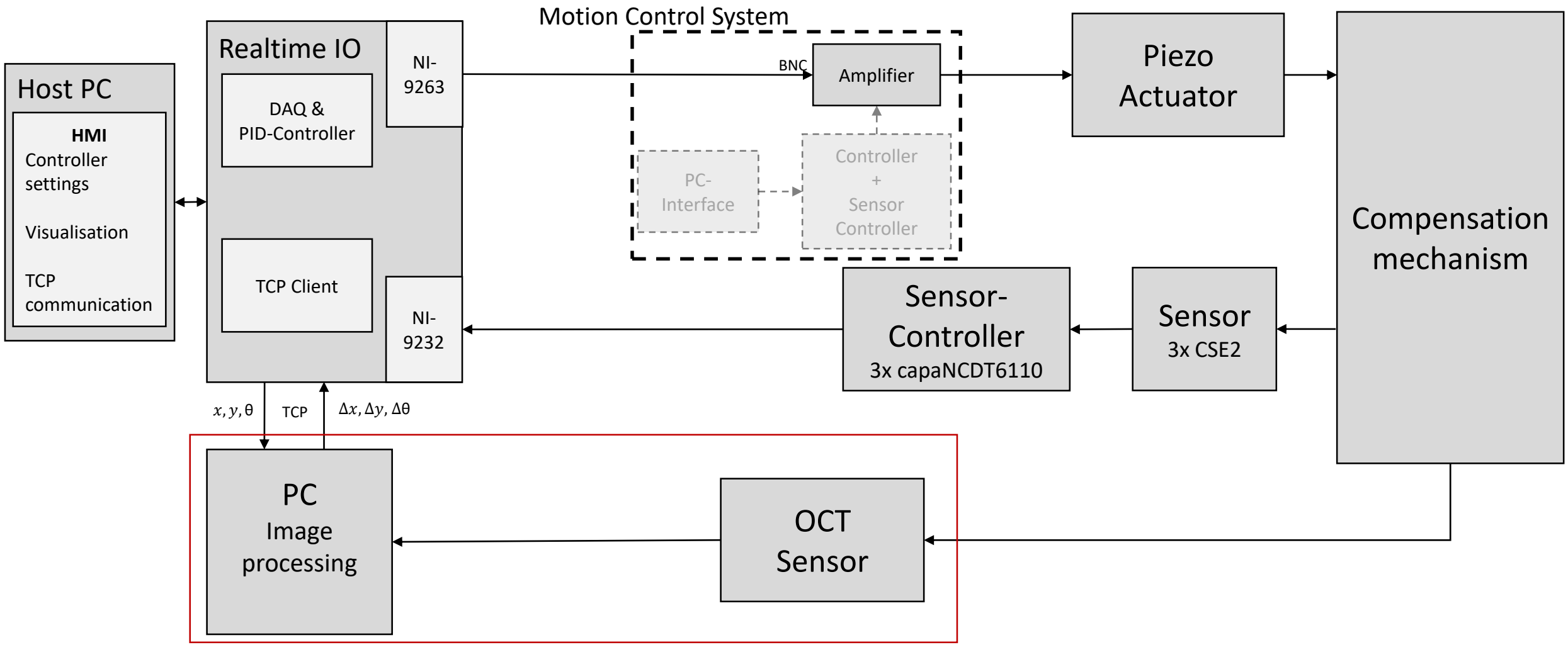


In mould process monitoring: image processing





Compensation and alignment system



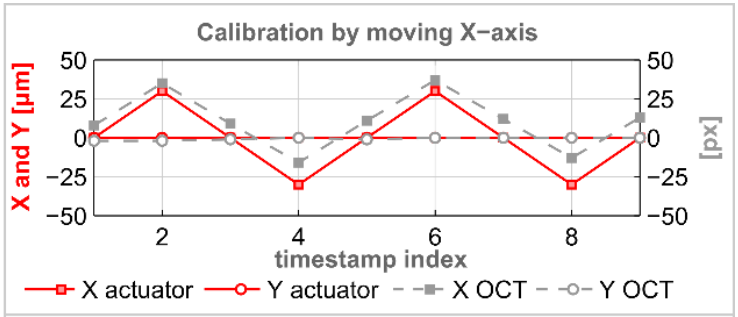
Compensation and alignment system

Coordinate System calibration

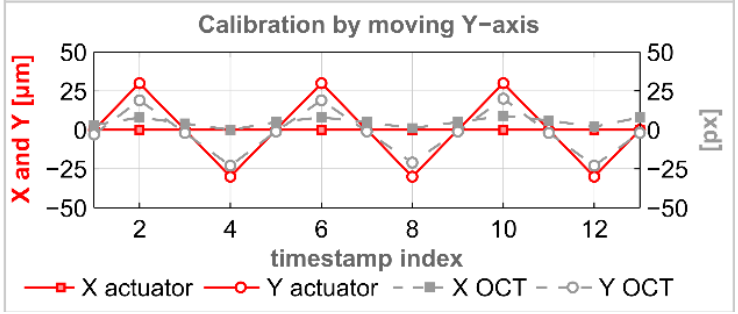
$$\begin{pmatrix} x \\ y \end{pmatrix}_{OCT} = A \cdot \begin{pmatrix} x \\ y \end{pmatrix}_{actuator} = \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \cdot \begin{pmatrix} x \\ y \end{pmatrix}_{actuator}$$

$$\begin{pmatrix} x \\ y \end{pmatrix}_{actuator} = A^{-1} \cdot \begin{pmatrix} x \\ y \end{pmatrix}_{OCT} = B \cdot \begin{pmatrix} x \\ y \end{pmatrix}_{OCT}$$

a)

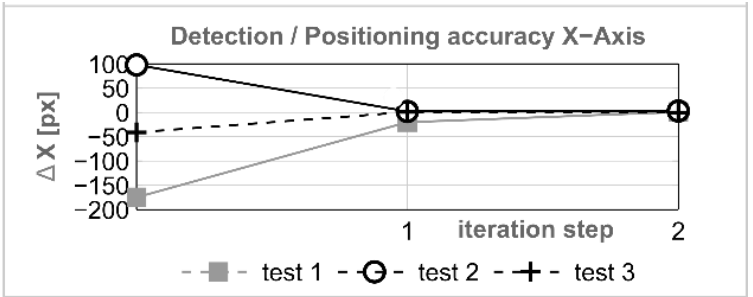


b)

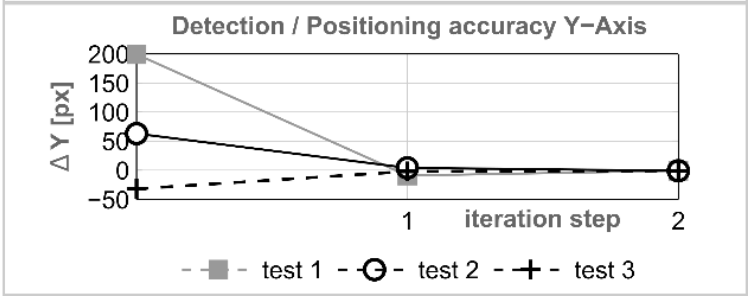


Positioning accuracy

c)



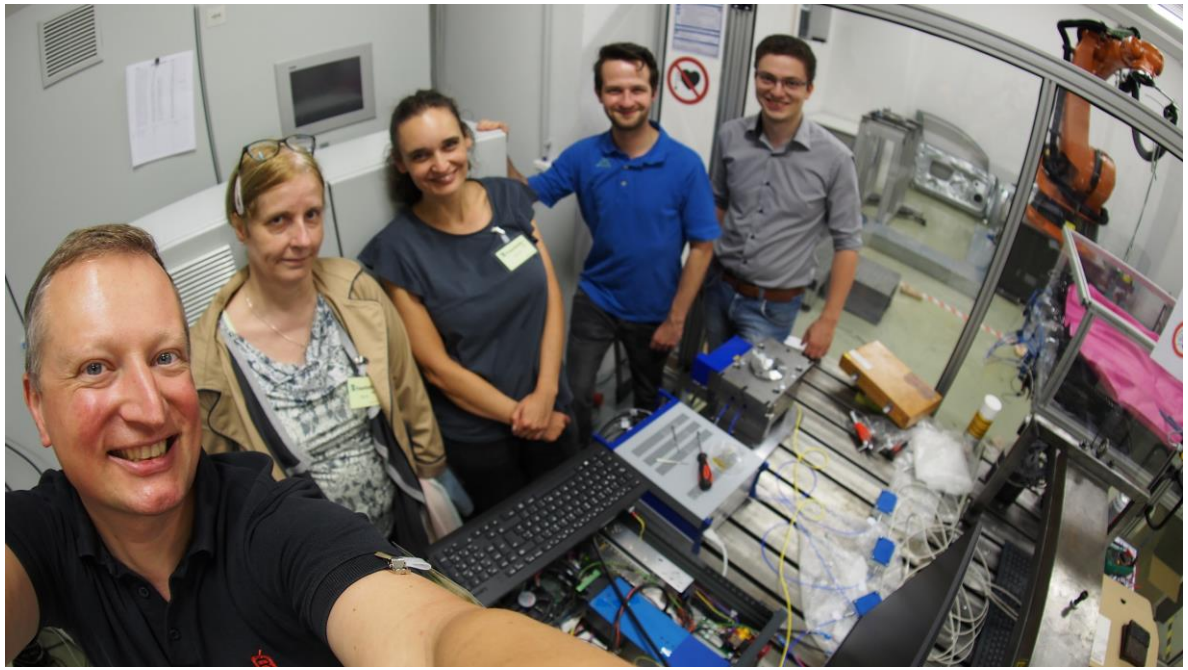
d)



Summary

- Novel in-mould positioning system developed
- Correction detection based on OCT
- OCT has the potential for
  - pre-injection and
  - post-injection

  product quality monitoring

Acknowledgement

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  - Günther Hannesschläger
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