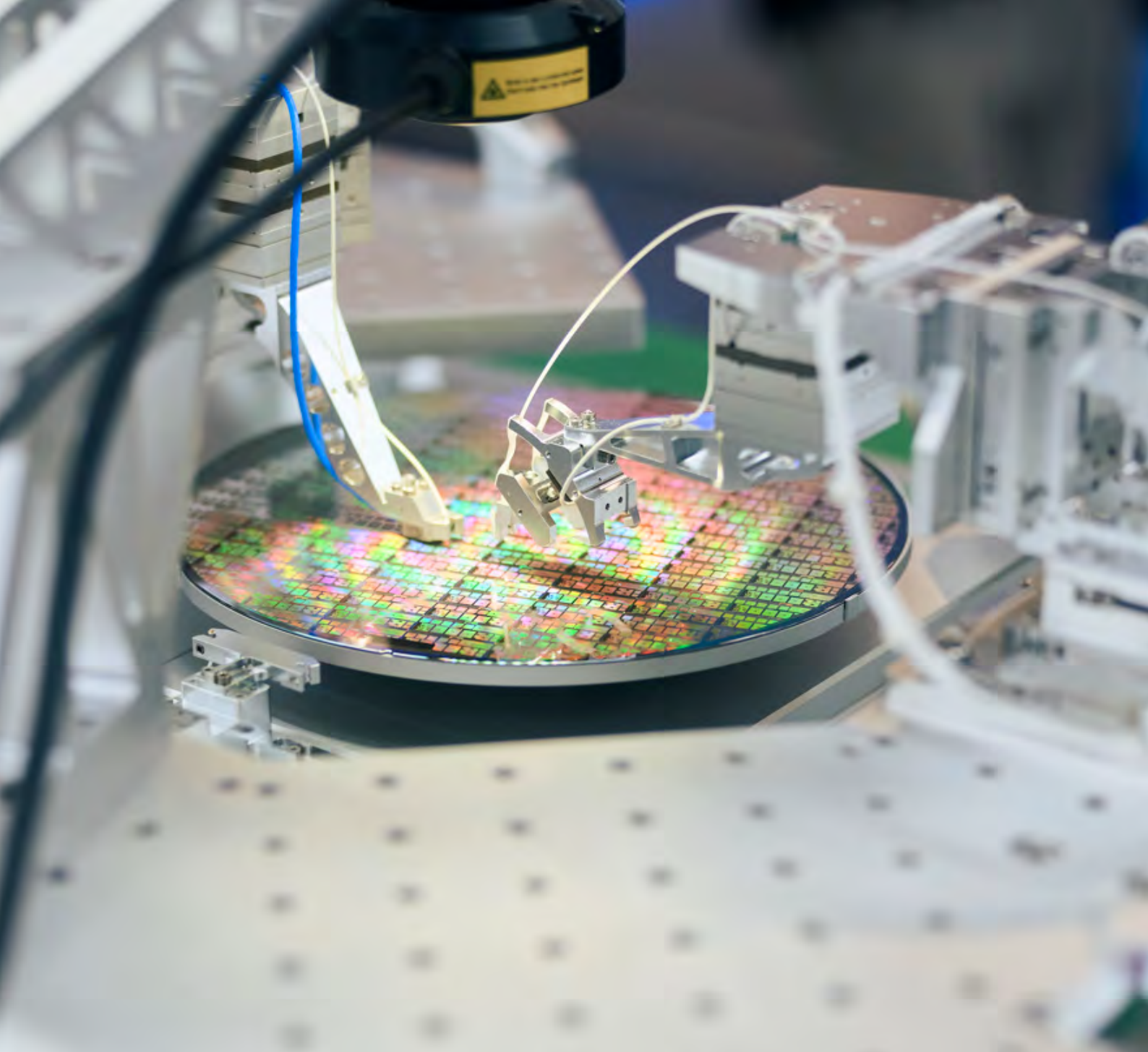
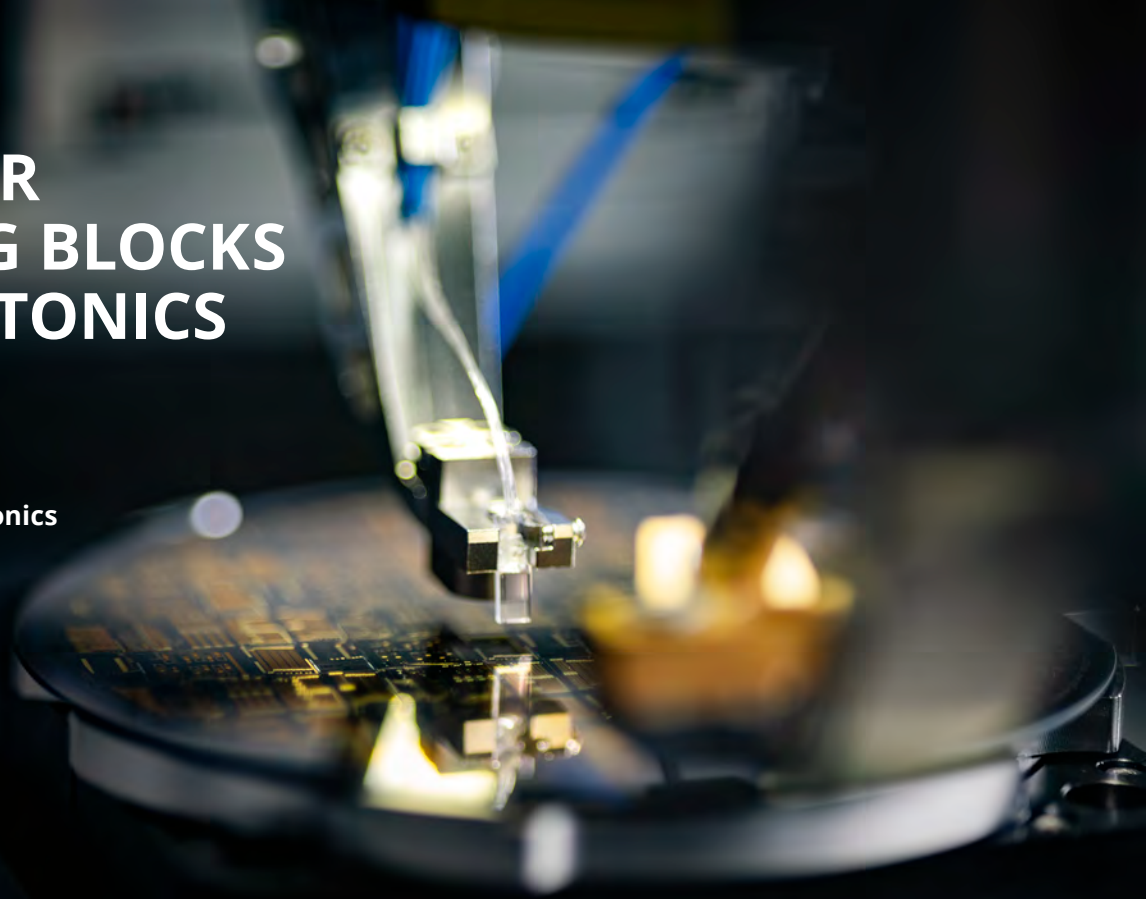




Modular Alignment Architecture for Photonics Testing

MODULAR BUILDING BLOCKS FOR PHOTONICS TESTING

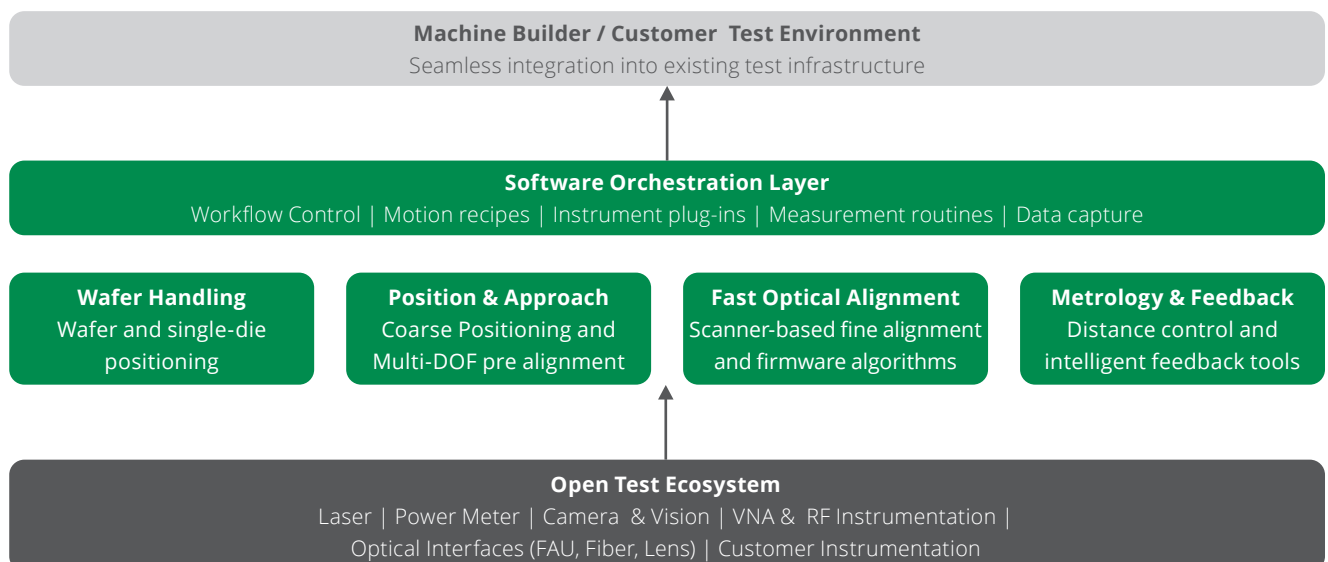
For machine builders,
integrators and photonics
manufacturers



Example configuration: Electro-optical RF characterization of LTOI Mach-Zehnder modulators at wafer level.

Photonics testing requires precise, repeatable and application-specific optical access to the device under test. Depending on the optical interface, device geometry and measurement strategy, different system architectures are required – from wafer handling and coarse positioning to high-speed fine alignment and feedback-driven metrology.

SmarAct combines complementary hardware building blocks with software orchestration and device plug-ins. This modular approach enables tailored application-specific photonics test architectures while seamlessly integrating third-party optical, electrical and measurement equipment.

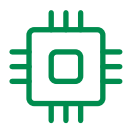


Application-Specific Photonics Testing and Characterisation

Different devices, measurement tasks, optical interfaces and test stages require different system architectures.

Photonics testing is not a single fixed application. Depending on the device under test, the measurement objective, the optical interface and the required level of automation, different system architectures are needed.

SmarActs modular building blocks can be configured to match these different application scenarios – from early R&D and characterization to small-batch operation and high-throughput production test.



Device under Test

Active and passive photonic devices create different alignment and measurement requirements.

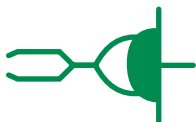
- Modulators
- Passive components
- Lasers & detectors
- PIC assemblies



Test Type

Measurement goals define the required instrumentation and workflow.

- Optical
- Electro-optical
- RF characterization
- Functional test
- Quantum PICS



Optical Interface

The optical interface strongly influences the alignment strategy.

- Grating coupling
- Edge coupling
- Trench coupling



Test Level

Test architectures scale from feasibility studies to production-oriented testing.

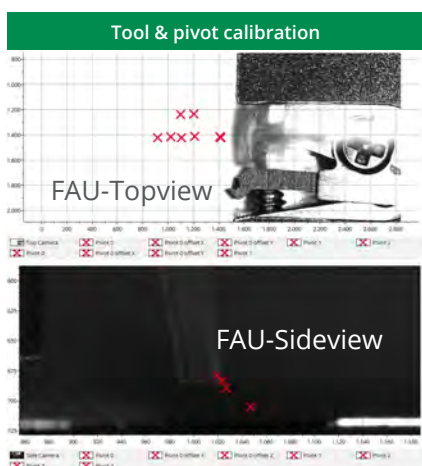
- R&D
- Characterization
- Small batches
- HVM test

One modular architecture. Many photonics testing approaches. **Build the architecture your device, interface and process require.**

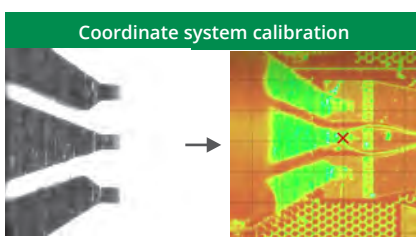
Application Spotlight

Automated Electro-Optical Wafer-Level Testing

One possible configuration of SmarAct's modular photonics testing architecture – combining motion, calibration, optical alignment, instrumentation and data acquisition in one automated workflow.



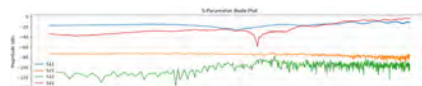
Sub-micron tool calibration



Unified wafer, tool and
inspection coordinates.



Third-party optical, electrical and
RF instruments can be integrated
via plug-ins. Example: Anritsu
VNA.



Representative EO/RF
measurement

Orchestrated in our Development Software

Calibration • Wafer Navigation • Alignment • Instrument Control • Data Acquisition



DUT
LTOI MZM



Test Type
EO RF Characterization



Optical Interface
Grating, Coupling



Test Level
Automated Wafer/Die Level



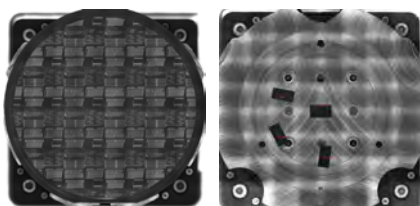
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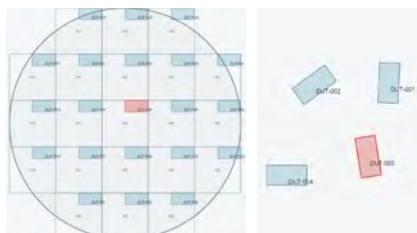


Tool & pivot calibration



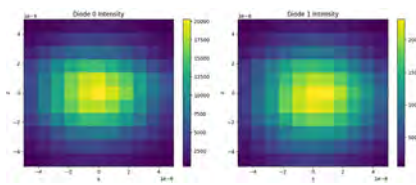
Full wafer overview and die-level inspection for comprehensive coverage.

DUT Detection



Automated device detection and classification directly on wafer or single dies.

Optical Alignment



High-precision optical alignment for single and multi channel optical pathways.

Modular Hardware, Intelligent Workflows. Open Integration

Building the Photonics Test Chain

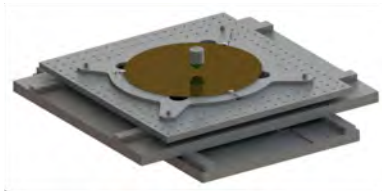
From Wafer Positioning to Automated Optical Characterization.

Once the test application is defined, the required system can be built from modular functional layers. SmarAct provides configurable building blocks for positioning, alignment, metrology and automation – while remaining open to customer and third-party instrumentation.

Development Software Orchestration

Workflow Control • Motion Recipes • Alignment Routines • Instrument Plug-Ins • Measurement Routines • Data Capture

1. Move the DUT



Wafer & Die Handling

Position the wafer or device and move efficiently from site to site.

- Wafer positioning
- Wafer access
- Die-to-die motion
- Optional leveling

2. Approach the Interface

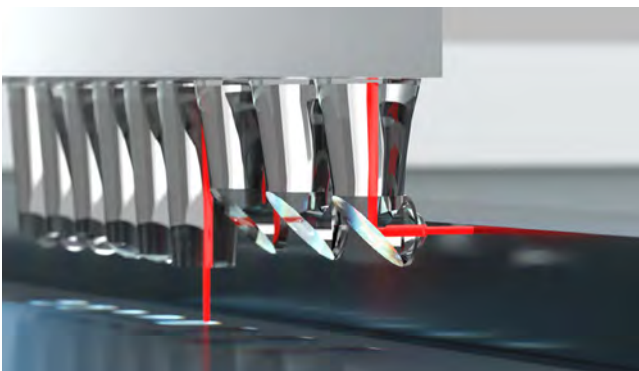


Positioning & Pre-Alignment

Bring fibers, FAUs, Probes or optical heads into the required position and orientation.

- Coarse XYZ
- Angular preset
- 6-DOF positioning
- Tool approach

3. Measure & Reference

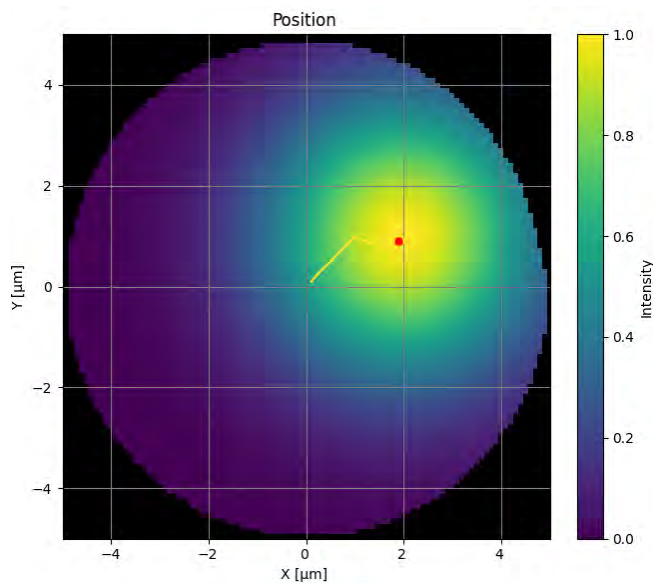


Metrology & Feedback

Capture local distance, height and surface information required for stable approach and reliable alignment

- Distance sensing
- Wafer topography
- Height reference
- Drift feedback

4. Optimize the Coupling

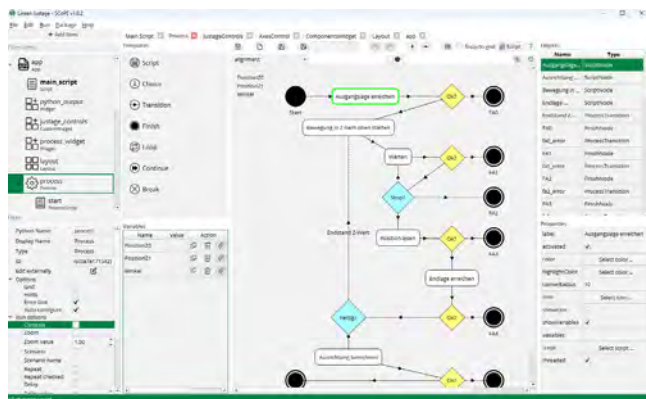


Fast Optical Alignment

Find first light and maximize optical coupling with high-speed motion and search strategies.

- First light
- Single/multi-channel
- Fine alignment
- Optimization algorithms

5. Measure the DUT



Measurement & Instrument Integration

Execute the optical, electro-optical or RF measurement and acquire the relevant test data.

- Optical / EO / RF
- Instrument plug-ins
- Data capture
- Customer interface

Modular Building Blocks for Photonics Testing

Not every application requires every layer. You can configure only the building blocks your device, interface and process require.

1. Move the DUT – Wafer & Die Handling

Move the DUT efficiently from site to site while providing the access, stability and precision required by the test process. SmarAct solutions range from standard XY stages to customized wafer platforms with advanced positioning and metrology.

Standard Wafer & Sample Positioning

Compact XY stage for wafer and sample positioning.



SOM-MS-180150M (2 DOF)

Travel Range (X, Y): 121 mm, 101 mm

Velocity: 300 mm/s

Unidirectional Repeatability: ± 200 nm

Large working area for 300 mm wafers and test platforms.



MLL-400 (2 DOF)

Travel Range (X, Y): 300 mm, 300 mm

Velocity: 200 mm/s

Unidirectional Repeatability: ± 90 nm

Advanced Wafer Positioning (optional)

Optional solution from the broader SmarAct portfolio for demanding wafer-level architectures



EM TriPod 400 (3 to 6 DOF)

300 mm wafer capability

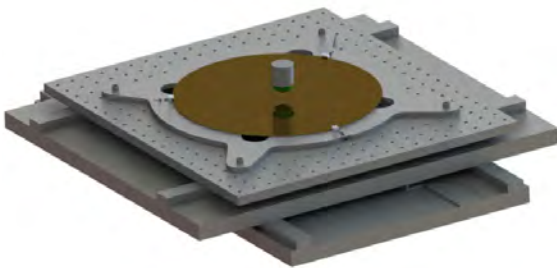
Active leveling/tilt compensation

Double-sided access

Interferometric position feedback

Scale from standard motion to customized mechanics, advanced positioning and metrology.

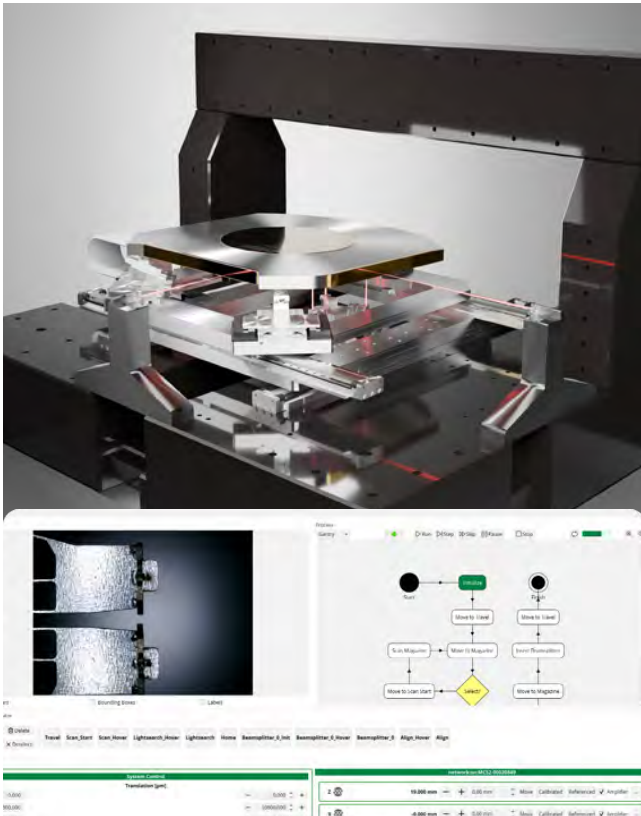
Customized Wafer Stage Concepts



Application specific mechanics and access concepts

- Central aperture/ double-sided access
- Customized footprint
- Wafer chuck integration
- Application-specific travel and mechanics

High End Wafer Metrology



Available for test processes that require advanced wafer metrology.

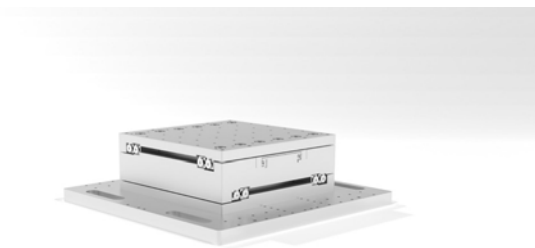
- High-precision positioning and metrology
- Bow & warpage characterization
- Automated process control and visualization

2. Approach the Interface

Bring fibers, FAUs, probes or optical heads into the required position and orientation above the DUT. Different interfaces require different degrees of freedom – from simple lateral positioning to full 6-DoF pre-alignment.

Positioning & Pre-Alignment Modules

Lateral Pre-Positioning



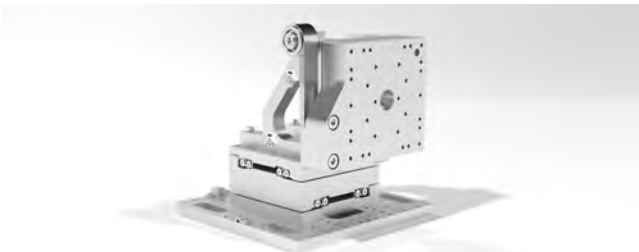
XY CLS-9292 (2 DOF)

Travel Range (X, Y): 63 mm, 63 mm

Smallest Increment: 1 nm

Unidirectional Repeatability: ± 40 nm

Positioning and Vertical Approach



XYZ CLS-5252 (3 DOF)

Travel Range (X, Y, Z): 31 mm, 31 mm, 31 mm

Smallest Increment: 1 nm

Unidirectional Repeatability: ± 40 nm

Positioning and Vertical Approach



SMARPOD CLS-32.5 (6 DOF)

Translation (X, Y, Z): 20 mm, 20 mm, 10 mm

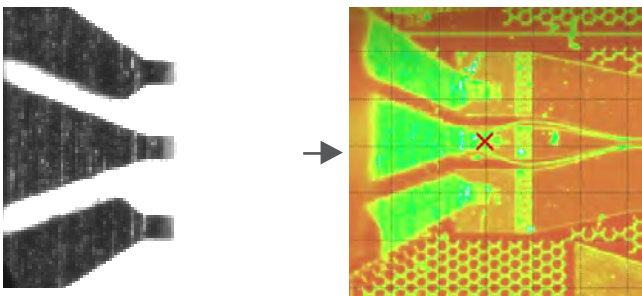
Rotation (θ_x , θ_y , θ_z): 3°, 6°, 8°

Smallest Increment: 1 nm / 1 μ°

Unidirectional Repeatability: ± 50 nm

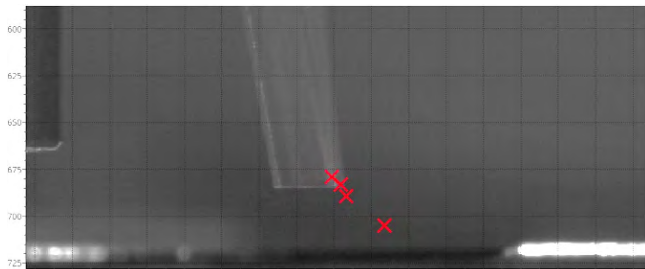
Degrees of freedom depend heavily on the chosen PIVOT

Tool Setup & Calibration



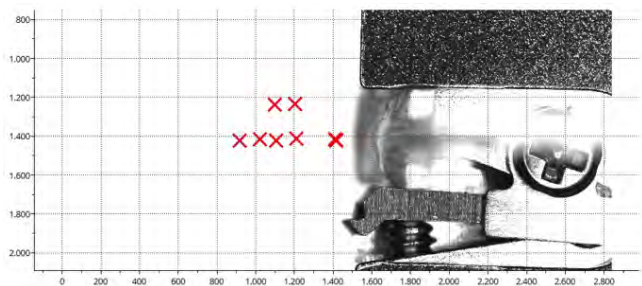
Establish the position and orientation of the optical tool

- Probe head / FAU referencing
- Definition of the working position
- Tool orientation preset
- Reproducible setup conditions



Identify the effective working point for angular motion

- Determine the pivot point of the optical tool
- Support accurate multi-DoF positioning
- Minimize parasitic motion during angle adjustment
- Improve repeatability of pre-alignment



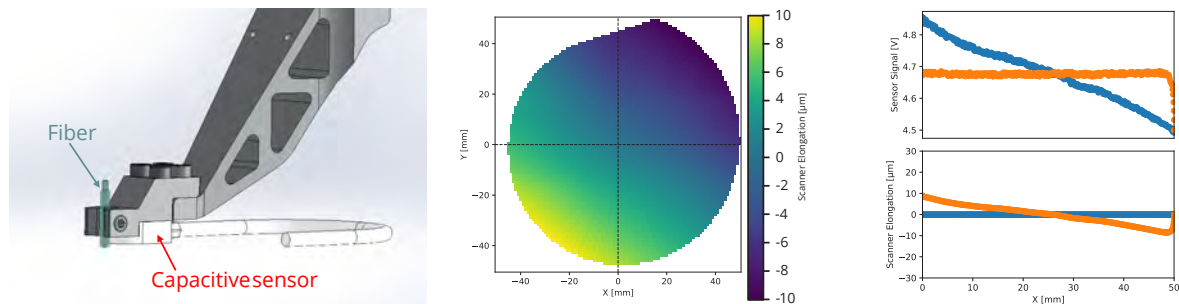
3. Measure & Reference

Metrology & Feedback

Generate the local position, distance and surface reference required for stable, repeatable photonics testing, metrology links the device, the tool position and the process data into one reliable reference frame.

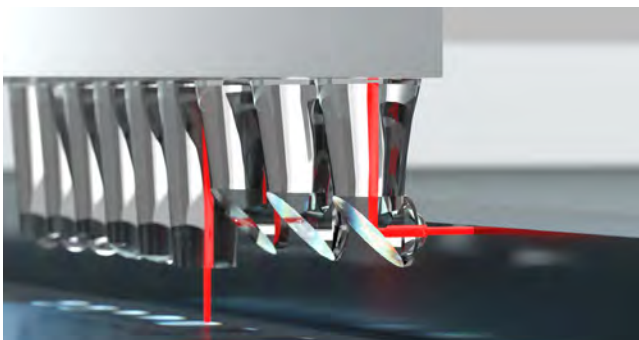
Local Distance & Position Feedback

Capacitive Sensor integration for height control



- Resolution: 10 nm
- Non-contact local height control
- Stable tool-to-sample distance
- dynamic z correction
- Reference signal for approach and positioning

Absolute optical distance measurement



Working range: 10 – 300 μm

Accuracy: < 0.2 μm

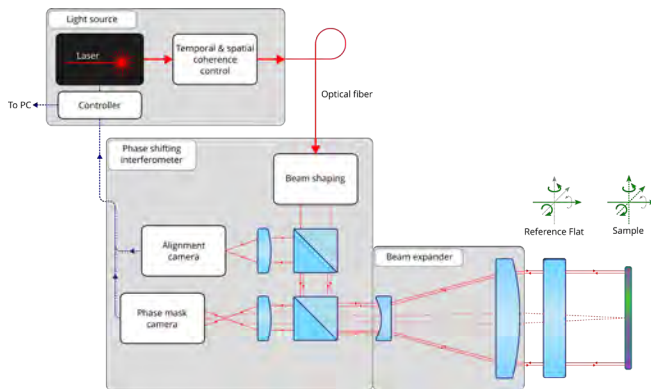
Repetition Rate: > 1 kHz

Multi-channel capability: > 4 channels

Measurement wavelengths: 840 / 1310 / 1550 nm

- Distance signal for fast approach and z-feedback
- Lateral distance measurement with structured optical interfaces
- Additional feedback signal for height-sensitive optical alignment
- Supports trench coupling and other height-critical interfaces
- Single- or multi-channel sensing concepts

Phase Shifting Interferometry

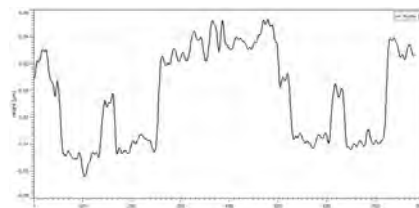
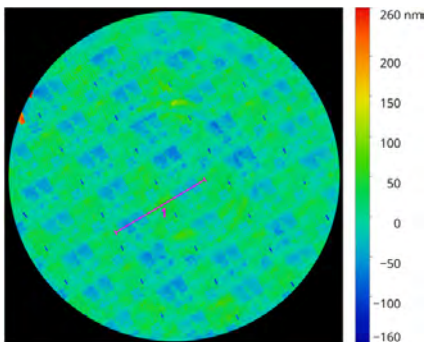


Parameter	Value
Method	Fizeau
Measured sizes	ø 10 ... 300 mm
Repeatability	$\leq 10 \text{ nm}^1$
Sample reflectivity	4% ... 100%
Single measurement duration	$< 1 \text{ ms}$
Continuous measurement rate	5 Hz ... 30 Hz
Measurements	Bow, Warp, TTV ²

¹ Repeatability below 1 nm currently in development

² In development

Example measurements



- Full wafer surface topography in a single measurement
- Bow, warp and TTV characterization
- Polished and patterned wafers
- Height maps for downstream positioning and test processes

Global wafer topography can provide reference data for subsequent positioning, approach and alignment steps.

4. Optimize Coupling

Fast Optical Alignment

Once the interface is positioned and locally referenced, fast optical alignment maximizes optical power and stabilizes coupling. SmarAct combines high-bandwidth scanner modules with embedded search and optimization routines for single-and multi-channel photonics testing.

Hardware-Scanner Modules

Piezo Scanners

High bandwidth XYZ fine alignment for fast and repeatable optical power optimization.



XYZ-Scanner PLF-3232

Scan Range: 60 μm (PLF3232), 200 μm (PLF5252)

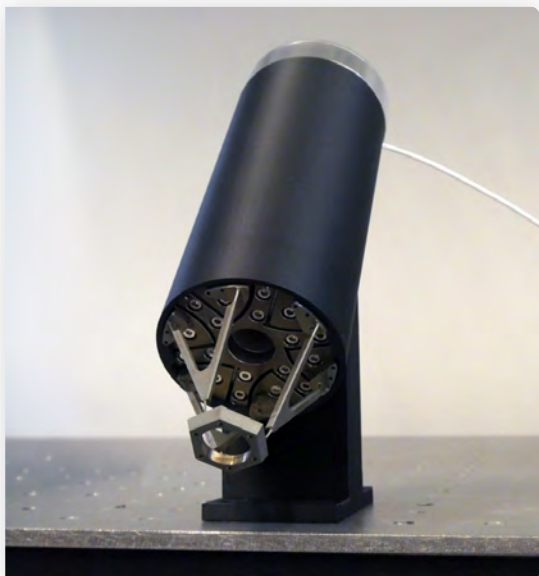
Open-Loop Resolution: < 1 nm

Sensor Resolution: 1 nm

Resonance frequency: 950 Hz

FIBA – Configurable Fast Alignment Platform

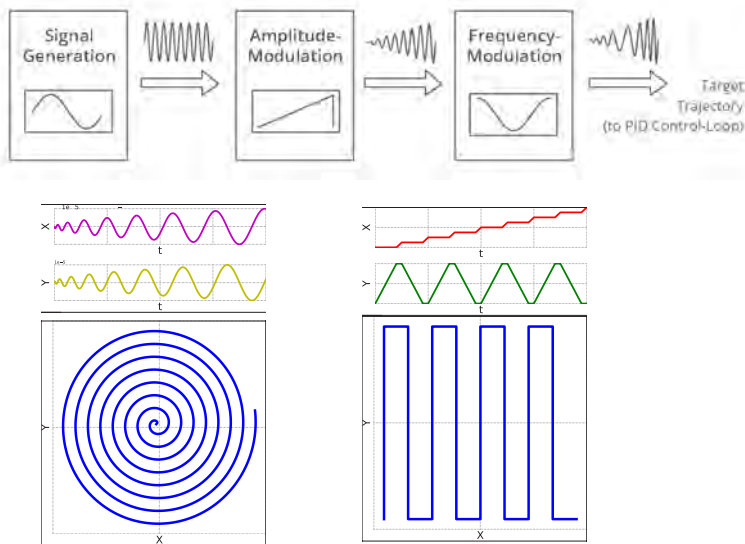
Designed for demanding optical alignment tasks where throughput, reliability and integration space matter.



- Configurable from 3 to 6 degrees of freedom
X: $\pm 150 \mu\text{m}$, YZ: $\pm 300 \mu\text{m}$
RX: $\pm 2^\circ$, RY: $\pm 2^\circ$, RZ: $\pm 0.75^\circ$ (pivot point 22.5 mm above O)
- Fast alignment cycles
Eigenfrequency 500 Hz with 12 g payload
Target is 200 Hz with fiber holder
- Parallel kinematics for compact, high-speed motion
- Standardized configurations for different optical interfaces and travel requirements
- Robust 24/7 industrial operation
- Compact footprint for parallelization and high-throughput testing

Waveform-based scan strategies & first light search

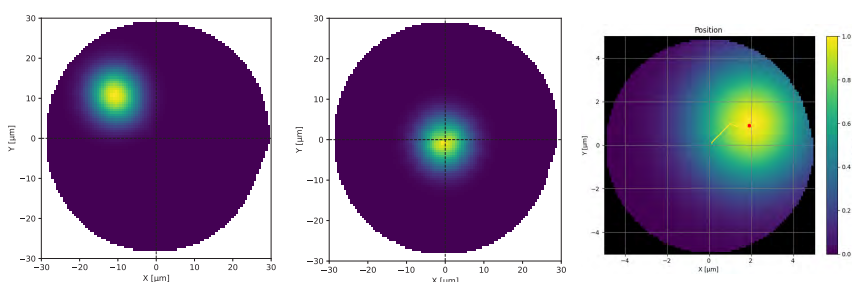
Configurable waveforms support first-light acquisition and efficient scanning across a wide range of applications.



- Configurable waveforms support first-light acquisition and efficient scanning
- Wide frequency range from 0.1 Hz to 1 kHz
- Various scan patterns (spiral, line, step, custom)
- Waveforms can be tailored to the application

High-Speed Signal Processing & Gradient Search

Real-time signal processing and gradient search enable fast, robust optimization of the optical coupling.



First light

Optimized coupling

Gradient search

- Capture position-dependent signals in real time
- Fast data handling for closed-loop optimization
- Gradient search reduces alignment time and compensates drift
- Fast scan & align in under 1 s with data-buffer rates up to 50 kHz

From first light to maximum coupling: hardware and algorithms work together to deliver fast, stable and repeatable optical alignment.

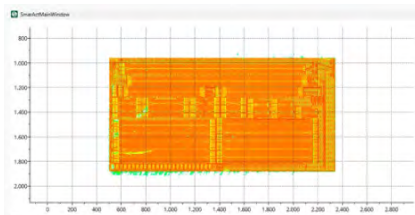
5. Measure the DUT

Measurement & Instrument Integration

Implement the measurement chain around the DUT with open interfaces. SmarAct combines motion, alignment, vision and third-party test equipment in one orchestrated workflow.

Open Instrument Integration

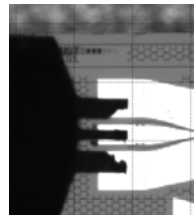
Vision & DUT Detection



Wafer/Chip overview
and detection



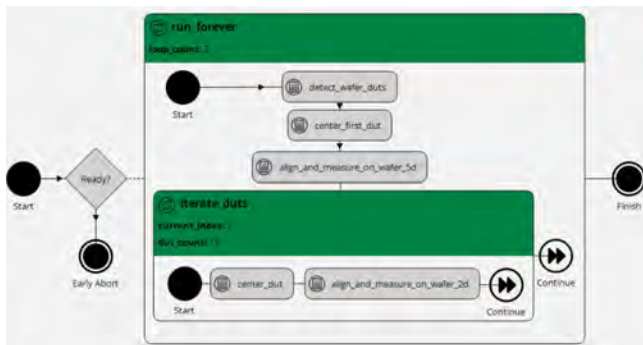
Die
identification



Landing &
autofocus

- Camera based DUT detection
- Die localization & orientation
- Support for landing and autofocus

Workflow implementation in the SmarAct Development Software

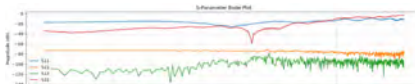


- Device plug-ins
- Measurement routines
- Trigger & synchronization
- Customer interfaces

Workflow implementation in SmarAct Development Software



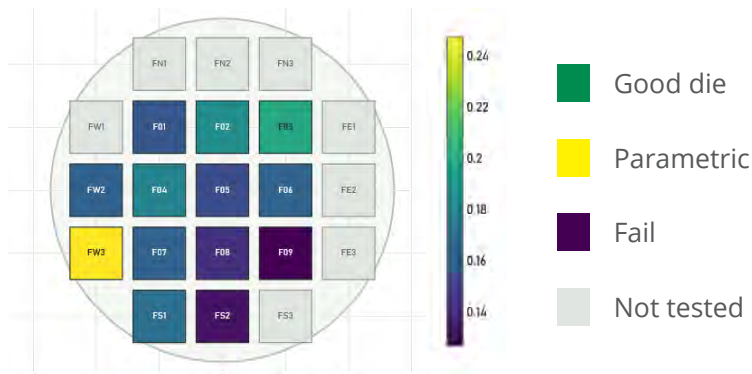
MS46524B VNA



- Device plug-ins
- Measurement routines
- Trigger & synchronization
- Customer interfaces

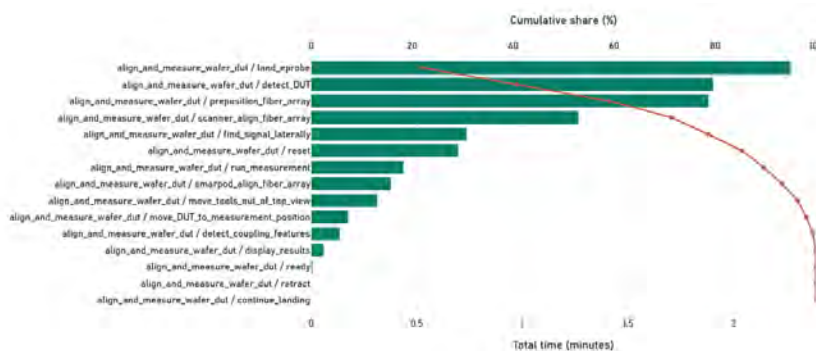
The platform is intentionally open so external instruments can be integrated via plug-ins. Measurement plug-ins can also be implemented directly in when required.

KDG Maps (example)



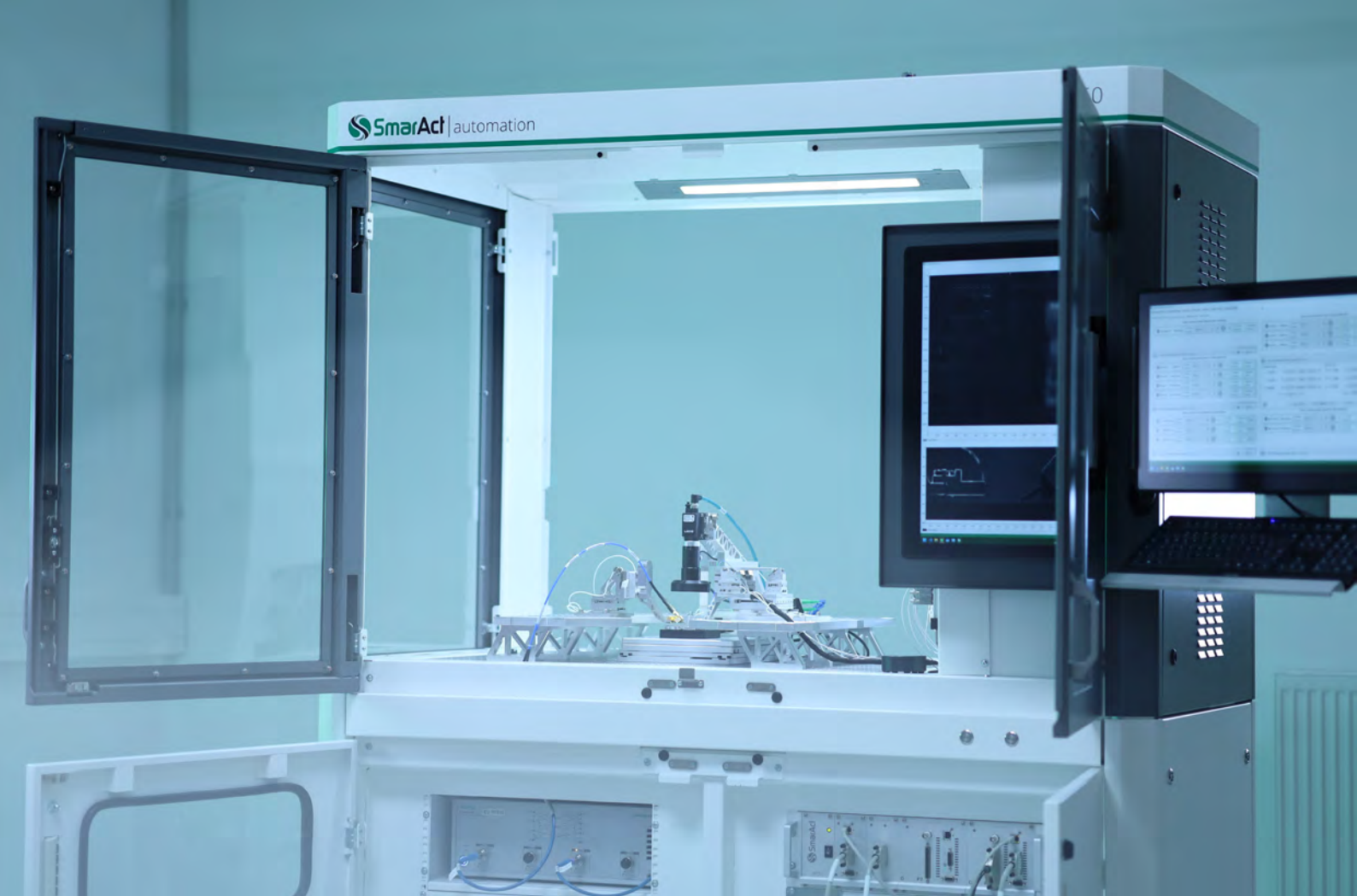
- Known good die measurements
- Measurement metadata
- Process workflows
- Per-die traceability

Process Optimization & Analytics



- Alignment Time optimization
- Calibration optimization
- Process control
- Workflow optimization
- Analysis of process steps

Turn measurement data into actionable process knowledge.



BUILD YOUR PHOTONICS TEST ARCHITECTURE

The SmarAct Align stack combines wafer handling, tool approach, fast optical alignment and measurement into one open platform architecture. Customers can use individual layers, integrate selected subsystems or implement a complete automated test workflow.

Choose Your Building Blocks

- 1 Move the DUT – Wafer & Die Handling
- 2 Approach the Interface – Positioning & Pre-Alignment
- 3 Measure & Reference – Metrology & Feedback
- 4 Optimize Coupling – Fast Optical Alignment
- 5 Measure the DUT – Instrumentation & Data Acquisition

You can freely choose the layers **your application** requires. Including optional software orchestration.

Open by Design

- Integrate SmarAct, customer and third-party technologies
- No lock-in on optical interface, DUT or instrumentation
- Our development software can orchestrate the workflow – but remains optional

From Modules to System Architecture

- Building Blocks – individual motion, metrology or alignment modules
- Functional Subsystems – application-specific combinations
- Application Architectures –complete, coordinated test workflows

Customize around Your Process

- Your device
- Your optical interface
- Your instrumentation
- Your software environment



With the development and production of market-leading solutions in the field of high-precision positioning, automation and metrology, the SmarAct Group reliably accompanies their customers in achieving their goals. The broad product portfolio – from single positioning stages to complex parallel kinematics, miniaturized robots, control systems and measurement technology – is complemented by automated microassembly solutions. Even the most challenging customer requirements can be met by maximum adaptability and complete in-house production.

Since its founding in 2005, SmarAct has steadily grown from a small team of engineers to a group of companies with three independent business units and over 300 highly skilled members. Today, SmarAct relies on years of experience and, above all, on a very passionate team with unconditional customer focus.

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