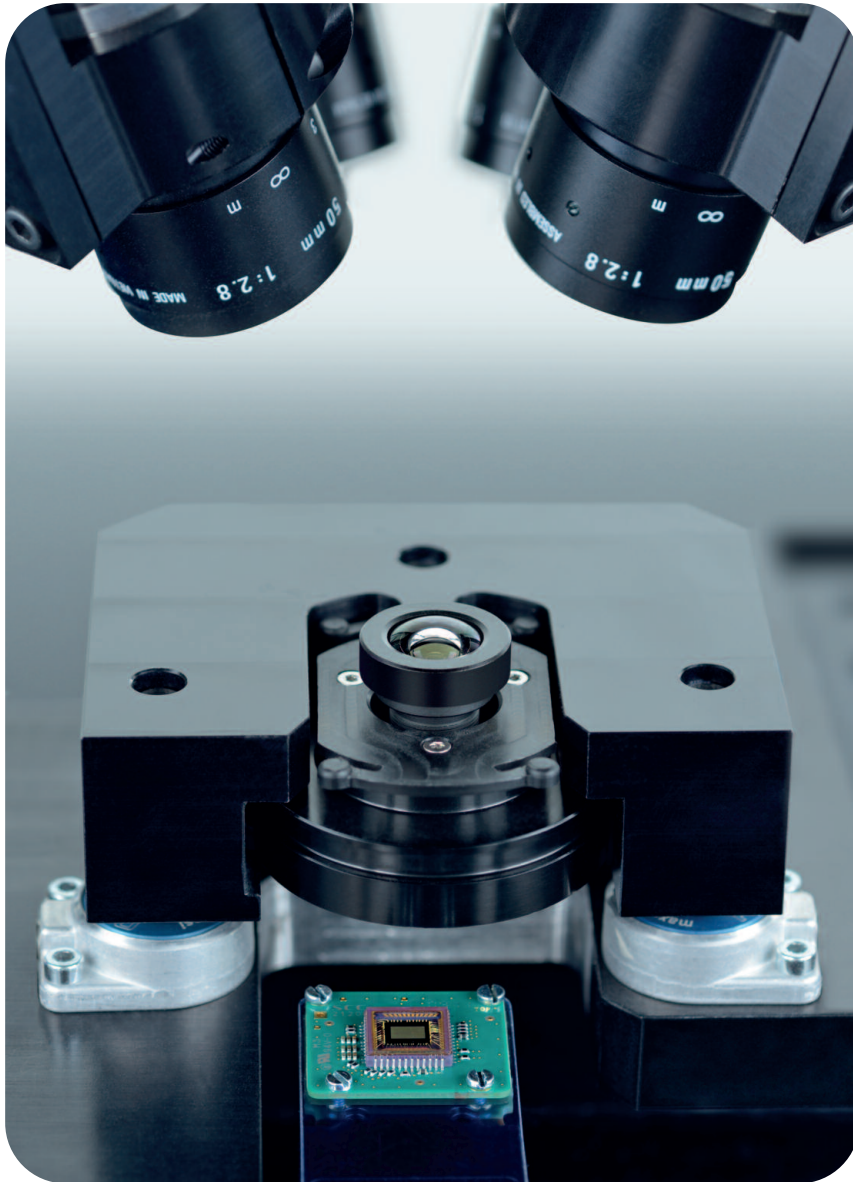


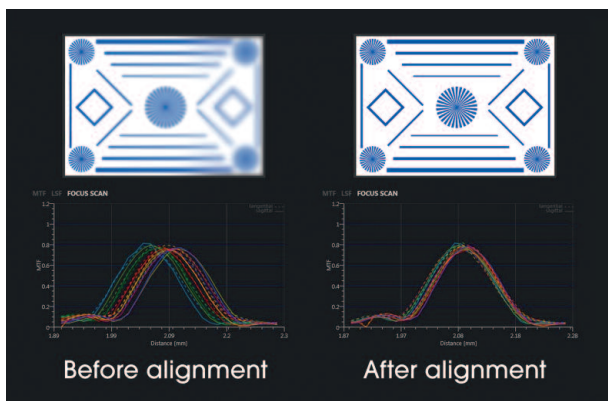
ProCam[®] Align

**Active Alignment, Assembly
and Testing of Camera Modules**



TRIOPTICS' ProCam® Align is a series of high precision alignment, assembly and testing solutions for camera module production from R&D to mass production.

ProCam® systems utilize active alignment, with up to 6 degrees of freedom, to align the optics and the sensor. Active alignment optimizes the image quality which increases yields and makes this production methodology cost-efficient for high-end camera applications.



Through Focus Scan before and after Active Alignment

The ProCam® Align technology includes alignment systems with test charts for applications with finite object distance, as well as innovative solutions with collimators for infinite and variable object distances.

Software controlled, focusing collimators allow both - infinite and finite object distances in the same measurement setup. Extremely wide field of view configurations, up to 170° FOV, are possible with this technology.

For highest precision MTF (Modulation Transfer Function) testing, cross targets are used. The MTF is derived from the LSF (Line Spread Function).

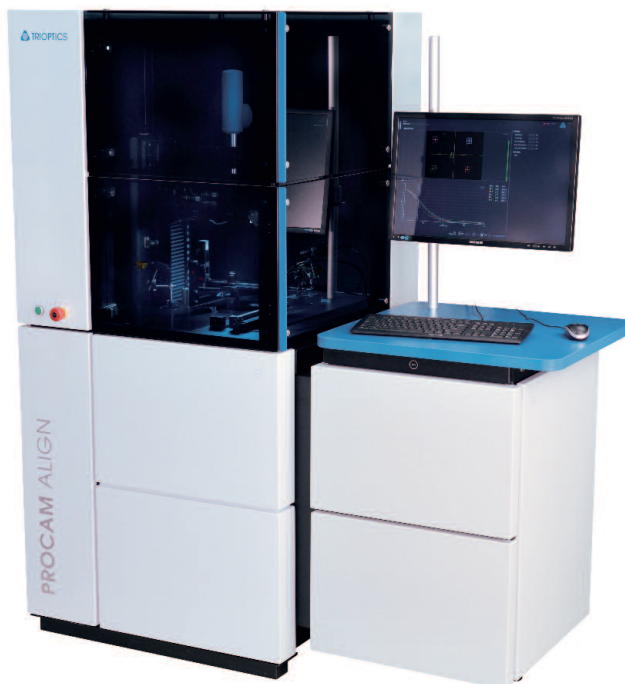
ProCam® Align Solutions

ProCam® Align – Smart Series

Compact with Small Footprint

With ProCam® Align Smart, TRIOPTICS offers a compact, stand-alone solution for camera module assembly from R&D to mid volume production applications.

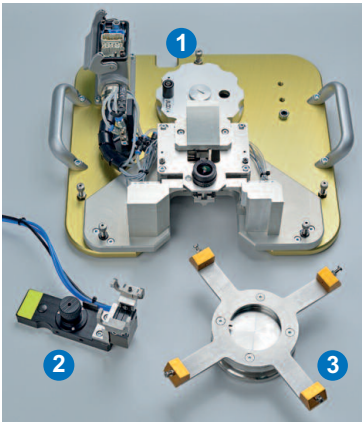
The manufacturing process starts with automated glue dispensing, followed by the alignment of the optics to the sensor or vice versa. Alignment includes precise adjustments for translation, tilt, focus and rotation to allow for optimal image quality. The process finishes with the automated curing process.



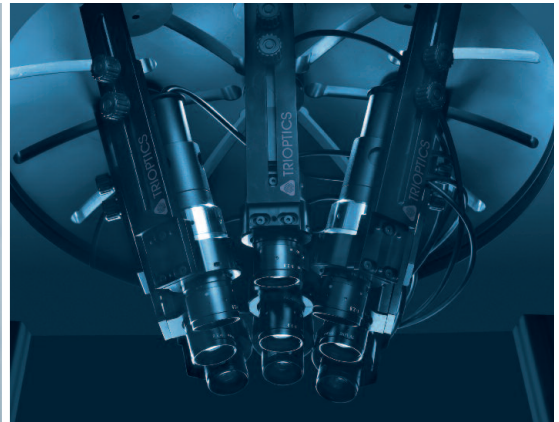
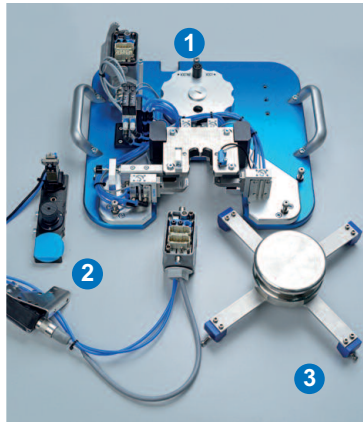
ProCam® Align Smart-Series

High Flexibility

By using exchangeable assembly jigs, the ProCam® Align Smart features the possibility of manufacturing multiple camera module types within one instrument. These customized jigs allow very short changeover times between the assemblies of different types of camera modules.



Exchangeable Assembly Jigs – Color-encoded for different Camera Modules.



Collimator Dome for Infinity Conjugated Samples

- 1 Exchangeable lens plate
- 2 Exchangeable align gripper
- 3 Exchangeable gauge for collimator set up

Main Features

- Active alignment with sub-micron/sub-arcmin precision in up to 6 degrees of freedom based on real-time MTF characterization derived from LSF
- Perfect match between optical metrology and alignment mechanics assures highest precision in the market
- Innovative target projection for infinite-finite and finite-finite conjugated samples
- Optimized for R&D to mid volume production
- High flexibility: assembly of multiple camera module types
- Short changeover time
- Automated process: handling, gluing, aligning and curing
- Integrated software for process control
- Final MTF quality control
- Cleanroom compatible
- Proprietary Procedure for the x/y-alignment of stereo cameras

ProCam® Align – Inline Series

Modular Production Line

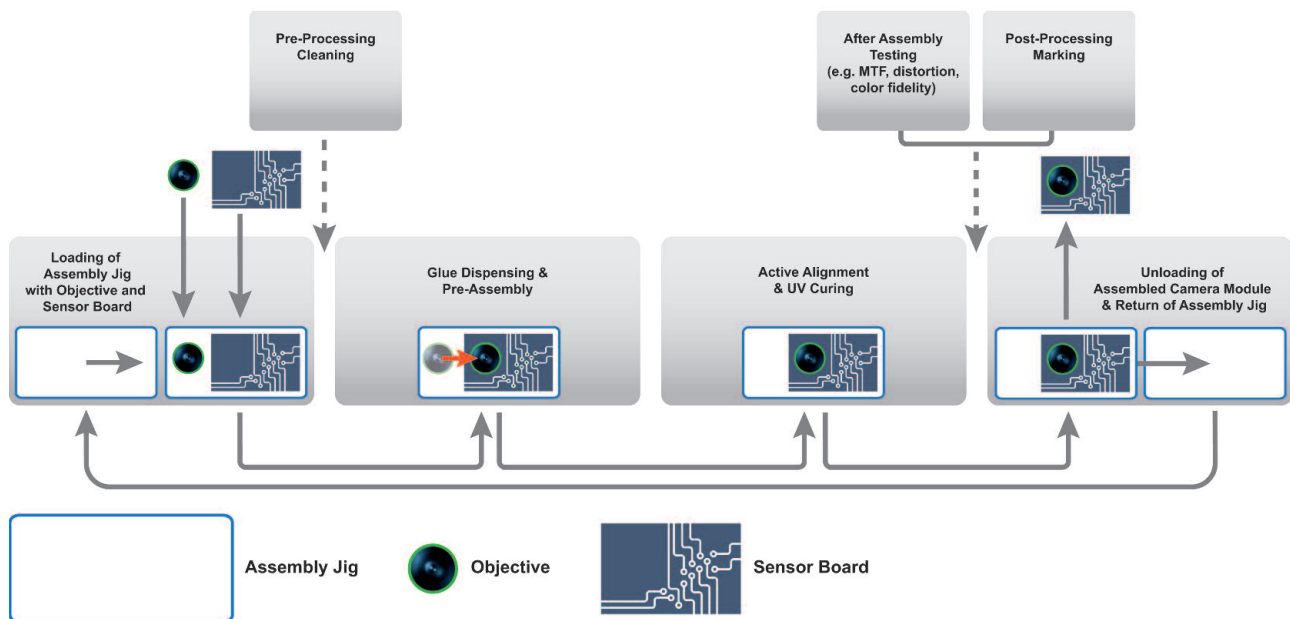
With ProCam® Align Inline TRIOPTICS offers a modular production line for assembly of quality camera modules in mass production.

The fully automated assembly line covers the complete process of camera module production involving loading, handling, pre-testing, cleaning, gluing, aligning, curing, testing, marking and sorting. The solution consists of exchangeable modules which can be selected and exchanged individually on customers' requirements.



Automated Glue Dispensing Module

Due to parallel processing, this production line leads to increased outputs. Various types of camera modules can be produced within one production line by using different, exchangeable assembly jigs.



Exemplary Setup of an Modular Production Line for Camera Module Assembly

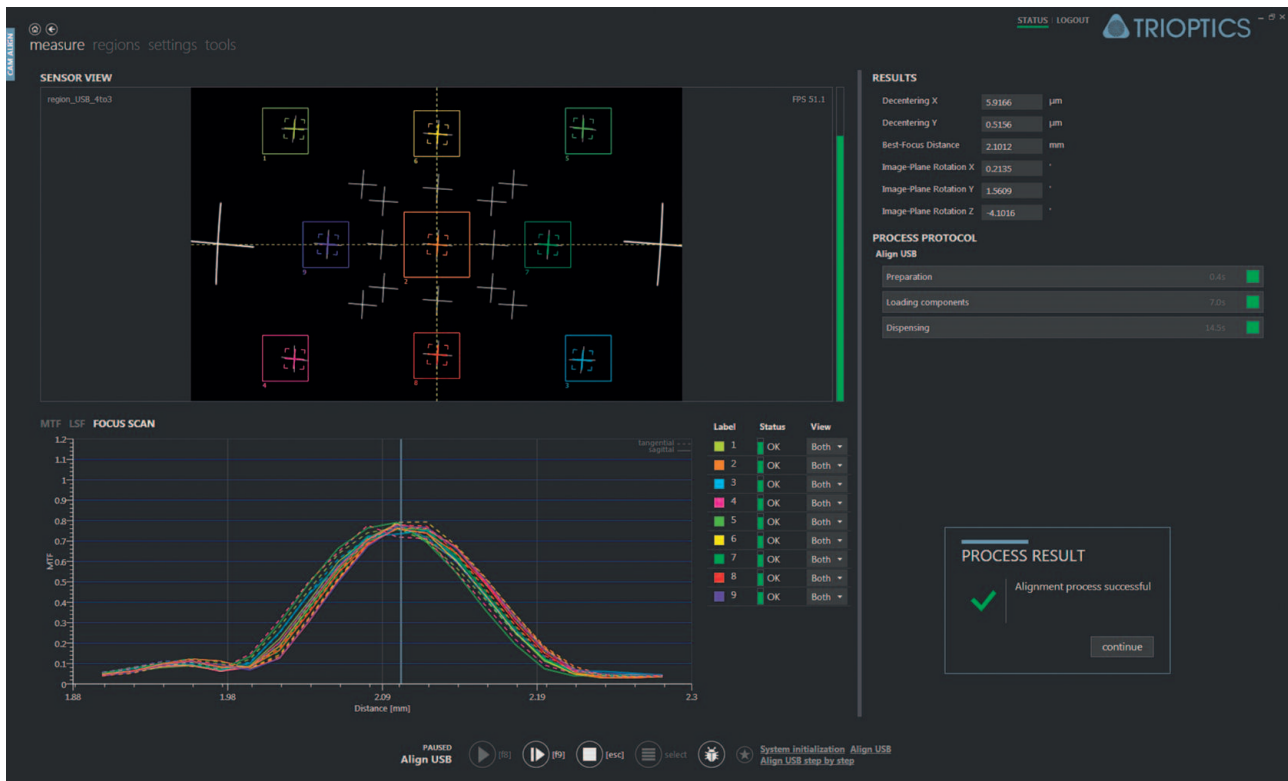
Main Features

- Active alignment with sub-micron/sub-arcmin precision in up to 6 degrees of freedom based on real-time MTF characterization
- Perfect match between optical metrology and alignment mechanics assures highest precision in the market
- Innovative target projection for infinite-finite and finite-finite conjugated samples
- Parallel processing: assembly line optimized for high volume camera module production
- Modular concept for maximal flexibility
- High degree of automation
- For end-of-line testing: ProCam® Test modules
- Integrated software for process control
- Final MTF Quality Control

ProCam® Align Software

The ProCam® Align software "CamAlign" consists of components for the fully-automated active alignment and assembly process:

- Using high precision image analysis algorithms, all relevant parameters of the alignment process such as the MTF at multiple field positions and the tilt of the image plane are analyzed in real-time and used in the alignment process.
- All modules are software controlled for the highest automation integration.
- With the integrated scripting tool, the measurement and alignment process can easily be tailored to specific customer needs and devices.
- The measurement data of the used components as well as of the finished camera module can be stored or written in a data base or production management systems for full traceability.
- Loadable configuration files for different types of camera modules.
- User rights on an individual user level



ProCam® Align Software

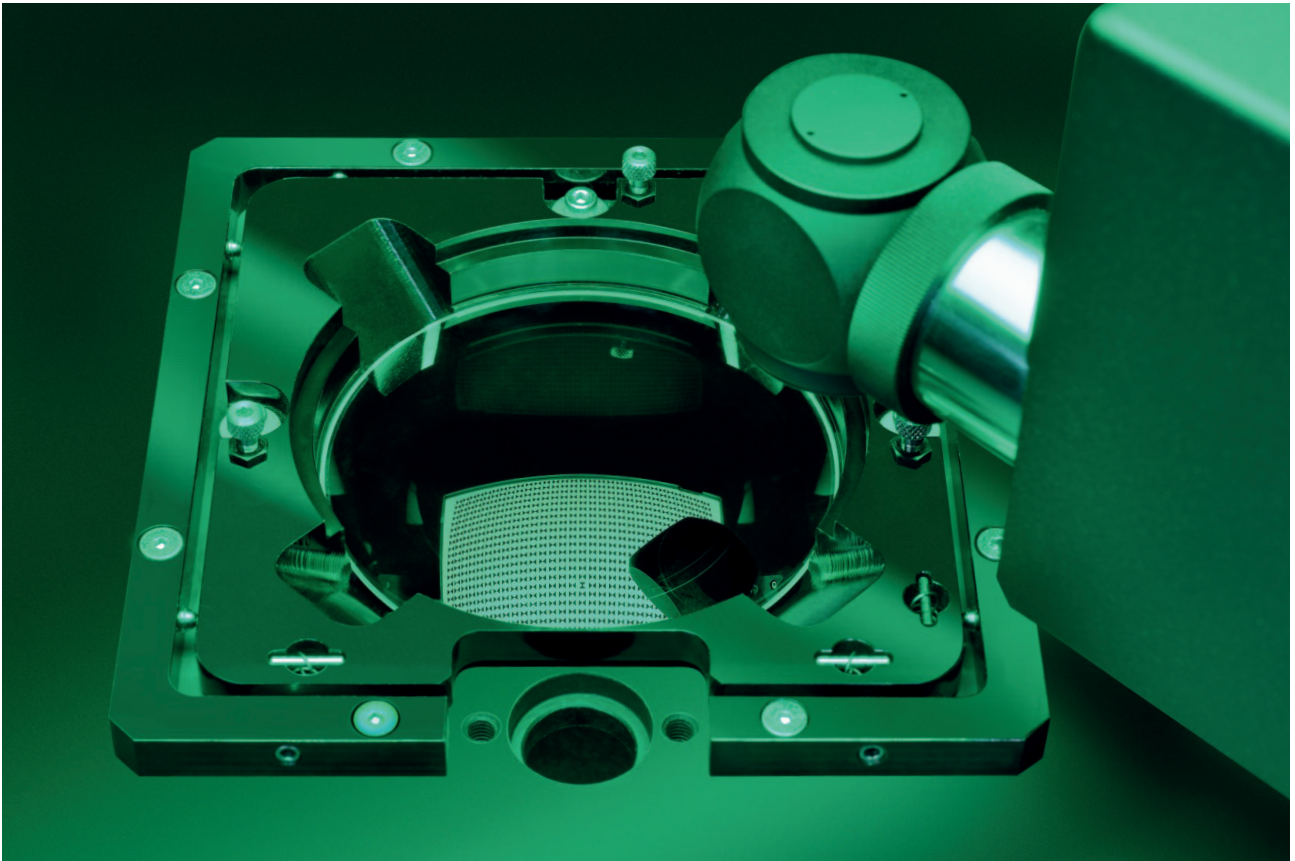
Overview of the ProCam® Align Solutions

	ProCam® Align – Smart Series	ProCam® Align – Inline Series
Systematization		
Description	Compact, stand-alone device	Modular production line
Application	Assembly	Assembly
Processing	Serial	Parallel
Output	R&D to mid volume	High volume
Target Projection	Test chart/collimator	Test chart/collimator
Production Process		
Automated Sample Loading	—	●
Pre-Processing Cleaning	—	●
Automated Glue Dispensing	●	✗
Active Alignment (up to 6 axes)	✗	✗
Automated UV-Curing	✗	✗
After Assembly Testing	●	●
Post-Processing Steps	—	●
Upgradeable for Different Samples	●	●

✗ Core Modules ● Optional Modules — Not Available

**Testing of Camera Modules
ProCam® Test**

For end-of-line testing of the assembled camera modules, the production line can be extended with ProCam® Test modules for detailed optical tests in one inline process. This includes the unique measurement of through focus MTF even after curing.



View inside a ProCam® Test Module for Measuring the Optical Distortion of a Camera

ProCam® Align Specifications

	ProCam® Align – Smart Series	ProCam® Align – Inline Series
Alignment Degrees of Freedom (DoF)	up to 6	up to 6
6 DoF Linear Alignment Resolution	< 0.1 μm	< 0.1 μm
Final Sample Linear Alignment Accuracy	< 2 μm	< 2 μm
6 DoF Tilt Alignment Resolution	< 0.1 arcsec	< 0.1 arcsec
Final Sample Tilt Alignment Accuracy	< 2 arcmin	< 2 arcmin
Sample Effective Focal Length	1 to 12 mm	1 to 12 mm
Sample Diameter	2 to 30 mm	2 to 30 mm
Field of View: Test Chart Field of View: Collimators	up to 70 ° up to 170 °	up to 70 ° up to 170 °
Max. UPH (Units Per Hour)	120*	more than 240*
Footprint (Width, Depth, Height)	1640 mm, 880 mm, 1840 mm	depending on customers' requirement straight line, closed loop, U-shaped, L-shaped
Camera Interface	MIPI, SPI, various analog, USB, FireWire, CamLink, GigE, custom (CAN, etc.)	MIPI, SPI, various analog, USB, FireWire, CamLink, GigE, custom (CAN, etc.)

* Depending on camera module frame rate, length of curing process and number of different parameters to be measured



TRIOPTICS GmbH · Optische Instrumente
Hafenstrasse 35-39 · 22880 Wedel / Germany
Phone: +49-4103-18006-0
Fax: +49-4103-18006-20
E-mail: info@trioptics.com · <http://www.trioptics.com>

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