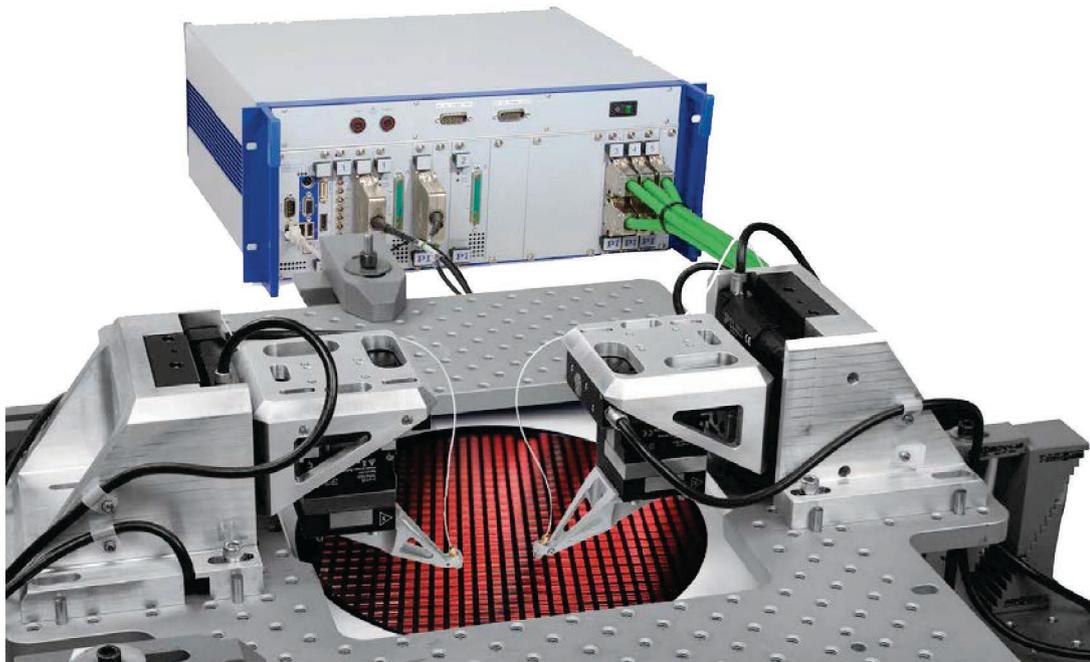


Fast, Industrial, All-Digital Optical Alignment Subsystems

UNIQUE CAPABILITIES ADDRESS TECHNICAL & ECONOMIC REQUIREMENTS
FOR TEST AND PACKAGING OF SILICON PHOTONICS AND FIBER OPTIC DEVICES



The Unique FMPA Platform

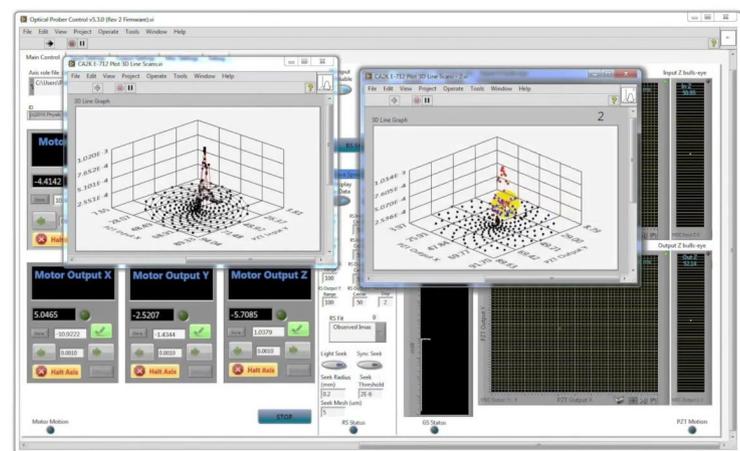
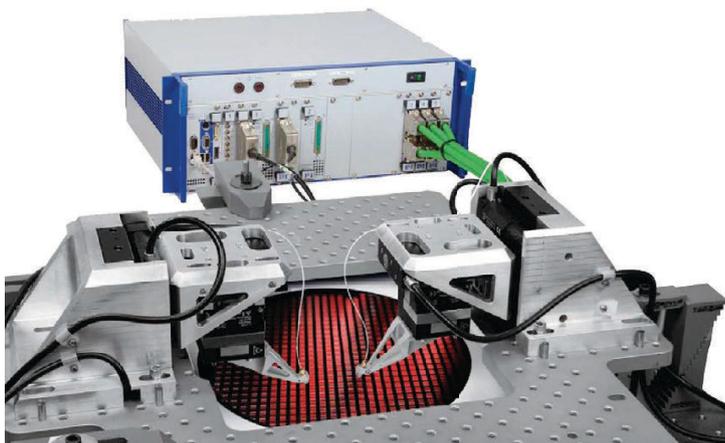
The rapid advent of Silicon Photonics offers promise for bandwidth, parallelism, efficiency and extensibility, and it presents many challenges for test and packaging processes.

Key among these is the need to align fiber optic devices to optimize optical throughput before testing or packaging can begin. Simple economics necessitates fast throughput in this unpredictable nanoscale-accurate step. SiP devices often need alignments in multiple degrees of freedom across more than one input or output coupling, and these can interact, presenting moving targets.

PI's new, groundbreaking Fast Multichannel Photonics Alignment (FMPA) subsystems address these unmet needs. For process development through final packaging, their fab-focused architecture provides the capability, reliability, throughput and device safety necessary for profitable manufacturing.

An example real-time system-control GUI was built on PI's software libraries, running a fast area scan on both sides over 100x100 micron capturing range (bottom image). This takes typically between 0.25 and 0.7 seconds.

To address needs from lab to fab, PI's FMPA offers a modular approach suitable for end-user developmental implementation; meanwhile our strategic partners offer tool-level integrated solutions to address entire manufacturing steps, for example for electro-optic wafer probing or for device assembly.



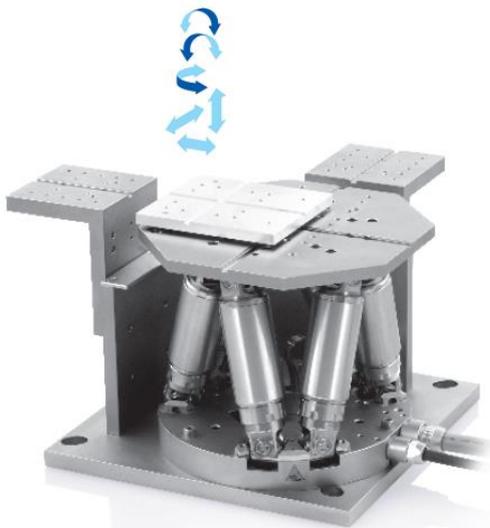
TOP: The double-sided FMPA system with two XYZ hybrid positioners consisting of servomotor stages and a piezo scanner.

BOTTOM: Real-time system-control GUI example, built from PI software libraries.

The Unique FMPA Platform

The system is composed of:

- One or more high-speed, closed-loop piezoelectric nanopositioners of 100 μm travel in X, Y and Z. Each is mounted on:
- A long-travel, closed-loop positioner composed of either an XYZ servo-motor stage stack or a 6-degree-of-freedom compact hexapod. (The latter provides automatic angular optimization for array devices and others with angular sensitivities.)
- Controls integrating advanced parallel optimization technology for the various degrees of freedom and ultra-high-speed areal scanning algorithms.



The Hexapod 6-D aligner offers extreme flexibility along with very high dynamics, stiffness and stability due to its parallel kinematics design with extremely low moving masses. Another advantage of the hexapod design is the randomized pivot point, programmable with one single command.

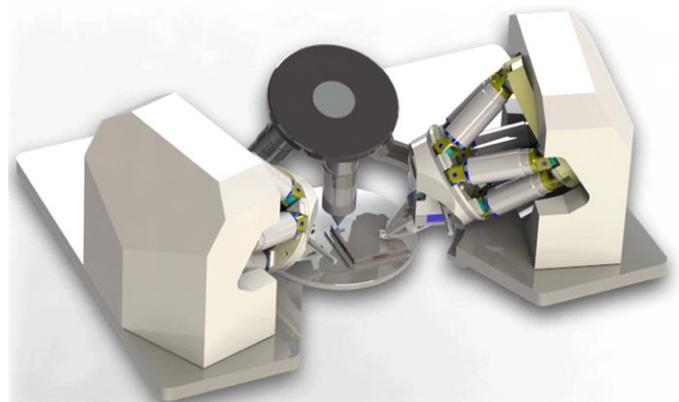
The controllers offer high-speed interfaces and are supported by a wealth of software frameworks including dynamic libraries for Windows, Linux and OS X, and broad support of popular programming environments including LabVIEW, MATLAB, C# and Python. For compatibility with legacy fab controllers, simple ASCII communication can also be used.

PI's all-digital controls, combined with closed-loop motion devices, allow soft limits to be set for all motion axes. This is key to device safety — no small matter when performing fast optical probing processes microns away from patterned wafers worth millions!



The E-712 FMPA high performance controller offers high-speed, integrated, firmware-based scanning and peak finding algorithms, automatic centroid fit strategies for upright and tilted Gaussian and top-hat distributions and simultaneous real time tracking.

An important feature is the fully integrated alignment and scanning capability. These functions are called by high-level mnemonic commands, necessitating minimal host-computer resources and communications. Included are simultaneous tracking and optimization capabilities for transverse and (for waisted couplings) Z alignments. The fast areal scans include unique automatic modeling for accurate centering of straight and tilted Gaussian and top-hat profiles. Built-in data-recorders and waveform generators with an array of general-purpose analog and TTL inputs and outputs facilitate device and process characterization.



Wafer level alignment with double sided 6-axis hexapod aligners and 3D piezo scanners

Applications / Specifications

The modularity of these systems allows virtually any application to be addressed. The table below summarizes the most common configurations.

Optical metrology of sufficient dynamic range and bandwidth is also required. In-device monitor photodiodes and waveguide detectors can often be utilized. Consult with PI on recommendations for external metrology subsystems.

Example Application	Waveguide Device Wafer Probing	Laser or Detector Device Wafer Probing	Array Device Packaging Automation	Array Device Wafer Probing
Angular Optimization Required	Typically no	Typically no	Yes	Yes
Fast Alignment Mechanism	1 ea. XYZ Piezo Scanner (P-611)	2 ea. XYZ Piezo Scanner (P-611)	1 ea. XYZ Piezo Scanner (P-611)	2 ea. XYZ Piezo Scanner (P-611)
Supporting Long-Travel Mechanism	1 ea. XYZ ultraprecision servomotor positioners, 25mm (M-122)	2 ea. XYZ ultraprecision servomotor positioners, 25mm (M-122)	1 ea. Precision 6-Axis Hexapod Aligner (H-811)	2 ea. Precision 6-Axis Hexapod Aligner (H-811)
Controls	1 ea. E-712	1 ea. E-712	1 ea. E-712 1 ea. C-887.52	1 ea. E-712 2 ea. C-887.52
Ordering Information	F-712.MA1	F-712.MA2	F-712.HA1	F-712.HA2

Key Specifications	
Number of Alignment Channels	Virtually unlimited (may require multiple systems)
Coupled/Interacting Channels	Doesn't matter
Multi-Channel Alignments	Parallel, Simultaneous
Single Mode Alignments	Yes
Multi Mode Alignments	Yes
Fast Areal Scans	Sinusoidal Raster, Spiral
Automatic Centroid Fit Strategies	Gaussian, Tilted, Top-Hat
Real Time Tracking	Yes (simultaneous)
Z Alignments	Yes (for waisted couplings)
Motion Control	DC Servomotor & Closed-Loop Piezo Nanopositioning
Positioning Resolution	2nm
First-Light Seek	Up to Full Field (100x100 micron)
Fast Areal Scan	300-400msec
Typ. Areal Scan Time	
Fine Alignment	0.5-2sec
Typ. Gradient Search Lock-On	Virtually independent of number of inputs, outputs & DOFs
Gradient Search Throughput	Simultaneous, Parallel
Transverse Alignments	Simultaneous, Parallel
Waisted Z Alignments	
Wavelengths	320-1060 or 950-1630nm, or custom
Interfacing	TCP/IP Ethernet, USB 2.0, RS-232
Controller Format	4U Rackmount
Software Compatibility	Windows .dll, Linux .so, OS X .dylib ASCII I/O, Compatible with Legacy Automation Controllers All Textual Languages LabVIEW, MATLAB, Python...
Custom Configurations	Welcome

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- Market and business development experts who listen to what customers in specific market segments want and enable the PI Group to develop products that fulfill these requirements.

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