

OPAL-SD: single-die testing

AUTOMATED TEST STATION FOR INTEGRATED PHOTONICS

- Industry's most accurate, repeatable, traceable, fast and flexible testing of photonic integrated circuits (PIC).



KEY FEATURES

- Research-grade solution for PIC testing and characterization
- Flexible design with reconfigurable probes
- Software suite for measurement automation and data processing
- Ultra-precise optical heads—ideal for surface and edge coupling
- Precise DC and RF probing manual positioners

APPLICATIONS

- Integrated photonics die testing for R&D stage
- Optical and electronic characterization of PIC
- Transceiver optical sub-assembly development

OPAL-SD PLATFORM

The OPAL single-die test station for integrated photonics is composed of a 4-axis manual stage and chuck, as the base system, motorized optical head(s) and manual electrical head(s), including a top-vision system. The station also comes with a side camera, a server-grade PC and a license for the PILOT software suite.

It offers fully automated optical probe navigation at the die-level, and manual electrical probing. When combined with the advanced optical measurements capabilities of EXFO's product line of optical instrumentation, this system provides an unmatched solution for optical spectrum analysis as well as electro-optic testing such as BER. Together with the PILOT software suite, the OPAL-SD station becomes a complete, flexible and scalable solution.

The OPAL single-die station is part of a larger family of test stations and can be used as a stepping stone to increase throughput capabilities. EXFO's multi-die and wafer stations share many of the OPAL-SD elements, particularly the probe heads, vision system and more importantly, the PILOT software—allowing flexible migration from single-die testing to wafer characterization. OPAL platforms come with an advanced automation software providing high-performance functionalities to control the motion and vision systems as well as any test instrumentation from EXFO or third-parties. The advanced features of the software on data analysis and AI modeling transform measurements of PIC into properly informed decisions and actions on the user's side.

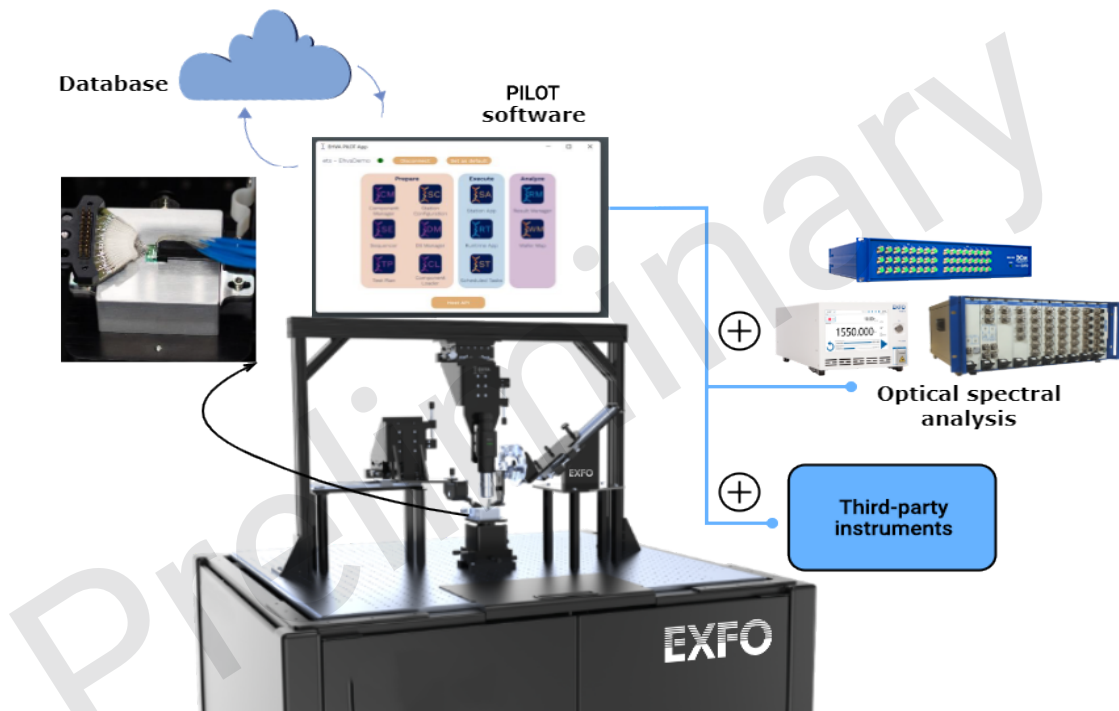


Figure 1. OPAL-SD platform as a characterization solution with PILOT software

PILOT AUTOMATION SOFTWARE

The PILOT software suite gives tremendous capabilities to the single-die station and transforms it into an automated testing station and a source of quality measurements that can be processed into actionable data. The complete suite of applications supports the full test-and-measurements flow and help users to become more data-driven.

The sequencing environment provides the instrument drivers, analysis tools and built-in optimization algorithms. Its low-code approach enables an expertise-free programming experience. Users can build advanced logical sequences, swap hardware and execute the sequences seamlessly. The system, during execution, tracks all experimental and hardware conditions.

The analysis tool allows the user to launch computations synchronously or asynchronously based on defined logical conditions. It also provides standard hooks to analysis and business intelligence software such as Python, Matlab, JMP, Excel and Power BI.



Figure 2. PILOT software suite

GOING FURTHER THAN MERE TESTING

The cloud and software-as-a-service (SaaS) nature of the PILOT software imply a vast list of benefits. For instance, multiple users can contribute and easily interact together for the elaboration and execution of the whole conception cycle because they are interrelated, through the platform, simulations, DUTs information and definitions, experimental results, analysis, and visuals. It also provides an on-demand computation and storage platform for optimized and stable data.

EXFO aims to generate as much intelligence as possible from the data with the least amount of energy for its customers. As such, the system also comes with a wafer/die-level metric analysis and visualization tool, making information and intelligence sharing a reality.

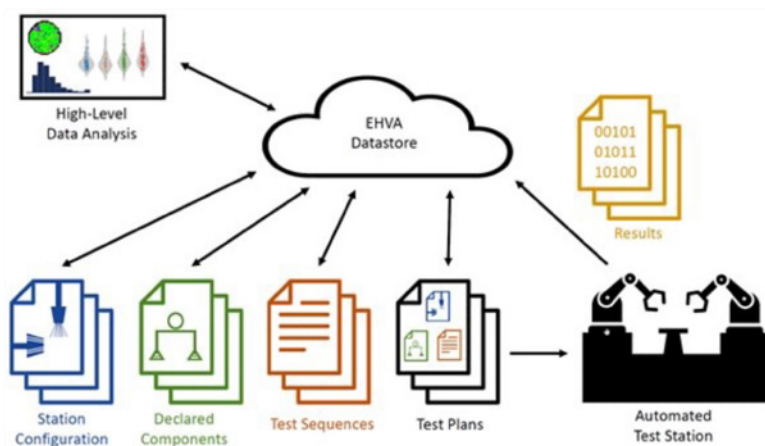
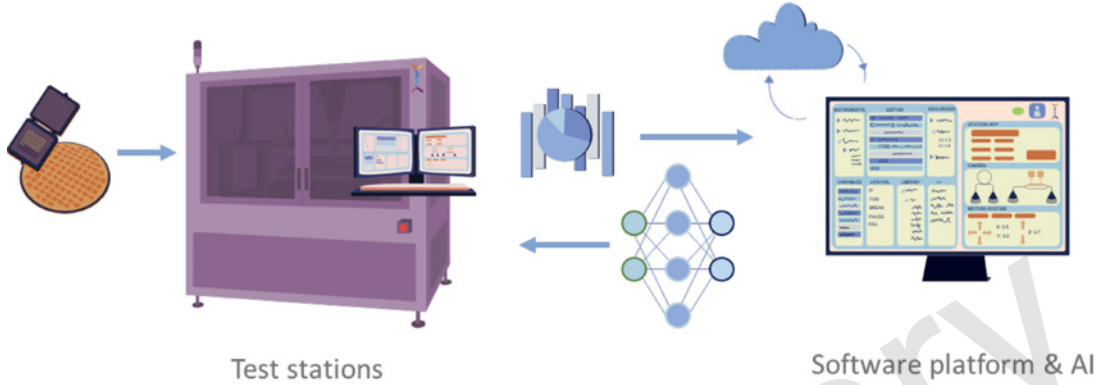


Figure 3. Cloud and software-as-a-service nature of the PILOT software

BENEFITS




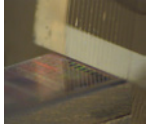

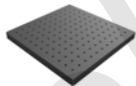


- EXFO aims to provide the user with insight and knowledge, enabling data-driven decision-making. The foundation lies in its powerful automated test stations and software suite, coupled with a structured database. These tools can be leveraged to gather massive amounts of high-quality data from the measurement of photonic integrated circuits.
- The control software is flexible and allows system interoperability. Customers can then create and customize their own control and test and use it as needed, seamlessly.
- Advanced automation software empowers users to define and maintain a logical structure among the circuit components, design parameters, simulation results, experimental results and conditions, computations results and sequences. This provides all support needed for absolute traceability and reliability and naturally creates a dataset that is a report-ready and AI-ready.



Preliminary

OPAL-SD PLATFORM COMPONENTS




The OPAL-SD platform consists of a basic configuration to perform initial PIC testing and characterization. All the components can be purchased as single items at anytime, for upgradability.

COMPONENTS			
BASIC STATION	Chuck		Provides excellent and smooth surface with switchable vacuum. An optional advanced chuck that also offers thermal capabilities and coaxial electrical connection is available.
	Manual 4-axis stage		Enables precise position adjustment of the chuck and die. Coarse alignment and ease of displacement from an electro-optic circuit to another when multiple electrical arms are present.
	Vision		3-axis manual translation stage for top vision system. Includes an entry-level top vision system for operation purposes. A high-quality vision system for stable, repeatable and high-resolution for machine vision purposes is offered as an option. The upgrade includes an in-line fiber illumination scheme and features a large numerical aperture.
			Magnetic toggleable, side-view with ultra-long working distance camera to provide easy and repeatable adjustment of optical/electrical probes.
	PILOT software		Full software suite for automation and control of test station, instruments and data. Allows users to define and maintain a logical structure among circuit components, design parameters, simulation results, experimental results and conditions, computations results and sequences. This provides all support needed for absolute traceability and reliability while naturally creating a dataset that is report-ready and AI-ready.
	Also included		Honeycomb optical breadboard, server-grade PC, controllers and cables.
PROBES ^a	Electrical (PRE)		4-axis manual electrical probe positioners. Fine alignment and long travel range. Probe holders compatible with most DC and RF probes.
	Optical (PRO-XX)		<p>PRO-P60: Motorized 6-axis nanometer-precision piezo-based hexapod for precise and fast operation. Features a virtual pivot point capability, enabling seamless optimization of the injection angle. Can be used for both edge and surface coupling. Ideal for R&D applications.</p> <p>PRO30/PE30: Motorized 3-axis, direct drive aligner with unmatched repeatability, longevity and reliability. Can be used for both edge and surface coupling. Ideal for production.</p> <p>PRO-SE30: Motorized 3-axis, screw-driven aligner with high reliability. Please select other optical head options if high-repeatability edge-coupling is required. Ideal for entry-level R&D or production with surface coupling.</p> <p>Options for all PRO optical heads: A slider and manual screws concept allows to easily toggle the fiber array into engaged/disengaged positions and to manually position the fiber array during preparation steps. Includes a clamp that fits most fibers and fiber arrays.</p>

a. Optical fiber / array and probe RF not included.

BUILD YOUR STATION CONFIGURATION

The OPAL platform being a modular solution, it can fit customer needs through the setup of up to 4 heads simultaneously in any combination. Optical or electrical probes can be positioned around the device under test in any orientation: North, East, South and West. This flexibility enables customers to tailor and scale testing to their needs for optimal results. The table below shows some of the many possible application examples.

MEASUREMENT SETUP	EXAMPLES OF STATION CONFIGURATION
<p>Optical surface coupling only. Best suited for entry-level solution.</p>	 <p>Single-die base stage: Manual 4D translation stage with vacuum chuck</p> <p>Pro-SE30: 3-axis, screw-driven aligner</p> <p>Top/side vision system</p>
<p>Electro-Optical, surface coupling and edge-coupling capable. Best suited for R&D.</p>	 <p>Single-die base stage: Manual 4D translation stage with vacuum chuck</p> <p>4-axis manual electrical probe positioner</p> <p>Optical probe PRO-P60: 6-axis nanometer-precision and piezo-based hexapod</p> <p>Top/side vision system</p>
<p>Electro-Optical, surface coupling and edge-coupling capable. Best suited for industrial production.</p>	 <p>Single-die base stage: Manual 4D translation stage with vacuum chuck</p> <p>Thermal chuck: Vacuum and temperature controlled chuck</p> <p>4-axis manual electrical probe positioner</p> <p>PRO-P30 or PRO-PE30: 3-axis, direct drive aligner</p> <p>Top/side vision system</p>

SPECIFICATIONS

As EXFO continuously improves its products, the delivered station may differ slightly from the one shown in the CADs and images used throughout this document.

SINGLE-DIE BASE STAGE, 4-AXIS MANUAL	
X,Y axis travel (mm)	27
Z axis travel (mm)	9
Rz axis travel (degrees)	20
X, Y axis displacement/revolution (mm)	0.3175
Z axis displacement/revolution (mm)	0.085
Rz axis displacement/revolution (degrees)	1.2
Chuck size (mm)	Typical: 50
Vacuum zones	Typical: 3
Optional: Thermal chuck temperatura range (°C)	Typical: -30 to 160. Contact EXFO for more options.
Optional: Thermal chuck temperature stability (°C)	Typical: 0.05
Optional: Thermal chuck temperature resolution (°C)	0.01

Optical head options :

PRO-P60: 6 MOTORIZED AXIS, PIEZO-HEXAPOD	
X axis travel (mm)	20
Y axis travel (mm)	11
Z axis travel (mm)	20
Rx axis travel (degrees)	23
Ry axis travel (degrees)	38
Rz axis travel (degrees)	26
X, Y, Z axis resolution (nm)	1
Rx, Ry, Rz axis resolution (arcsec)	0.04
X, Y, Z axis unidirectional repeatability (nm)	Typical: 50
Rx, Ry, Rz unidirectional repeatability (arcsec)	Typical: 1.5

PRO-P30/PE30: 3 MOTORIZED AXIS, DIRECT-DRIVE	
X, Y, Z axis travel (mm)	25
X, Y, Z axis resolution (nm)	Typical: 2
X, Y, Z axis bidirectional repeatability (nm)	Typical: 75

PRO-SE30: 3 MOTORIZED AXIS, SCREW-DRIVEN	
X, Y, Z axis travel (mm)	50
X, Y, Z axis resolution (nm)	100
X, Y, Z axis bidirectional repeatability (nm)	Typical: 750
X, Y, Z, axis accuracy (µm)	Typical: 7

ELECTRICAL HEAD, 4-AXIS MANUAL	
X, Y, Z axis travel (mm)	48
X, Y, Z axis displacement/revolution (mm)	0.3
X, Y, Z axis accuracy (μm)	Typical: 2
Tilt travel (degrees)	10
Tilt displacement/revolution (degrees)	Typical: 0.7
Rail system X axis travel (mm)	180
Z axis coarse step travel (mm)	Min: 6.35 Max: 56

TOP VISION SYSTEM	
Bridge system with 3-axis manual positioner	
X, Y, Z axis travel (mm)	48
Z axis coarse step travel (mm)	Min: 6.35 Max: 19
X, Y axis displacement/revolution (mm)	1.41
Z axis displacement/revolution (mm)	0.3175
Magnification (X)	Typical: 10
Numerical Aperture	Typical: 0.28
Depth of focus (μm)	3.5
Field of view (μm)	880
Working distance (mm)	Typical: 34
Resolution (MP)	Typical: 5.1
Frame rate (fps)	Typical: 34
Illumination type	In-line, fiber-based LED illuminator (option)
Type	Color 12-bit
Wavelength	Visible, Visible and IR available (option)

SIDE VISION SYSTEM	
Magnification (X)	Typical: 3
Numerical aperture	Typical: 0.043
Field of view (mm)	Typical: 2.2
Working distance (mm)	Typical: 11
Resolution (MP)	Typical: 5.1
Frame rate (fps)	Typical: 34
Type	Color, 12-bit

MAIN SYSTEM	
Mass (kg)	Typical: 160
Length (mm)	1219
Width (mm)	914
Base	High-quality honeycomb optical breadboard
Work-station computer	Intel i7 CPU, 32Gb RAM, 1Tb SSD, 2 Ethernet ports, Multiple USB ports, Windows 10 Pro, mouse and keyboard included
Monitors	2 x 27-in screens

Preliminary

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