SPEC SHEET

OPAL-EC – Wafer-level edge-coupling testing

AUTOMATED TEST STATION FOR INTEGRATED PHOTONICS

- Accurate, repeatable, flexible, fast testing of photonic integrated circuits (PIC) with traceable results.

KEY FEATURES

Complete PIC testing platform for precise and repeatable optical alignment and electrical probing

Preparation, automated execution (navigation, alignment, instrument control) and data management (repository, analysis) with the included EXFO Pilot software suite

Different probe head options, as needed: optical head models with up to 6 motorized axes for surface- and edge-coupling with single fibers or fiber arrays; Electrical heads with manual or motorized axes

Best-in-class repeatability of optical probe heads and base motion systems

Industry first multiport edge-coupling testing at wafer level

Wafer, stretch-tape, multiple dies or bar testing with the same station

Flexible design with repositionable optical and RF/DC probes

Compatible with wafers of up to 12 in (300 mm)

APPLICATIONS

From R&D, design verification and process development to pilot production and manufacturing

Opto-electronic testing on integrated photonics platforms: silicon photonics, indium phosphide, III-V, polymer, heterogeneous

In-depth analysis of statistical circuit performance and yield

DUT-agnostic: can test singulated dies (single to tens), reticles, custom cuts, bars, 12-inch wafers

Application-agnostic: telecom and datacom transceivers, quantum, LIDAR, sensors, AI for surface- and edge-coupling with single fiber or fiber-array to prototyping and pilot production

OPAL SERIES

The OPAL-EC station is part of the OPAL family of test stations dedicated to PIC testing, offering different performance, capability and throughput levels. These test stations are:

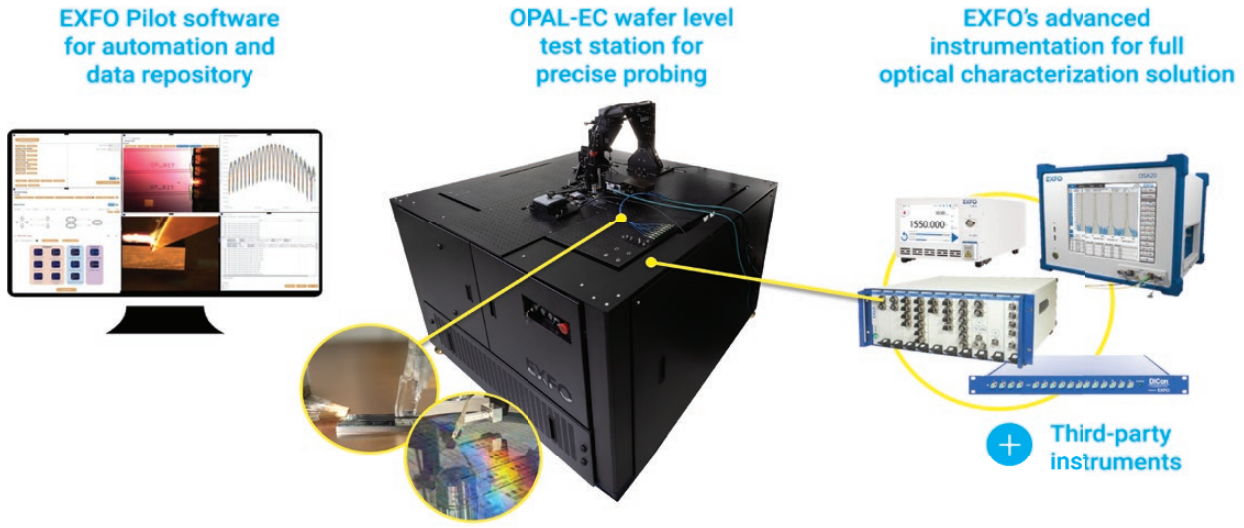
- OPAL-SD: a single-die station
- OPAL-MD: a multi-die station
- OPAL-EC: an edge-coupling wafer-level station

All test stations are driven by the EXFO Pilot software. Therefore, the test process and user training developed on one station is completely transferable to another station of the OPAL family. The optical heads, electrical heads, vision systems and IT kits are also transferable from one station to another, lowering barriers for hardware upgrades.

	OPAL-SD	OPAL-MD	OPAL-EC
DUT	Single die	Single die up to multi dies	Single die up to 12-in wafer
Work area (mm)	50 × 50	100 × 100	Φ300
Coupling mode	Surface and edge coupling		
Alignment	Manual or automated	Full automated	Full automated
Chuck	Ambient or dew-point (> 0 °C) to 120 °C (32 °F to 248 °F) 3 vacuum zones	Ambient or dew-point (> 0 °C) to 120 °C (32 °F to 248 °F) 4 vacuum zones	Ambient or 5 °C to 200 °C (41 °F to 392 °F) 4 vacuum zones
Rotation base stage	Manual rotation: 20°	Motorized rotation: 15°	Motorized rotation: 105°
Probe configuration	Optical and electric probes Up to 4		
EXFO Pilot software	Test plan execution, automation, analysis and a license are included with the station		

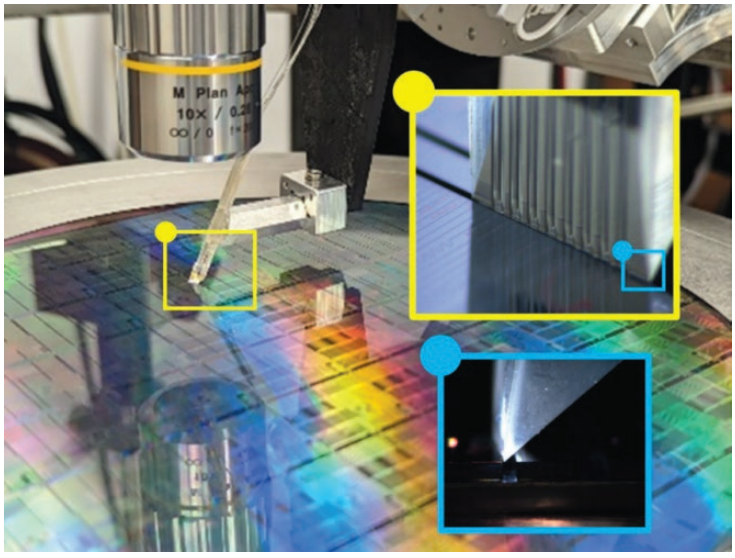
OPAL-EC PLATFORM

The OPAL-EC edge-coupling wafer-level test station delivers industry-leading characterization of integrated photonics with accurate, repeatable, flexible and fast hardware. The EXFO Pilot software suite enhances the OPAL-EC hardware capabilities by transforming the hardware into an automated testing station and a source of quality measurements that can be digested into actionable data. The complete suite of applications is a platform that supports the full test-and-measurements flow and help users to become more data-driven. Combined with EXFO's advanced optical measurements capabilities and open to any third-party instrument, this complete platform is the ideal PIC testing solution.



EXFO's platform for wafer-level PIC testing, with OPAL-EC test station, EXFO Pilot software, and EXFO's leading solutions for optical characterization of PIC. Third-party instruments can be added and controlled by EXFO Pilot.

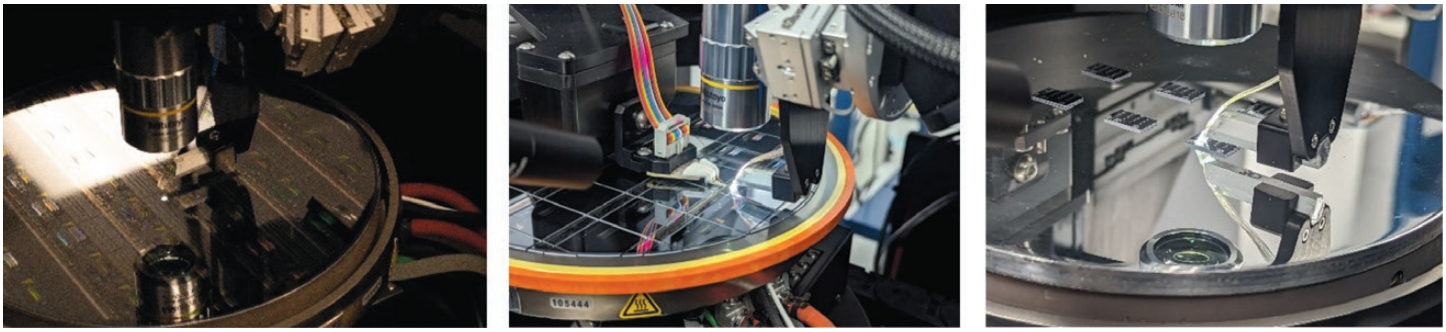
The station's hardware consists of an ultra-repeatable 4-axis motion system wafer positioning stage, allowing 105° rotation with a chuck to hold up to 12-in (300-mm) wafers with thermal control as an option. Adapter plates enable tests for single dies, bars and multiple dies making it one station to fit all form factors. The station can accommodate up to four probing heads with a choice of optical or electrical probes. It also includes high-resolution, in-line brightfield top vision system and telecentric side vision systems. The system includes dedicated license for the EXFO Pilot software, installed on an industrial rackmount computer.



Edge-coupling within trench on wafer using a special fiber array and the OPAL-EC-300 station.

An industry-first capability: the station's state-of-the-art components enable fully automated, highly repeatable, multi-port, optical edge-coupling alignment at the wafer-level through trench coupling. This accuracy level disrupts the typical reliance on surface grating coupler as additional proxies for die screening at the wafer level. This, in turn, allows for testing the complete circuit, including the production ports that will be used for packaging, much earlier in the production chain, which eliminates costly steps and increases global yield and circuit performances.

The same test station can also swiftly be reconfigured in-situ and used for surface-coupling alignment.



Re-testing the same circuits with a single OPAL-EC station over the process chain: from wafer, to singulated dies on stretch-tape, to multiple depopulated dies on a plate adapter. Here, with optical surface coupling and DC probe.

OPAL-EC PLATFORM COMPONENTS

A test station consists of the OPAL-EC main system station with the EXFO Pilot software. Probing heads (optical and electrical) types and number of units should be added for a complete system, depending on the requirements. Other options are available to accommodate more specific needs, such as a thermal chuck.

SPECIFICATIONS

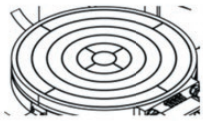
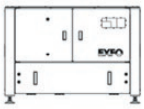
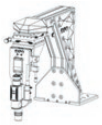
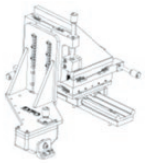
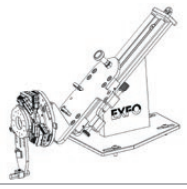
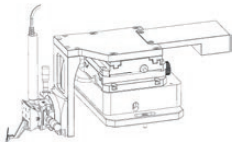
WAFER POSITIONING STAGE		
Option name		**OPAL-EC-300**
XY axis	Travel range (mm)	300
	Resolution (µm)	0.003
	Accuracy (µm)	0.75
	Bi-directional repeatability (µm)	0.1
	Maximum process speed (mm/s)	100
	Orthogonality arcsec	1
	Motor type	Direct-drive linear motors, noncontact encoder
Z axis (height)	Travel range (mm)	5
	Resolution (µm)	0.0008
	Accuracy (µm)	1.5
	Bi-directional repeatability (µm)	0.3
	Maximum speed (mm/s)	4
	Motor type	Direct-drive brushless linear motor
Rz axis (wafer rotation)	Travel range	105°
	Resolution	0.36 arcsec; 0.0001°
	Accuracy	80 arcsec; 0.02°
	Repeatability	3 arcsec; 0.0008°
	Maximum speed (rpm)	600
	Motor type	Direct-drive brushless rotary motor, mechanical bearing

CHUCK			
Option name	**RT-FN**	**TH-G**	**TH-F**
Range (°C) [a]	Ambient	5 - 200	5 - 200
Resolution (°C)	-	0.01	0.01
Stability (°C)	-	±0.05 (> 25) and ±0.1 (< 25)	±0.05 (> 25) and ±0.1 (< 25)
Heating rate (°C/min)	-	40	40
Cooling rate (°C/min)	-	–5	–5
Surface flatness (µm)		< 25	< 25
Vacuum		300-mm round chuck with 4 concentric vacuum zones	
Electrical surface [b]	Floating	Grounded, nickel or gold surface	Floating triaxial (coaxial as option), nickel or gold surface

ORDERING INFORMATION			
	OPAL-EC-300-RT-FN Ambient chuck, floating	**OPAL-EC-300-TH-xy** Thermal chuck 5 °C - 200 °C, grounded xy = GN grounded, nickel surface xy = GG grounded, gold surface xy = FN floating, nickel surface xy = FG floating, gold surface	

a. Other temperature ranges available upon request.

b. Other electrical surface options available upon request.

	COMPONENTS		DESCRIPTION
OPAL-EC MAIN SYSTEM	**Chuck**		Nickel surface, ground polished, ambient temperature, chuck with 4 vacuum zone. Electrical surface connection options. Thermally controlled chuck with heating and cooling capabilities, with range from 5 °C to 200 °C, 4 vacuum zones, available in gold or nickel surface
	Wafer positioning base stage		High accuracy, 4° of freedom wafer positioning with capacity to rotate a wafer by 105°. 300 mm (12-in) diameter chuck and XY travel range
	Vision system		Top high-resolution video system with 10X magnification using in-line coaxial illumination and 2.9 MP color camera on XYZ manual adjustment.
			Side view 2.9 MP color camera with 3X telecentric magnification on XY manual adjustment.
	Additional accessories		Industrical rackmount PC and accessories (KMV), two 27-in monitors.
	EXFO Pilot software dedicated license		Full software suite for complete test and measurement flow of PIC. Automation and control of test station, instruments and data for absolute traceability and reliability of results that are report-ready and AI-ready. Additionnal floating licenses available, for multi-user collaboration from anywhere
PROBING HEADS [a]	**Electrical head**		4-axis manual electrical probe positioners. Fine alignment and long travel range. Probe holders compatible with most DC and RF probes. • PRE-00: manual • PRE-MO: motorized
	Optical head		**PRO-H:** 6-axis motorized piezo-based hexapod (resolution of 1 nm) for precise and fast operation. For edge coupling and surface coupling. Features virtual pivot point capability. Ideal for R&D.
			**PRO-S:** up to 6-axis motorized DC servo aligner (25-mm XY travel, resolution of 10 nm). Motorized pitch (injection angle) and manual roll and yaw angular adjustment. For surface and edge-coupling. Ideal for production scenario. **PRO-ECO:** 6 screw-driven aligner (25 mm) and 6-axis motorized. Ideal for surface coupling. Multiple options of optical probe holders are available, with various configurations and angles for surface and edge-coupling, from single-fiber to large fiber array unit

a. Optical probes (fiber array, fiber) and electrical probes (DC, RF) are not included in the system. If these components are required, please contact an EXFO representative.

TOP VISION SYSTEM

MECHANICAL BASE HOLDER	
Mounting	Compatible with metric and imperial optical breadboard, at 90° and 45°
X, Y, Z axis travel range (mm)	48
X, Y axis displacement/revolution (mm)	1.41
Z axis displacement/revolution (mm)	0.3175
VISION SYSTEM	
Magnification (X)	10
Numerical aperture	0.28
Depth of field (µm)	3.6
Horizontal field of view (mm)	0.88
Working distance (mm)	34
Resolution (MP)	2.9
Maximum frame rate (fps)	144
Sensor format (inch)	2/3
Sensor type	Color, global shutter, 12 bit
Wavelength	Visible
Illumination type	In-line through video microscope unit, LED illuminator

ORDERING INFORMATION

OPAL-TVS-00 Standalone vision system (no mount)	**OPAL-TVSW** Vision system with multi-die and wafer mount as well as manual XYZ adjustment

SIDE VISION SYSTEM

MECHANICAL BASE HOLDER	
Mechanical positioning	6D manual coarse adjustment with articulated arm, XY manual translation stage
Mounting	Compatible with metric and imperial optical breadboard, at 90° and 45°
X, Y axis travel range (mm)	48
X, Y axis displacement/revolution (mm)	1.41
VISION SYSTEM	
Lens type	Telecentric
Magnification [a] (X)	3
Numerical aperture	0.093
Field of view (mm)	2.9 × 2.2
Working distance [b] (mm)	65
Wavelength range	Visible
Resolution (MP)	2.9
Maximum frame rate (fps)	144
Sensor format (inch)	2/3
Sensor type	Color, global shutter, 12 bit
Wavelength	Visible

ORDERING INFORMATION

OPAL-SVS-00

a. Other magnifications options (0.5X, 1X, 2x, 4X, 6X, 8X) available upon request.

b. Other working distances options (40 mm, 110 mm) available upon request.

OPTICAL HEAD [a]

Option name	PRO-H	PRO-S	PRO-ECO
Motorized axis	X, Y, Z, Rx, Ry, Rz	X, Y, Z, Rx, Ry, Rz [b]	X, Y, Z, Rx, Ry, Rz
Configuration	Parallel hexapod, piezo [d]	Serial stack, DC servo	Serial stack, screw
X axis travel (mm)	20	25	
Y axis travel (mm)	11	25	
Z axis travel (mm)	20	4.8	12.5
X axis resolution (nm)	1	10	200
Y axis resolution (nm)	1	10	200
Z axis resolution (nm)	1	60	25
X axis repeatability (nm)	Unidirectional: 50	Bidirectional: 70	Bidirectional: 1250
Y axis repeatability (nm)	Unidirectional: 50	Bidirectional: 70	Bidirectional: 1250
Z axis repeatability (nm)	Unidirectional: 50	Bidirectional: 250	Bidirectional: 125
Rx axis travel (°)	23	10	
Ry axis travel (°)	38	10	
Rz axis travel (°)	26	10	
Rx axis resolution (arcsec)	0.04	4	
Ry axis resolution (arcsec)	0.04	4	
Rz axis resolution (arcsec)	0.04	4	
Rx axis repeatability (arcsec)	Unidirectional: 1.5	7	
Ry axis repeatability (arcsec)	Unidirectional: 1.5	7	
Rz axis repeatability (arcsec)	Unidirectional: 1.5	7	
Full virtual pivot point	Yes	No	No
Included [c]		Fiber/array holder	

ORDERING INFORMATION

PRO-H-61-20	PRO-S-XX-20	PRO-ECO-60-20
	xx = 30 3 motorized axes (XYZ) and 3 manual axes (Rx, Ry and Rz)	
	xx = 40 4 motorized axes (XYZ and Rx) and 2 manual axes (Ry and Rz)	
	xx = 41 4 motorized axes (XYZ and Ry) and 2 manual axes (Rx and Rz)	
	xx = 42 4 motorized axes (XYZ and Rz) and 2 manual axes (Rx and Ry)	
	xx = 50 5 motorized axes (XYZ and RxRy) and 1 manual axis (Rz)	
	xx = 51 5 motorized axes (XYZ and RxRz) and 1 manual axis (Ry)	
	xx = 52 5 motorized axes (XYZ and RyRz) and 1 manual axis (Rx)	
	xx = 60 6 motorized axes (XYZ & RxRyRz)	

a. Other optical options and configurations are available upon request.

b. Various configurations are available. X, Y, Z are always motorized and angles can be motorized, up to all 6 axes. Specifications here are for all motorized axes, travel may differ for manual version.

c. Multiple options are available for surface and edge coupling configuration, multiple angles available.

d. Piezo equipped with exchangeable drive-units for an easy and fast replacement without the necessity to fully dissemble the positioning system.

OPTICAL PROBE HOLDER

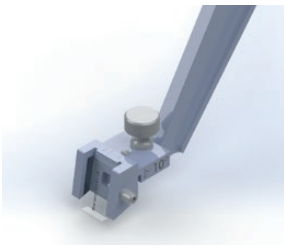
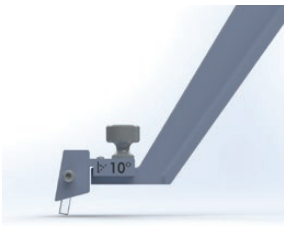
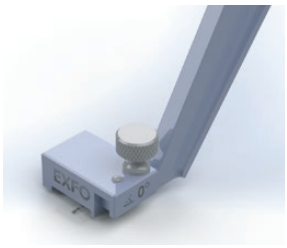
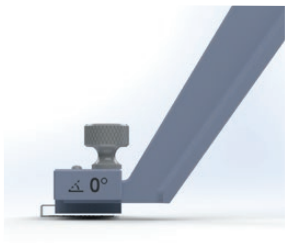
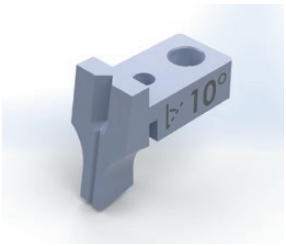
SINGLE FIBER HOLDERS [a]

Model	Coupling type	Injection angle (°)
FS8P	SC	8
FS10P	SC	10
FE0P	EC	0

FIBER ARRAY HOLDERS

Model	Coupling type	Injection angle (°)	Mechanical release [b]	Fiber array width (mm)
AS8P	SC	8	No	< 4.5
AS10P	SC	10	No	< 4.5
AE0P	EC	0	No	< 4.5
AS8RS	SC	8	Yes	2.5 - 6
AS8RW	SC	8	Yes	6 - 20
AS10RS	SC	10	Yes	2.5 - 6
AS10RW	SC	10	Yes	6 - 20
AE0RS	EC	0	Yes	2.5 - 6
AE0RW	EC	0	Yes	6 - 20

a. Glue or any other securing mechanism not provided. Can be sold pre-glued with the required fiber (SMF, MMF, PMF, …)
b. For mechanically releasable models, the required 0.9 mm hex key is included.

	SURFACE COUPLING	EDGE COUPLING
FIBER ARRAY HOLDERS	 	 
SINGLE FIBER HOLDERS		

ELECTRICAL HEAD

Option name	PRE-00	PRE-MO
Translation stages type	Manual	Motorized X, Y, Z, manual probe angle
X , Y axis travel range (mm)	48	50
Z axis travel range (mm)	48	25
X , Y, Z axis resolution (nm)	-	100
X , Y, Z axis repeatability (µm)	-	1, bidirectional, typical: 0.3
X, Y, Z axis accuracy (µm)	Typical: 2	5
X, Y, Z axis speed (mm/s)	-	5
X, Y, Z axis displacement/revolution (mm/rev)	0.3	-
Tilt travel	10°	10°
Z coarse step travel (mm)	Min: 6.35 Max: 56	Min: 12.5 Max: 100

ORDERING INFORMATION

	PRE-00-20	PRE-M0-20

EXFO PILOT AUTOMATION SOFTWARE

EXFO Pilot is a software platform that orchestrates the complete flow of PIC test and measurement: (i) test preparation, (ii) execution of fully automated navigation, alignment and measurements at a high-throughput and (iii) analysis and data management of the results.

Connect & launch

EXFO Pilot app

Prepare

Station configuration

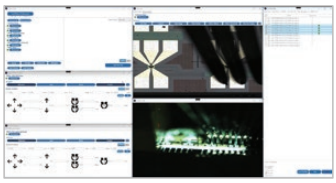
Test plan

Sequencer

Component manager

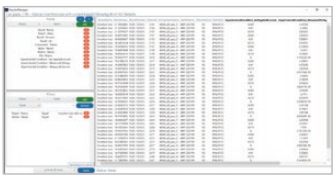
Python script manager

Execute



Station app

Analyze



Result manager

EXFO Pilot app: Prepare – Execute – Analyze with a single software suite.

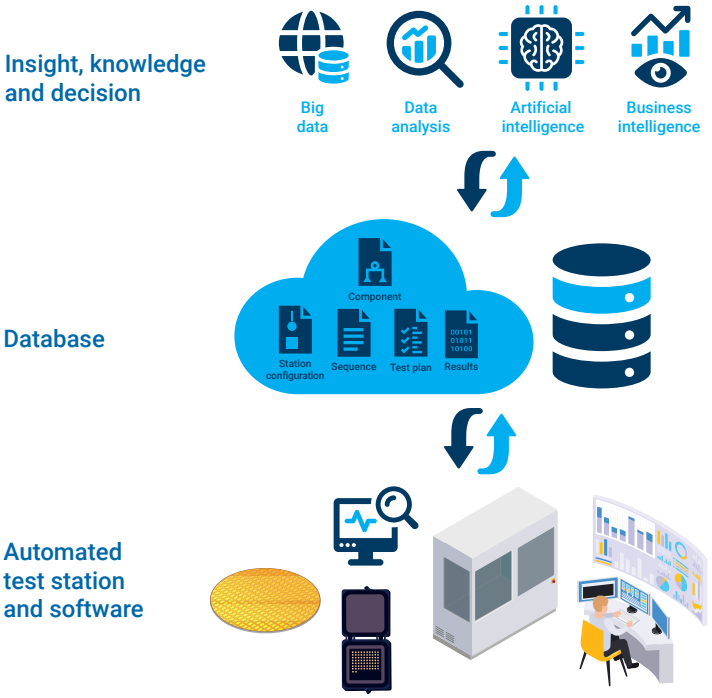
POWERFUL AND SCALABLE

From application architecture to implementation, the software is designed for scalability in time and volume and helps to implement best practices. It streamlines automation of tasks (preparation, data analysis, reporting) and measurements (navigation, alignment, instrument control) to increase effectiveness. It is composed of multiple applications, each designed for its specific task, with de-coupled concepts and responsibilities.

EXFO Pilot's PREPARE apps helps define which components are being tested, with which instruments, how to test and what to test. Existing Python scripts can also be easily included in the test process. The EXECUTE app offer manual and fully automated ways to run the tests and control the connected instruments and station. The ANALYZE apps allow database queries and fetch information relevant to particular characterization.

DATABASE BENEFITS

Underlying all applications, the software is linked to a database (cloud-based or on-premises), that acts as a data repository for all of the elements (results and experimental conditions, station configuration, test definition, component definition, drivers, Python scripts). It therefore enables multi-users, multi-site collaboration with a shared common workspace of the data. The database is relational, traceable and scalable to high-volume, making the system natively compatible and designed to support advanced data analysis, artificial intelligence, and business intelligence tools through built-in tools or by interoperability.



OPAL test stations and EXFO Pilot software automates PIC testing with powerful, scalable features, utilizing multiple applications linked to a collaborative database for advanced data analysis and AI.

BUILD YOUR STATION CONFIGURATION

The OPAL-EC platform provides a flexible test environment to build a custom configuration, that can be modified at any time based on your needs and lowers design-for-test (DfT) requirements. Optical and electrical probes can be positioned around the wafer or die under test in any cardinal orientation (East/West/North/South), up to a total of four.

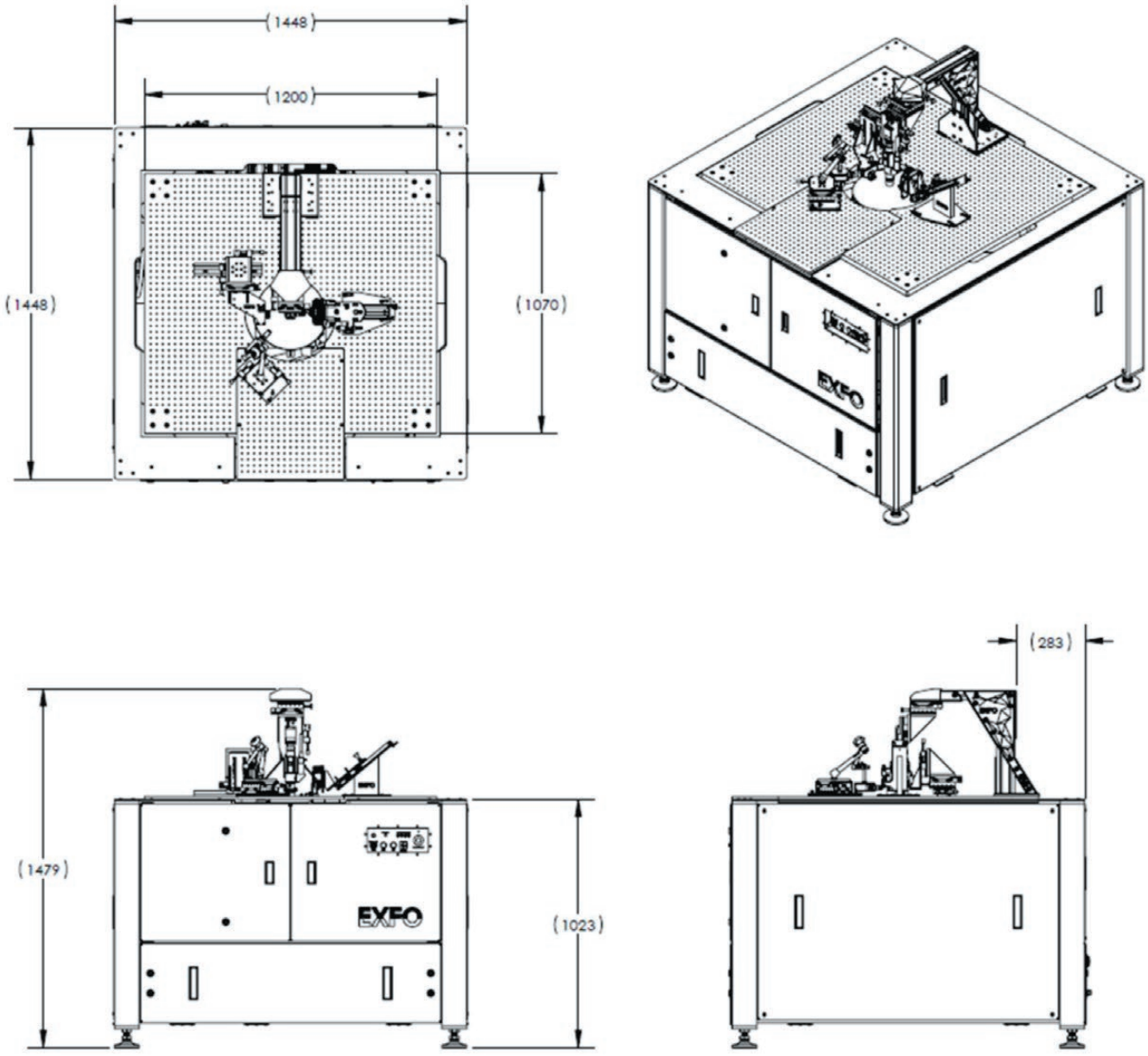
Reconfiguration of OPAL-EC for optical and electrical heads at any time for fast re-tooling.

GENERAL SPECIFICATIONS

MAIN SYSTEM	
Size (H × W × D)	1496 mm × 1448 mm × 1448 mm
Mass (kg) [a]	1250
Operating temperature (°C)	18 - 22
Storage temperature (°C)	0 - 40
Operating humidity (RF)	20% - 60%
Storage humidity (RF)	10% - 70%, non-condensing
Base	Enclosed base system Granite base for passive vibration isolation Front doors and removable front optical breadboard for wafer loading
Optical breadboard	Grid of M6 threaded mounting holes 25 mm hole spacing Black anodized for reduced reflections
Workstation computer	3U rackmount industrial, Intel i7 CPU, 2 x 16 GB RAM DDR5, 1 TB SSD, Nvidia RTX 5060 GPU, 3 Ethernet ports, multiple USB ports, additional PCIe slots, Windows 11 Pro, mouse and keyboard included
Monitors	2 × 27-in
Additional communication ports on base station for equipment	Ethernet Cat6 RJ54, USB-A 3.0
Cables, power supply, drive, controllers	All included

a. The exact mass of the main system depends on the selected configuration.

TECHNICAL DRAWINGS



Technical drawing of the OPAL-EC-300 main system with dimensions in millimeters.
Shown here with one (1x) PRO-P60 optical head and one (1x) PRE-00 manual electrical head. Not shown are the included the industrial rackmount PC, and the IT Kit (monitors, keyboard, mouse). Not shown are the chiller and the thermal chuck controller included with the (-TCH option). Non-final.

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