SPEC SHEET

OPAL-MD – Multi-die test station

AUTOMATED TEST STATION FOR INTEGRATED PHOTONICS

- Accurate, automated, fast and cost-effective testing of photonic integrated circuits (PIC) with traceable results.

KEY FEATURES

- Characterization of multiple singulated dies in one automated execution
- 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 PILOT software suite
- Flexible design with repositionable optical and electrical RF/DC heads
- Different optical head options, as needed: Up to 6 motorized axes for surface and edge coupling with single fibers or fiber arrays

APPLICATIONS

- From R&D, design verification and process development to pilot production
- Automated testing of multiple singulated dies from multi-project wafer run
- In-depth analysis of statistical circuit performance and yield
- Opto-electronic testing on any integrated photonic platform: silicon photonics, indium phosphide, III-V, polymer, heterogeneous, etc.
- Application-agnostic: telecom & datacom transceivers, quantum, LIDAR, sensors, AI, etc.

OPAL-MD PLATFORM

The OPAL-MD multi-die test station provides high performance characterization for integrated photonics with accurate, repeatable, flexible and fast hardware. The PILOT software suite enhances the OPAL-MD hardware capabilities to provide an automated testing station and a source of quality measurements that can be turned into actionable data. The complete suite of applications is a platform that supports the full test-and-measurements flow and helps users to become more data-driven. Combined with EXFO's advanced optical measurement capabilities and open to any third-party instrument, the OPAL-MD is a complete platform for PIC testing.

Figure 1. EXFO's platform for multi-die testing comprising the OPAL-MD test station, PILOT software and EXFO devices for optical characterization of PIC. Third-party instruments can be added and controlled by PILOT.

The station's hardware consists of a motorized 4-axis motion system chuck positioning stage, holding one or multiple samples over an area of 100×100 mm, with thermal control as an option. The station can accommodate up to three probing heads for optical or electrical probes. It also includes a high-resolution, in-line brightfield top vision system and a telecentric side vision system. The system includes a dedicated license for the PILOT software suite, installed on an industrial rackmount computer.

The high resolution and repeatability of the base motion system and motorized optical probe translates to lower insertion loss and error margin on optical measurements.

Figure 2. Testing multiple singulated dies at once with motorized base stage and automated navigation.

By providing the capability to test multiple dies and circuits efficiently, without human intervention during test execution, the OPAL-MD is effective at building a comprehensive and accurate dataset. It enables the users to get insight from statistical analysis; this data can be used to analyze and extract foundry-specific fabrication variations, system performance and yield can be performed. Such information is valuable to iterate R&D towards high-performance and fabrication-tolerant circuits while developing the fabrication and test process for increased robustness, yield and performance.

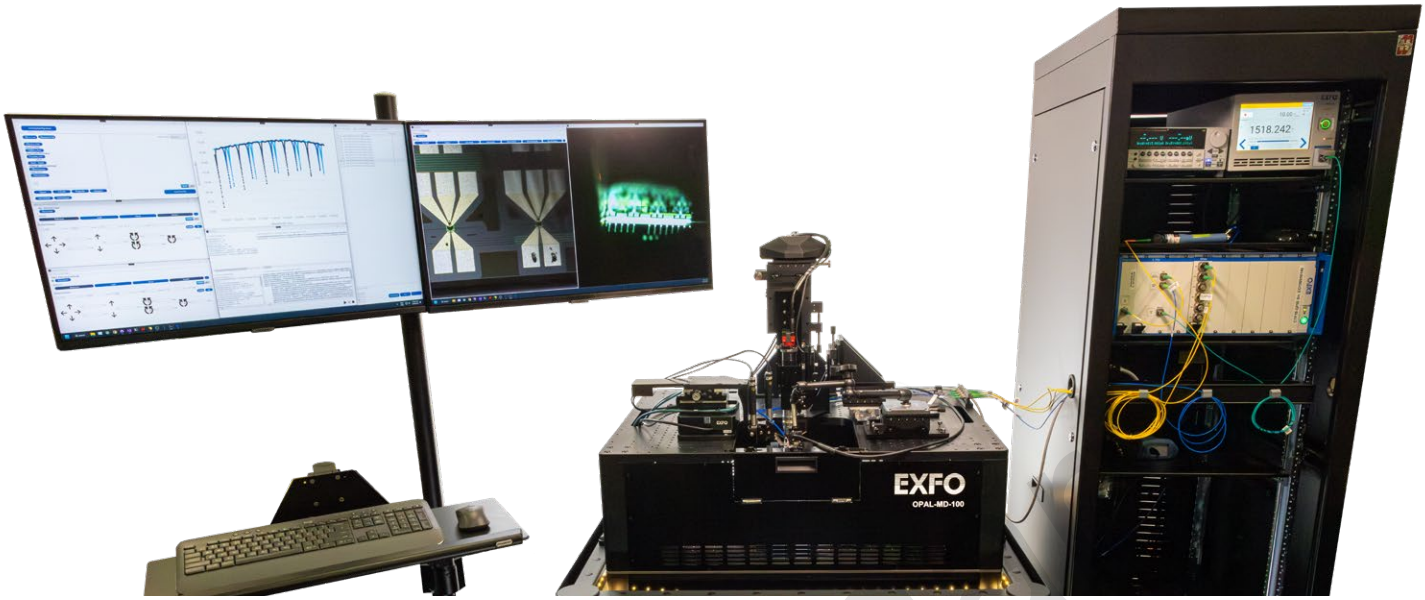


Figure 3. Test setup comprised of EXFO's OPAL-MD, PILOT software, CTP10 and T500S or T200S lasers, as part of a complete and automated test and data management solution for optical characterization of photonic integrated circuits.

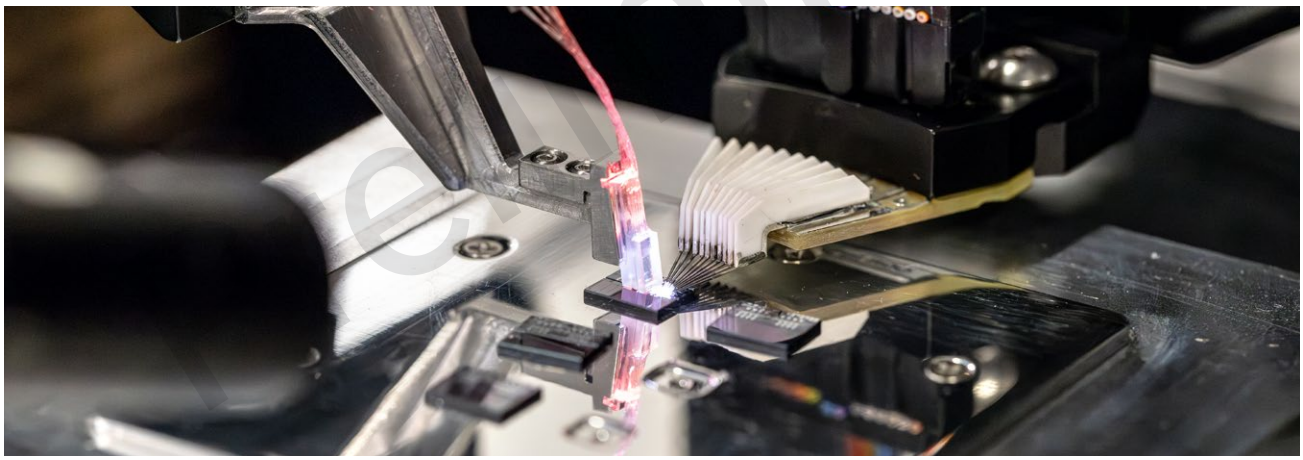


Figure 4. Optical and electrical probing. Shown here with fiber array for surface coupling and DC probe. Probes not included.

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

All test stations are driven by the 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.

PILOT AUTOMATION SOFTWARE

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.

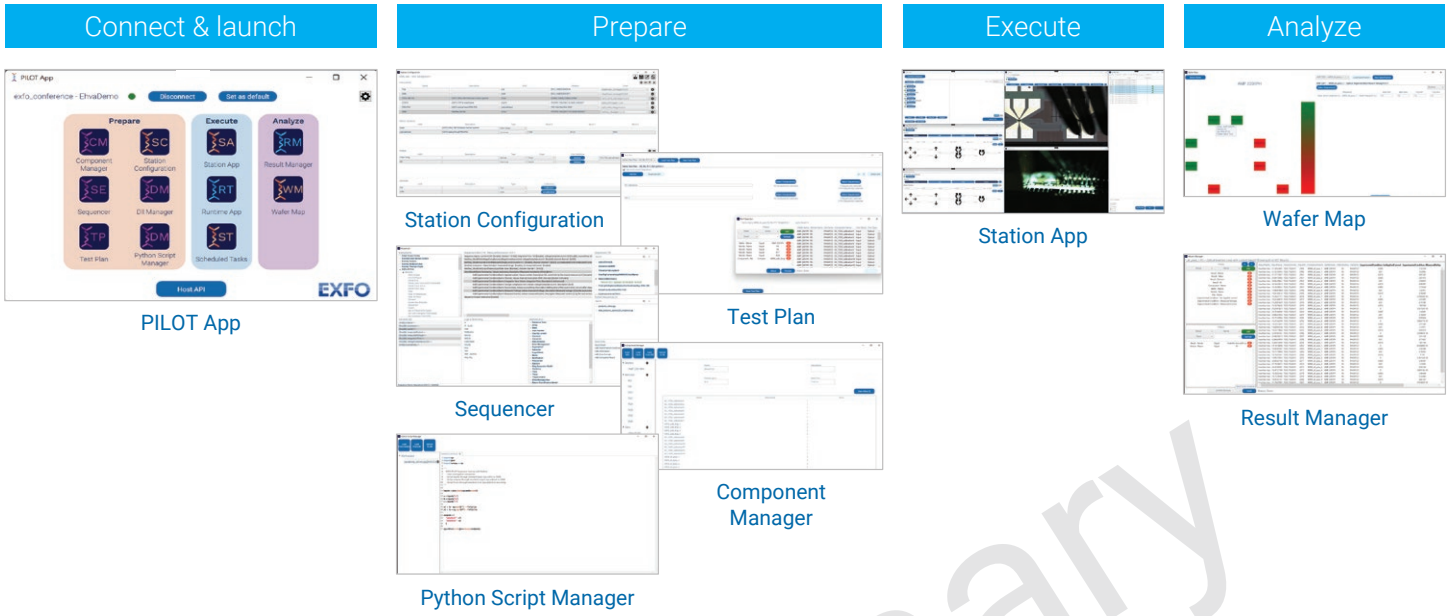


Figure 5. PILOT App: Prepare – Execute – Analyze with a single software suite.

POWERFUL AND SCALABLE

From software 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.

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.

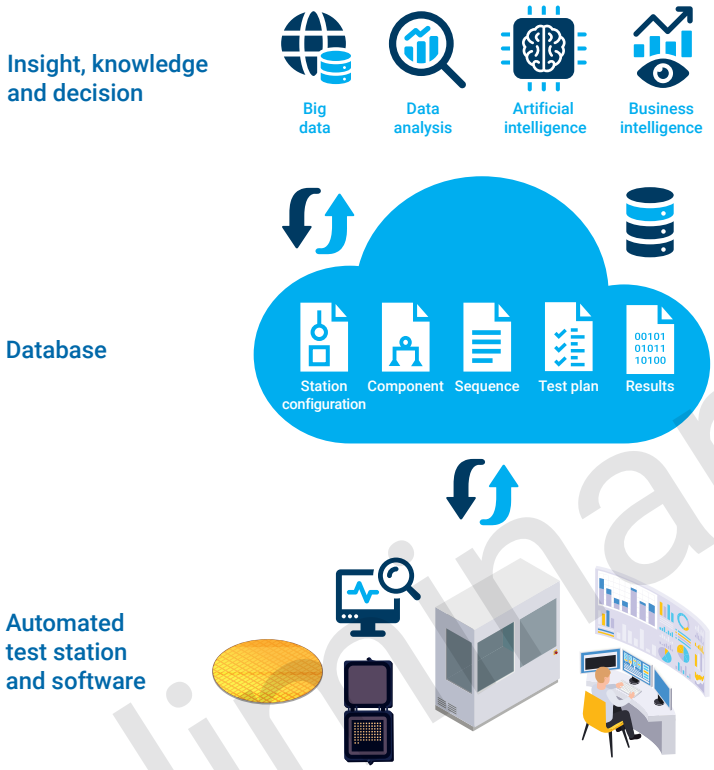
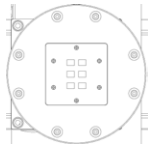
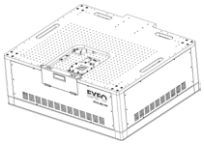
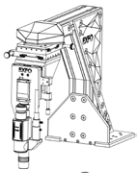
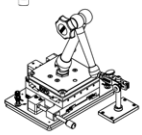
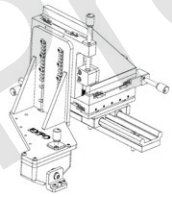
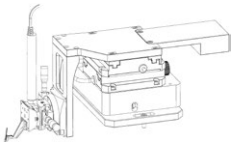


Figure 6. OPAL test stations and PILOT software automates PIC testing with powerful, scalable features, utilizing multiple applications linked to a collaborative database for advanced data analysis and AI.

OPAL-MD PLATFORM COMPONENTS

A test station consists of the OPAL-MD main system with PILOT software, with a thermal chuck as an option. Probing heads (optical and electrical) types and number of units should be added for a complete system, depending on the requirements.

	COMPONENTS		DESCRIPTION	OPTION NAMES AND DESCRIPTION
OPAL-MD MAIN SYSTEM	**Chuck**		Aluminum surface, ambient temperature, chuck with vacuum multi-die holders. Electrical surface connection options.	TCH: Thermally controlled chuck with heating and cooling capabilities, with range from –10 to 120 (°C), 4 vacuum zones.
	Wafer positioning base stage		Motorized 4-axis multi-die positioning. 100 mm of travel range in X and Y axes.	
	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.	
			Magnetic toggleable, side-view 2.9 MP color camera with 3X telecentric magnification on XY manual adjustment.	
	Additional components		Industrical rackmount PC and accessories. Two 27-inch monitors. All drives and cables.	• Free-standing workstation • Top enclosure
	PILOT app 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. One dedicated life-time license.	Additionnal floating licenses available, for multi-user collaboration from anywhere.
PROBING HEADS[a]	**Electrical heads**[b]		**PRE-00:** 4-axis manual electrical probe positioners. Fine alignment and long travel range. Probe holders compatible with most DC and RF probes.	PRE-MO: motorized, 25 mm range, 200 nm resolution
	Optical heads[c]		**PRO-P60:** 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. Includes and manual screws and rail concept to toggle between engaged/disengaged positions.	Other optical head options available, contact an EXFO representative
			**PRO-P40:** 4-axis motorized DC servo aligner (25 mm XY travel, 10 nm resolution). Motorized pitch (injection angle) and manual roll and yaw angular adjustment. For surface and edge-coupling. Ideal for production scenario.	

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.

b. Includes a probe holder compatible with most DC and RF probes.

c. Includes a probe holder compatible with most fiber arrays or single fibers.

BUILD YOUR STATION CONFIGURATION

The OPAL-MD platform provides a flexible test environment to build a custom configuration, that can be modified at any time as needed, lowering 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), up to a total of three.

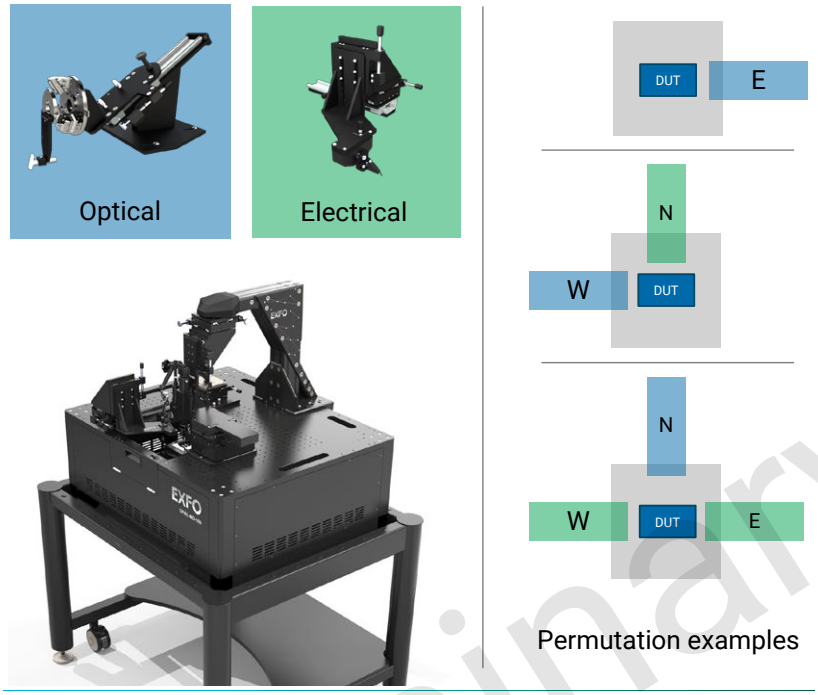


Figure 7. Reconfiguration of OPAL-MD for optical and electrical probing heads at any time for fast re-tooling.

TECHNICAL DRAWINGS

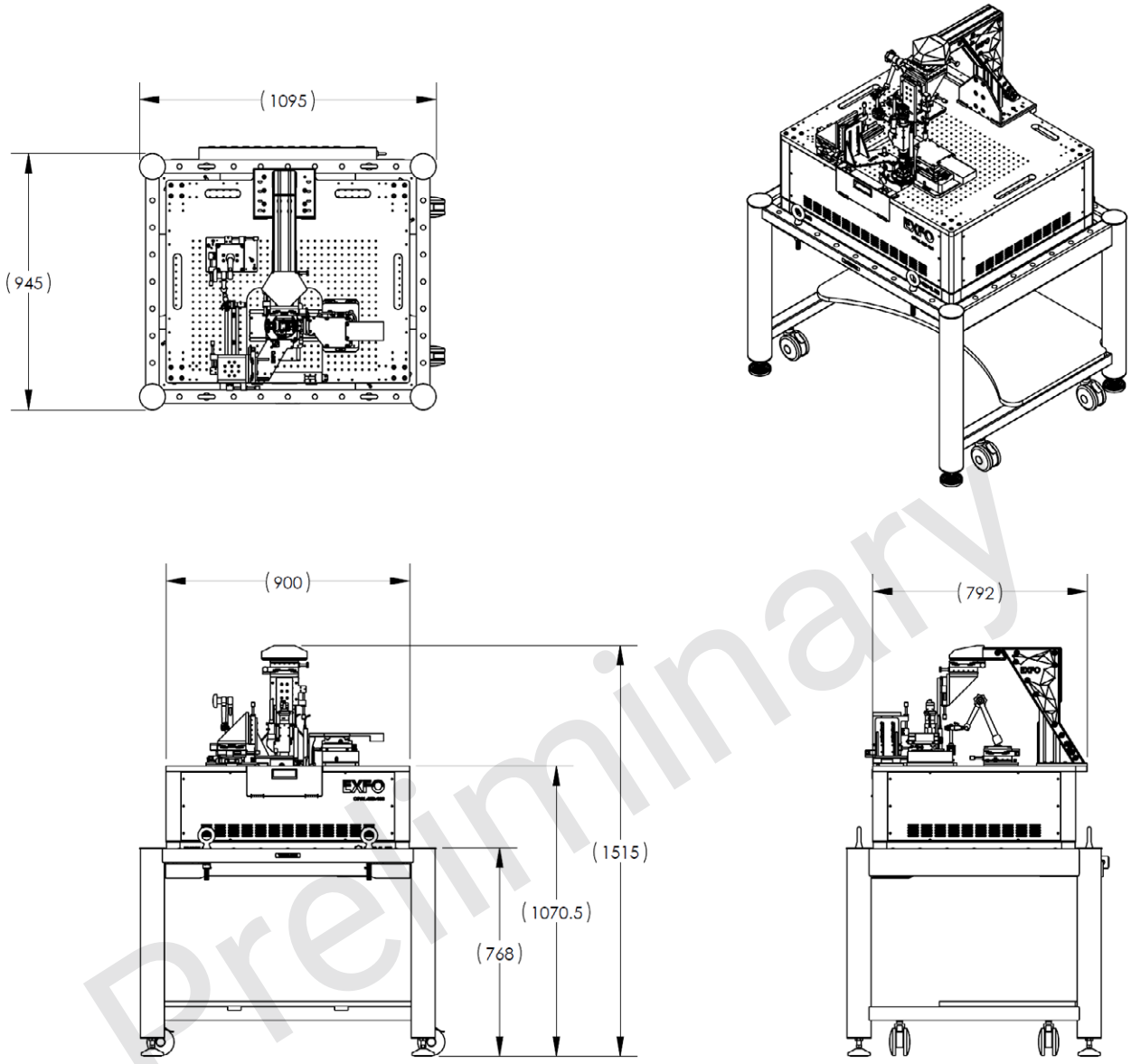


Figure 8. Technical drawing of the OPAL-MD-100 main system with dimensions in millimeters.
Shown here with one (1x) PRO-P40 optical head and one (1x) PRE-00 manual electrical head.
Not shown are the included industrial rackmount PC, and the IT Kit (monitors, keyboard, mouse).
Not shown are the chiller and the thermal chuck controller included with the (-TCH option). Non-final.

SPECIFICATIONS

CHUCK STAGE MOTION SYSTEM		
		OPAL-MD-100
MECHANICAL		
X, Y axis	Travel range (mm)	100
	Resolution (µm)	0.15
	Accuracy, typical (µm)	1
	Bi-directional repeatability, typical (µm)	1
	Maximum process speed (mm/s)	20
	Motor type	Recirculating ball bearing, stepper motor
Z axis	Travel range (mm)	4.8
	Resolution (µm)	0.06
	Accuracy, typical (µm)	0.6
	Bi-directional repeatability, typical (µm)	0.1
	Maximum speed (mm/s)	5
	Motor type	Linear ball bearings, DC motor
Rz axis	Travel range (degree)	15
	Resolution	0.9 arcsec; 0.00025 °
	Accuracy, typical	36 arcsec; 0.01 °
	Bi-directional repeatability, typical	9 arcsec; 0.0025 °
	Maximum speed (degree/s)	20
	Motor type	Crossed roller bearings, stepper motor
SOFTWARE		
PILOT software supported	Yes (station app GUI and sequencer)	
EXFO supported .dll driver	Yes	

CHUCK		
Option name	**TA**	**TCH**
Sample area	60 mm × 60 mm, square	100 mm × 100 mm, square
Range [a]	Ambient	–10 °C to 120 °C (14 °F to 248 °F)
Resolution	-	0.01 °C (32 °F)
Stability	-	0.05 °C (32 °F)
Heating rate	-	20 °C/min (68 °F/min)
Cooling rate	-	–10 °C/min (14 °F/min)
Vacuum zones [b, c]	1 zone, electronically controlled	4 zones vacuum grooves, electronically controlled
Electrical surface [d]	Grounded	
SOFTWARE		
PILOT software supported	Yes (station app GUI and sequencer)	
EXFO supported .dll driver	Yes	

a. Other temperature ranges available upon request.
b. Custom vacuum patterns available upon request.
c. Generic and custom vacuum adaptator plates available upon request.
d. Other surface electrical options available upon request: floating, triaxial.

TOP VISION SYSTEM	
Option name	**VHD**
MECHANICAL BASE HOLDER	
Mounting	Compatible with metric and imperial optical breadboard, at 90 and 45 (degree)
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
Field of view (mm)	2.4
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
SOFTWARE	
PILOT software supported	Yes (station app GUI and sequencer)
EXFO supported .dll driver	Yes
Available SDK languages	C, C++, .NET or Python APIs

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, 12 bit, global shutter
Wavelength	Visible
SOFTWARE	
PILOT software supported	Yes (station app GUI and sequencer)
EXFO supported .dll driver	Yes
Available SDK languages	C, C++, .NET or Python APIs

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-P60**	**PRO-P40**
Motorized axis	X, Y, Z, Rx, Ry, Rz	X, Y, Z, Ry (pitch)
Manual axis	-	Rx (yaw), Rz (roll) [b]
Motor type	Piezo, hexapod	X, Y, Z: DC servo Ry: stepper
X axis travel (mm)	20	25
Y axis travel (mm)	11	25
Z axis travel (mm)	20	4.8
X axis resolution (nm)	1	10
Y axis resolution (nm)	1	10
Z axis resolution (nm)	1	60
X axis repeatability (nm)	Uni-directional: 50	Bi-directional, typical: 50
Y axis repeatability (nm)	Uni-directional: 50	Bi-directional, typical: 50
Z axis repeatability (nm)	Uni-directional: 50	Uni-directional, typical: 60 Bi-directional, typical: 100
Rx axis travel (degree)	23	10
Ry axis travel (degree)	38	10
Rz axis travel (degree)	26	10
Rx axis resolution	0.04 arcsec; 0.00001°	50.8 (TPI)
Ry axis resolution	0.04 arcsec; 0.00001°	0.72 arcsec; 0.0002°
Rz axis resolution	0.04 arcsec; 0.00001°	50.8 (TPI)
Rx axis repeatability	Uni-directional: 1.5 arcsec; 0.0004°	-
Ry axis repeatability	Uni-directional: 1.5 arcsec; 0.0004°	Bi-directional, typical: 1.1 arcsec; 0.0003° Uni-directional, typical: 0.8 arcsec; 0.0002°
Rz axis repeatability	Uni-directional: 1.5 arcsec; 0.0004°	-
Pivot point capability	Yes	No
Possible orientations	North/East/West	North/East/West
Included	Rail system for toggling into engaged/disengaged positions, fiber array holder and single fiber holder	Fiber array holder and single fiber holder

OPTICAL HEAD		
Option name	**PRE-00**	**PRE-MO**
Translation stages type	Manual	Motorized X, Y, Z, manual probe angle
X , Y, Z axis travel range (mm)	48	25
X , Y, Z axis resolution (nm)	-	200
X , Y, Z axis repeatability (µm)	-	1.25
X, Y, Z axis accuracy (µm)	Typical: 2	2.5
X, Y, Z axis speed (mm/s)	-	0.4
X, Y, Z axis displacement/revolution (mm/rev)	0.3	-
Tilt travel (degree)	10	10
Rail system X travel (mm)	180	180
Z coarse step travel (mm)	Min: 6.35 Max: 56	Min: 6.35 Max: 57
Possible orientations	North/East/West	North/East/West

a. Other optical head options available upon request.

b. Motorized Rx (yaw) and/or Rz (roll) axis available upon request.

GENERAL SPECIFICATIONS – MAIN SYSTEM

Size (H × W × D)	1500 mm × 1095 mm × 945 mm (59 in × 43 ⅛ in × 37 ¼ in)
Weight (kg) [a]	350 kg (771.6 lb)
Operating environment [b]	Use in a clean environment to avoid temperature variations, vibrations, humidity and dust
Base	Enclosed base with front door for base motion system and chuck system. Base frame with passive vibration isolation not included, contact EXFO for more info.
Maximum number of electrical or optical heads	3
Optical breadboard	Grid of M6 threaded mounting holes, 25 mm hole spacing, black anodized for reduced reflections
Workstation computer	4U rackmount industrial, Intel i7 CPU, 64 GB RAM DDR5, 1 TB SSD, Nvidia RTX 4060 GPU, 3 Ethernet ports (10 + 2.5 + 1 Gbit/s), multiple USB ports, additionnal PCIe slots, Windows 11 Pro, mouse and keyboard included
Monitors	2 × 27-inch
Cables, power supply, drive, controllers	All included
Additional communication ports on base station for equipment	Ethernet Cat 6 RJ54, USB-A 3.0

Note: Use the system in a low-vibration environment. Excessive floor or acoustical vibration can negatively impact system performance. Although the base of the station includes a passive vibration isolation system, the expected vibration level for the operation of the OPAL-MD-100 should be equal to or below the VC-A vibration criteria curve for best performances, especially for edge-coupling alignment. The velocity should be below 50 µm/s, when measured by the one-third octave bands of frequency over 8 to 80 Hz. At this level, vibrations are not perceptible. Else, contact us for more information on an active vibration damping system.

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

b. Use the system in a controlled environment. Environmental temperature variations will degrade performance.

ORDERING INFORMATION

Probe station

OPAL-MD-100-XX

Chuck option
TA = Ambient temperature (no temperature control)
TCH = –10°C – 120°C temperature control (heating and cooling)

Example: OPAL-MD-100-TCH

Optical probe arm

PRO-XX

Probe arm grade
P60 = 6 motorized axis, 1 nm resolution, for edge and surface coupling
P40 = 4 motorized axis, 10 nm resolution, for edge and surface coupling

Example: PRO-P40

Electrical probe arm

PRE-XX

Probe arm grade
00 = Manual translation stage
MO = Motorized XYZ, manual probe angle

Example: PRE-MO

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

EXFO headquarters **T** +1 418 683-0211 **Toll-free** +1 800 663-3936 (USA and Canada)

EXFO serves over 2000 customers in more than 100 countries. To find your local office contact details, please go to www.EXFO.com/contact.

Printed in Canada 23/06