SPEC SHEET

OPAL-SD – Single-die testing

SEMI-AUTOMATED TEST STATION FOR INTEGRATED PHOTONICS

- Accurate, flexible, cost-effective and easily upgradeable testing of photonic integrated circuit (PIC) singulated die with traceable results.

KEY FEATURES

- Research-grade solution for semi-automated characterization of a singulated PIC die
- Precise and fast optical alignment and electrical probing
- Preparation, automated execution (navigation, alignment, instrument control) and data management (repository, analysis) with PILOT software suite (included)
- Flexible design with a choice of repositionable optical heads for surface and edge coupling with single fibers or fiber arrays, and electrical probe heads with manual or motorized axis

APPLICATIONS

- Optical and electrical probing and testing of PIC at the die, module or bar-level
- For R&D, low-volume design verification and test development
- Perfect for academia and R&D teams
- Platform-agnostic: silicon photonics, indium phosphide, III-V, polymer, heterogeneous
- Application-agnostic: telecom & datacom transceivers, quantum, LIDAR, sensors, AI

EXFO

OPAL-SD PLATFORM

The OPAL-SD single-die test station is a perfect stepping stone for high performance characterization for integrated photonics, offering the speed, accuracy and repeatability needed in the lab environment, whilst remaining flexible and upgradeable in design.

The PILOT software suite enhances the OPAL-SD hardware capabilities, providing a complete, flexible and scalable software environment for generating test sequences with a visual programming interface, controlling vision, motion systems and test instruments. The complete suite of software applications support the full test-and-measurements flow turning quality measurements into actionable data, helping users in becoming more data-driven.

The station's hardware consists of a 4-axis manual chuck positioning stage, holding one PIC sample, with thermal control as possible option, mounted on an optical breadboard that can accommodate up to three probe heads for optical or electrical testing. It also includes one top vision and one side vision camera system. A dedicated license for the PILOT software suite, installed on an industrial rackmount computer, is included.

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

- OPAL-EC: a wafer prober optimized for wafer-level edge coupling
- OPAL-MD: a multi-die station
- OPAL-SD: a single-die station

All test stations are driven by the PILOT software. The test process and user training developed on one station is completely transferable to another station of the OPAL family. Optical heads, electrical heads, vision systems and IT kits are also transferable from one station to another, ensuring seamless hardware upgrades.

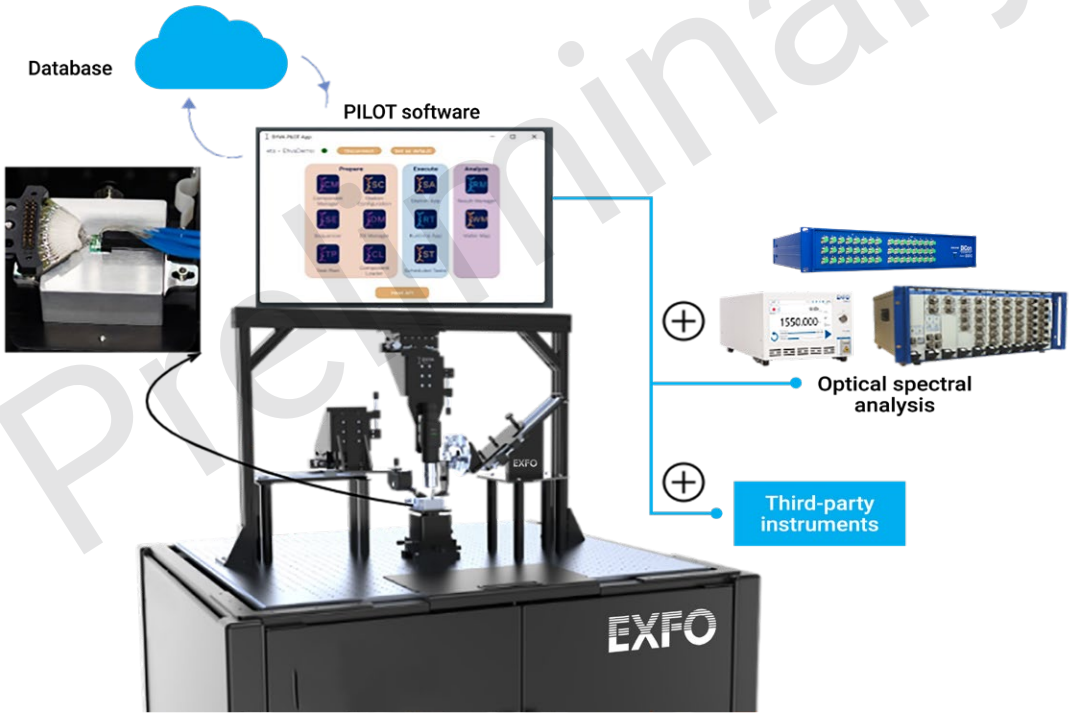


Figure 1. OPAL-SD platform as a characterization solution with PILOT software

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 and (iii) analysis and data management of the results..

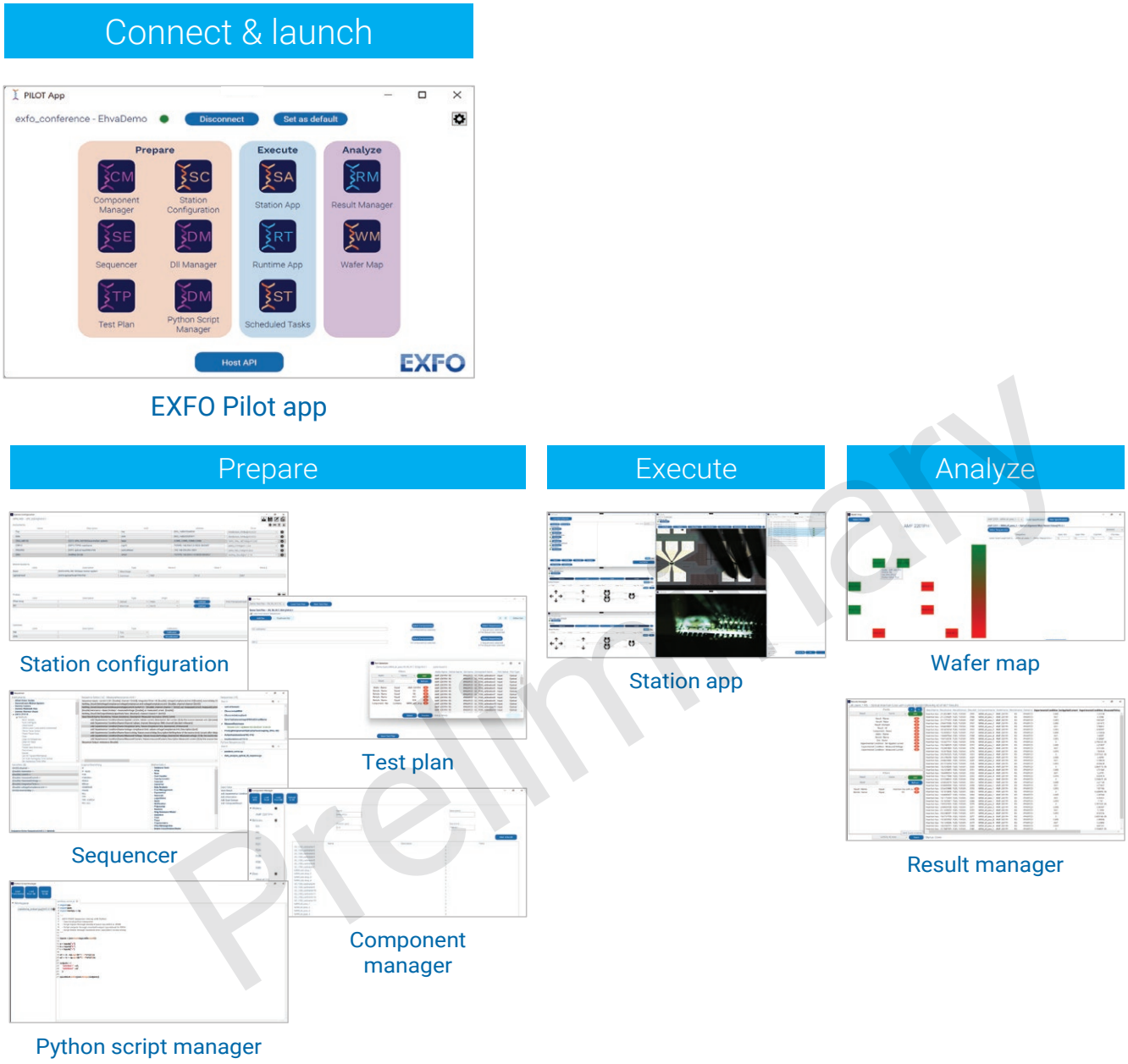


Figure 5. PILOT App: Prepare – Execute – Analyze with a single software suite.

POWERFUL AND SCALABLE

From application-specific 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.

PILOT's "Prepare" app helps to 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 offers manual and fully automated ways to run the tests and control the connected instruments and station. The "Analyze" app allows database queries while fetching information relevant to the 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.

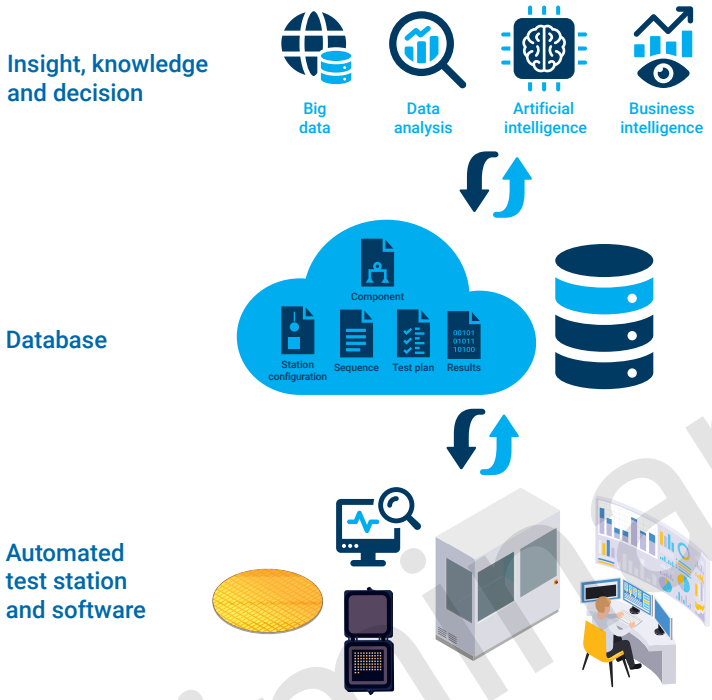
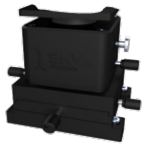
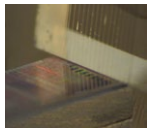
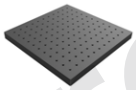
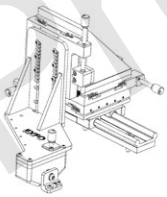
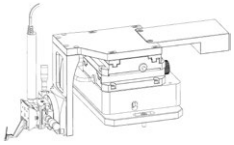


Figure 6. OPAL test stations and PILOT software automates PIC testing with powerful, scalable features, utilizing multiple applications linked to a collaborative database for advanced data analysis and AI.

OPAL-SD PLATFORM COMPONENTS

A test station consists of the OPAL-SD main system with two cameras, PILOT software installed on a PC and a thermal chuck as an option. Probe heads (optical and electrical) should be added for a complete system, depending on the requirements.

	COMPONENTS		DESCRIPTION	OPTION NAMES AND DESCRIPTION
OPAL-SD MAIN STATION	**Chuck**		TA: Aluminium surface, ambient temperature with vacuum for single-die holder.	TCH: Thermally controlled chuck with heating and cooling capabilities. Electrical surface connection also available as an option.
	Single-die positioning base 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. Manual 4-axis high-precision stage.	
	Vision system	 	HD video system with 10x magnification using in-line coaxial illumination on XYZ manual adjustment. Toggleable, side-view camera with 3X telecentric magnification on XY manual adjustment.	
	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 lifetime license. Industrial rackmount PC and accessories, one 27-inch monitor, all drives and cables.	Additional floating licenses available for multi-user collaboration from anywhere.
	Base		Honeycomb optical breadboard.	BENC200: Base frame to isolate base stage from vibration.
PROBE 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, XYZ axis electrical probe positioners, 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 mechanical toggle system between engaged/ disengaged positions. **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.	ECO series of optical head include a choice of 3, 4 or 6 motorized axis ideal for surface coupling applications. Available upon request.

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

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

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

BUILD YOUR STATION CONFIGURATION

The OPAL platform being a modular solution, it can fit customer needs through the setup of up to 3 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
Optical surface coupling only. Best suited for entry-level solution.	 **Single-die base stage** Manual 4D translation stage with vacuum chuck +  **ECO series** 3-axis, screw-driven aligner +  **Top/side vision system**
Electro-optical, surface coupling and edge-coupling capable. Best suited for R&D.	 **Single-die base stage** Manual 4D translation stage with vacuum chuck +  **4-axis manual electrical probe positioner** +  **Optical probe PRO-P60** 6-axis nanometer-precision and piezo-based hexapod +  **Top/side vision system**
Electro-optical, surface coupling and edge-coupling capable. Best suited for industrial production.	 **Single-die base stage** Manual 4D translation stage with vacuum chuck +  **Thermal chuck** Vacuum and temperature controlled chuck +  **4-axis motorized electrical probe positioner** +  **P40** 4-axis, direct drive aligner +  **Top/side vision system**

SPECIFICATIONS

A standard OPAL-SD test station includes: one OPAL-SD chuck stage motion system, one TA chuck, a top and side vision system, PC with PILOT software license and accessories.

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		
Option name	**TA**	**TCH**
Sample area	50 × 50 mm^2	50 × 50 mm^2
Range [a]	Room temperature	0 °C to 120 °C (32 °F to 248 °F)
Resolution	0.01 °C (32 °F)	0.01 °C (32 °F)
Stability	0.05 °C (32 °F)	0.05 °C (32 °F)
Heating rate	40 °C/min (68 °F/min)	40 °C/min (68 °F/min)
Cooling rate	–15 °C/min (14 °F/min)	–15 °C/min (14 °F/min)
Vacuum zones [b, c]	1 zone, electronically controlled	3 custom vacuum zones, electrically controlled
Electrical surface [d]	Electrical surface grounded (triaxial as option)	

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.

Optical head options

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: ±70
Y axis repeatability (nm)	Uni-directional: 50	Bi-directional, typical: ±70
Z axis repeatability (nm)	Uni-directional: 50	Uni-directional, typical: ±250 Bi-directional, typical: 100
Rx axis travel	23°	10°
Ry axis travel	38°	10°
Rz axis travel	26°	360° coarse, 10° fine
Rx axis resolution	0.04 arcsec; 0.00001°	50.8 (TPI)
Ry axis resolution	0.04 arcsec; 0.00001°	4 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: 7 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 counterweight

ECO-30, 40, 60 – 3, 4 OR 6 MOTORIZED AXIS, SCREW-DRIVEN	
X, Y, Z axis travel (mm)	25 (X, Y), 12.5 (Z)
X, Y, Z axis resolution (nm)	200 (X, Y), 25 (Z)
X, Y, Z axis bidirectional repeatability (nm)	Typical: 125 (X, Y, Z)
X, Y, Z, axis accuracy (µm)	Typical: ±4 (X, Y), ±1.5 (Z)

a. Optical fibers and electrical probes are not included with the probe arms.

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

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	25
Z axis travel range (mm)	48	25
X , Y, Z axis resolution (nm)	-	200
X , Y, Z axis repeatability (µm)	-	1, Bi-directional, typical: 0.3
X, Y, Z axis accuracy (µm)	Typical: 2	5
X, Y, Z axis speed (mm/s)	-	0.4
X, Y, Z axis displacement/revolution (mm/rev)	0.3	-
Tilt travel	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

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

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 x 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

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.

GENERAL SPECIFICATIONS – MAIN SYSTEM

Size (H × W × D)	1219 mm × 914 mm × 945 mm (48 in × 36 in × 37 ¼ in)
Weight (kg) [a]	160 kg (352.7 lb)
Operating environment [b]	Use in a clean environment to avoid temperature variations, vibrations, humidity and dust. Compressed air supply needed for chuck.
Base	High-quality honeycomb optical breadboard
Workstation computer	Intel i7 CPU, 32 GB RAM, 1 TB SSD, 2 Ethernet ports, multiple USB ports, Windows 11 Pro, mouse and keyboard included. Base frame available as an option.
Monitor	1 × 27-inch screen
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-SD 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-SD-XX

Chuck option
TA = Ambient temperature (no temperature control)
TCH = 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
ECO60 = 6 motorized axis, 200 nm resolution, for surface coupling
ECO40 = 4 motorized axis, 200 nm resolution, for surface coupling
ECO30 = 3 motorized axis, 200 nm resolution, for 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 25/07