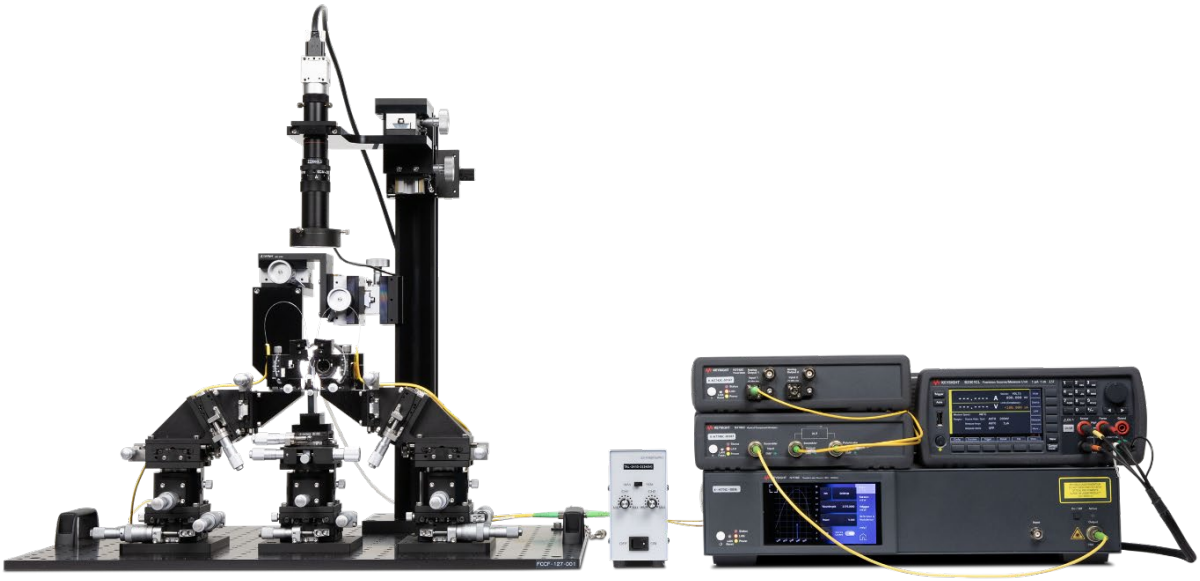
Semiconductor Teaching Lab Solution: Photonics IC Measurement

Empowering Semiconductor Education with a Ready-to-Teach Photonics IC Measurement Lab Solution

Introduction

Photonic Integrated Circuits (PICs) represent a transformative leap in optical technology, enabling the miniaturization of complex optical systems (such as lasers, waveguides, modulators, and detectors) into compact, energy-efficient microchips. As these platforms become essential for high-performance applications in data centers, quantum computing, and artificial intelligence, there is an increasing demand for skilled professionals capable of designing and measuring on-chip components. This teaching lab curriculum is designed to provide students with the foundational expertise required for advanced photonic device testing and optical coupling optimization.



KEYSIGHT

Module Overview

This comprehensive teaching module guides students through Photonic IC characterization. The curriculum begins with fundamental skills such as optical fiber preparation and manual probe station operation. It progresses through fixed and swept-wavelength measurements to characterize passive optical on chip device performance using both edge coupling and surface grating couplers. The parameters measured include Insertion Loss (IL) and Polarization Dependent Loss (PDL). The module concludes with Optical-to-Electrical (OE) responsivity measurements for a InGaAs PIN photodiode, utilizing industry-standard instruments to bridge the gap between theoretical principles and real-world semiconductor applications.

Target University Subjects	Target Year of Study	Prerequisites
Integrated Photonics and Optoelectronics	Undergraduate/Postgraduate	• University Laser Safety Training • Single-Mode Fiber (SMF) Theory • Keysight Instrument User Guides
Semiconductor Device Physics		
Optical Communications		
Optical Engineering		

Learning Outcomes

After completing the comprehensive lab exercises, students will be able to.

- **Operate industry-standard instrumentation**: Correctly configure and control Keysight N77xxC series instruments using standalone web interfaces and the N770010xC Photonics Application Suite (PAS).
- **Execute precise fiber and die handling**: Perform fiber stripping and cleaving to create optical probes, and safely transfer PIC dies from gel packs to vacuum chucks without damaging sensitive structures.
- **Analyze passive and active components**: Conduct absolute and relative power measurements, determine Free Spectral Range (FSR) and Quality Factor (Q) for resonators, and calculate PIN photodiode responsivity (A/W).
- **Master polarization techniques**: Control and stabilize the State of Polarization (SOP) and perform polarization-resolved measurements using advanced Mueller Matrix methods.
- **Apply safety protocols**: Implement essential laser safety procedures and handle bare optical fibers safely to prevent physical injury and equipment damage.

Lab Contents

The course includes seven (6) distinct lab sheets covering measurement principles.

Lab[1]	Title	Focus Area	Lab Time (Approx)
1	Getting Started – Probe Station[2] Operation	• Fiber cleaving, probe station[2] 6-axis alignment, and PIC die handling.	3 hours
2	Fixed Wavelength Power and Insertion Loss	• Absolute power, photodetector responsivity, and on-chip waveguide loss using the cutback method.	3 hours
3	Swept Wavelength Insertion Loss	• Instrument synchronization, swept wavelength IL, and characterization of Mach Zehnder Interferometers (MZI) and Ring Resonators.	3 hours
4	Polarization Control and Measurement	• State of polarization (SOP) manipulation, Poincare sphere visualization, and measuring PDL via the All-States method.	3 hours
5	Swept Wavelength Insertion Loss (IL) and Polarization Dependent Loss (PDL)	• Mueller Matrix method for single-sweep polarization resolved traces and angular dependence of grating couplers.	3 hours
6	Swept Wavelength Optical to Electrical (OE) PIN Diode Responsivity	• Integrating Source Measure Units (SMUs) to calculate responsivity (A/W) and Dark Current	3 hours

1. All lab sheets are provided in editable Microsoft Word formatted files.
2. Customer-supplied equipment. Contact your Keysight sales representative for recommended equipment or further information.

Benefits of the Photonic IC Measurement Lab

This solution, which combines advanced instrumentation with structured lab exercises, offers the following benefits:

- **Industry alignment**: Students gain hands-on experience with the same high-performance tools and measurement techniques (such as single-sweep Mueller Matrix analysis) used in high-volume foundry test stations.
- **Theoretical reinforcement**: The curriculum reinforces principles of Total Internal Reflection (TIR), waveguide geometries, and photodetector responsivity through practical application.
- **Comprehensive skillset**: The module covers diverse coupling techniques, including both edge coupling for mode matching and surface grating couplers for volume testing.
- **Scalable learning**: Starting with simple fiber-to-fiber alignment, the labs build toward complex system-level link budgeting and polarization-sensitive component design.

Required Equipment, Software, and Accessories

The following are the core system components utilized throughout the lab modules.

Hardware

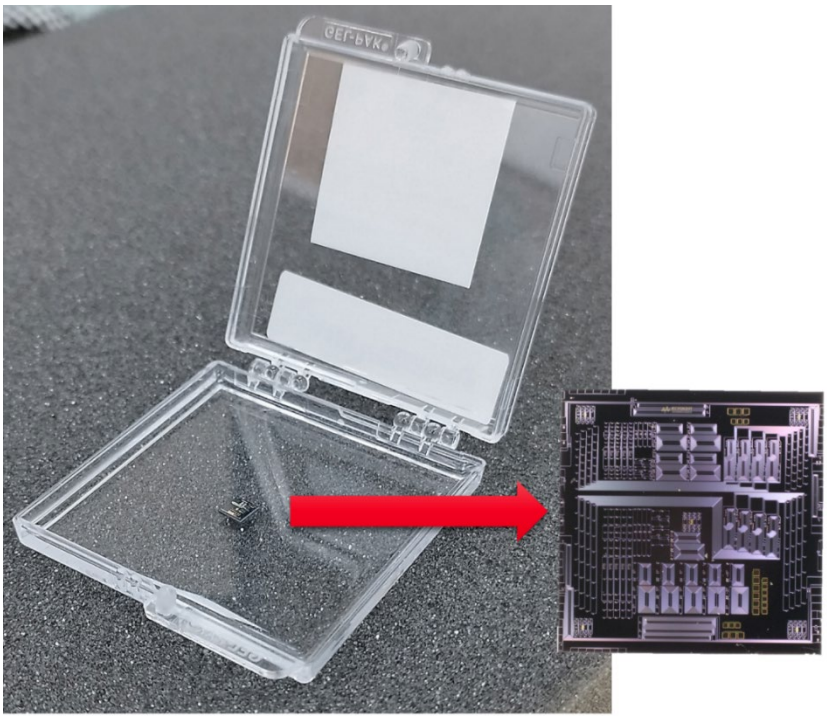
Equipment	Model
Swept wavelength source	N7778C 
Optical power meter	N7742C 
Polarization control and measurement	N7786C 
Source Measure Unit (SMU)	B2901CL 
Probe station	Customer-supplied equipment. Contact your Keysight sales representative for recommended equipment or further information.

NOTE: All images are for reference only, and details may vary based on the device and configuration.

Software

Software	Description
N7700100C	Polarization-Lambdascan Measurement Software Package
N7700102C	Fast Lambdascan Measurement Software Package

Accessories

Equipment	Model
Keysight Photonic Integrated Circuit (PIC)	UU103LAB-DUT 

ESD SENSITIVE DEVICE

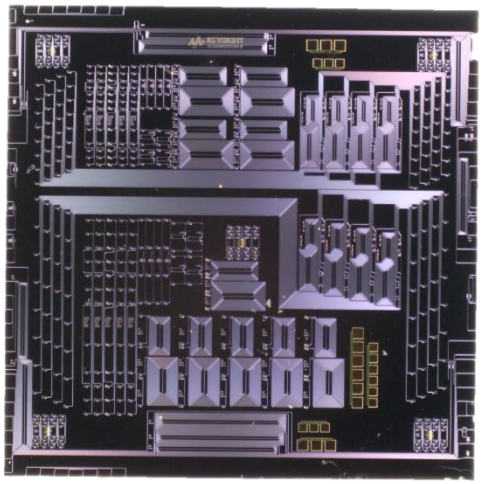
Handle with care. To prevent damage, discharge static electricity from your body before touching this component.

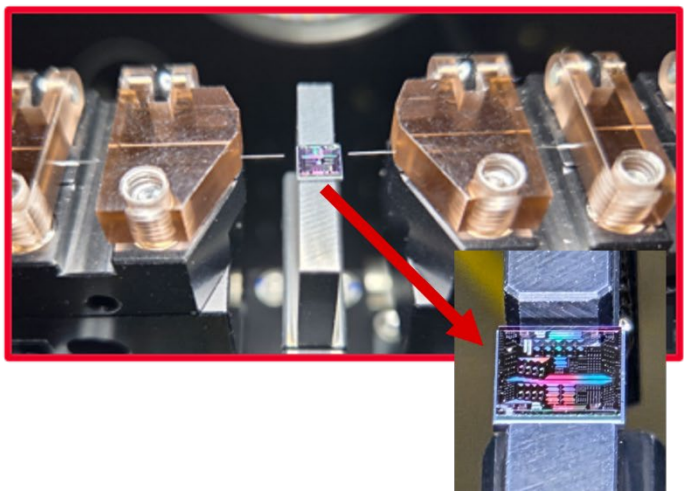
Storage

For optimal long-term reliability, store bare die in a dry cabinet maintained at **<10% RH** and a temperature of **18 °C to 28 °C**. To prevent contamination and damage during storage and handling, do not handle the die with bare hands. The die must be kept free from dust, oils, and other potential contaminants.

Features

- Dimensions: 4 mm x 4 mm





Applications

- A Device Under Test (DUT) for the Parametric Test and On-Wafer Measurement Teaching Lab solution.
- A lower cost DUT in replacement of a real semiconductor wafer for teaching in the universities.

Hardware and Software Configuration Requirements

Item	Description	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6
N7778C	Swept Wavelength Source	√	√	√	√	√	√
N774xC	Optical Power Meter	√	√	√	√	√	√
N778xC	Polarization Controller and Analyzer				√	√	√
B2901CL	Source Measure Unit (SMU)						√
N770010xC	Photonic Application Suite (PAS)			√		√	√
UU103LAB-DUT	Keysight Photonic Integrated Circuit (PIC)	√	√	√	√	√	
Probe Station*	Photonic Manual Probe Station	√	√	√	√	√	√

*Customer-supplied equipment. Contact your Keysight sales representative for recommended equipment or further information.

Regulatory Compliance

Regulatory Markings

The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives.

The UKCA (UK Conformity Assessed) marking is a UK product marking that is used for goods being placed on the market in Great Britain (England, Wales, and Scotland).

This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use.

Forty years is the expected useful life of the product.

Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU

The crossed out wheeled bin symbol indicates that separate collection for waste electric and electronic equipment (WEEE) is required, as obligated by the EU DIRECTIVE and other National legislation.

Please refer to keysight.com/go/takeback to understand your Trade in options with Keysight in addition to product takeback instructions.

Ordering Information

Product Number	Description	
UU103LAB	**Photonic IC Measurement Teaching Lab**	
	UU103LAB-100	N7778C (Tunable Laser Source, High Power and Low SSE, Value Line, Wavelengths 1490 nm -1640 nm), 1 unit Connector Interface
	[*Optional*] **UU103LAB-200**	N7788C Component Analyzer (1240 nm to 1650 nm), Angled Connect Connector, 3 units Connector Interface
	UU103LAB-300	N7742C Optical Multiport Power Meter (2-channel, Standard Wavelength) with Analog Output, 2 units Connector Interface FC
	[*Optional*] **UU103LAB-400**	B2901CL (Precision Source/Measure Unit, 1ch, 1 pA resolution, 21 V, 1.5 A), GPIO BNC Trigger Adapter, Kelvin Probe Set
	[*Optional*] **UU103LAB-500**	N7786C Polarization Synthesizer, Optimized for Optical C/L-Band, Angled Contact Connectors, 2 units Connector Interface
	UU103LAB-DUT	Photonic IC Measurement Teaching Lab DUT
	N7700100C[1]	Polarization-Lambdascan Measurement Software Package (PLS)
	N7700102C[2]	Fast Lambdascan Measurement Software Package (FLS)
	UU103-90002	Lab sheets
Optional		
Probe station[3]		

1. Select if **UU103LAB-200** or **UU103LAB-500** is selected.
2. Select if **UU103LAB-200** or **UU103LAB-500** is **NOT** selected.
3. Customer-supplied equipment. Contact your Keysight sales representative for recommended equipment or further information.

Conclusion

This lab series offers a robust educational framework for the next generation of optical engineers. By combining Keysight instrumentation with practical semiconductor handling, students transition from fundamental theory to industrial-grade proficiency. The skills acquired form the essential foundation for high-precision optical testing, photonic device design, and system-level performance optimization.

For sample materials, alignment support, and ordering information, contact your Keysight representative or visit keysight.com.