SWTEST
2026 CONFERENCE

35th ANNIVERSARY

Demonstration of Integrated Sources and Detectors Used for ATE Optical Wafer Testing of Silicon Photonic ASICs

OpenLight™

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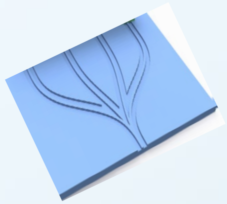
OpenLight Photonics

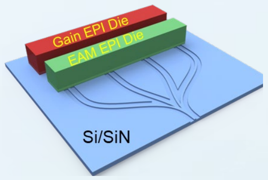
Overview

- Silicon photonics heterogenous integration technology
- Wafer and die test platforms
- Wafer ATE testing of photonic ASICs (PASICs)
  - Example 1: 1.6T transmitter with distributed feedback (DFB) lasers
  - Example 2: CWDM transmitter with tunable ring lasers (TRL)
- Summary

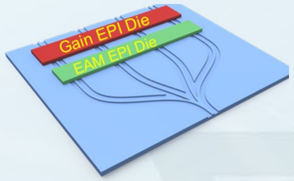
Heterogeneous Silicon Photonics Platform



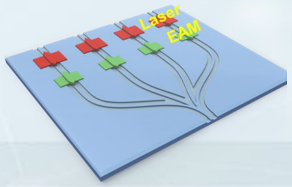
Patterned SiPh wafer with Si and SiN passives



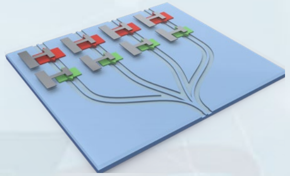
Multiple EPI die placement and bonding



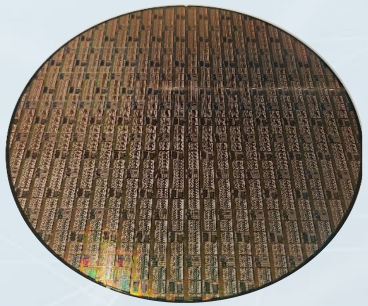
Substrate removal



III-V processing

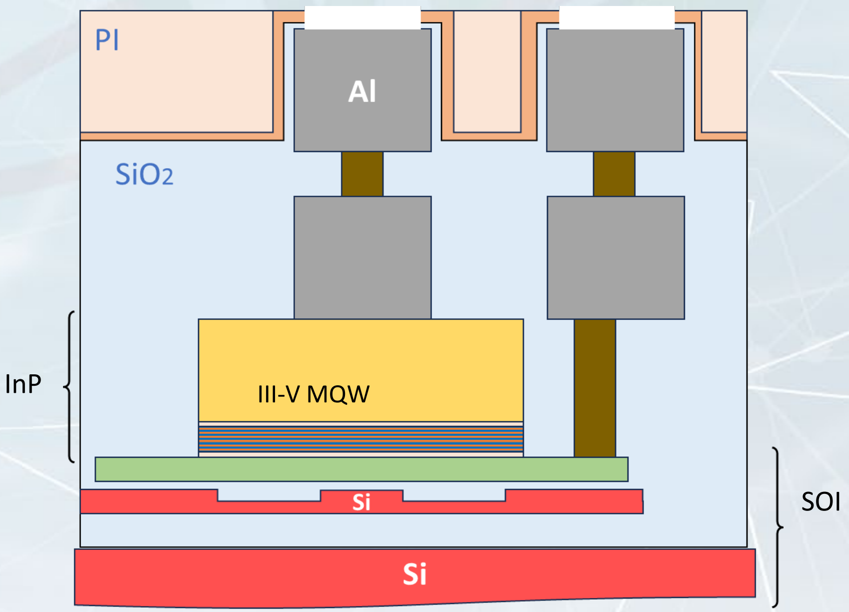


Metal and hermetic sealing



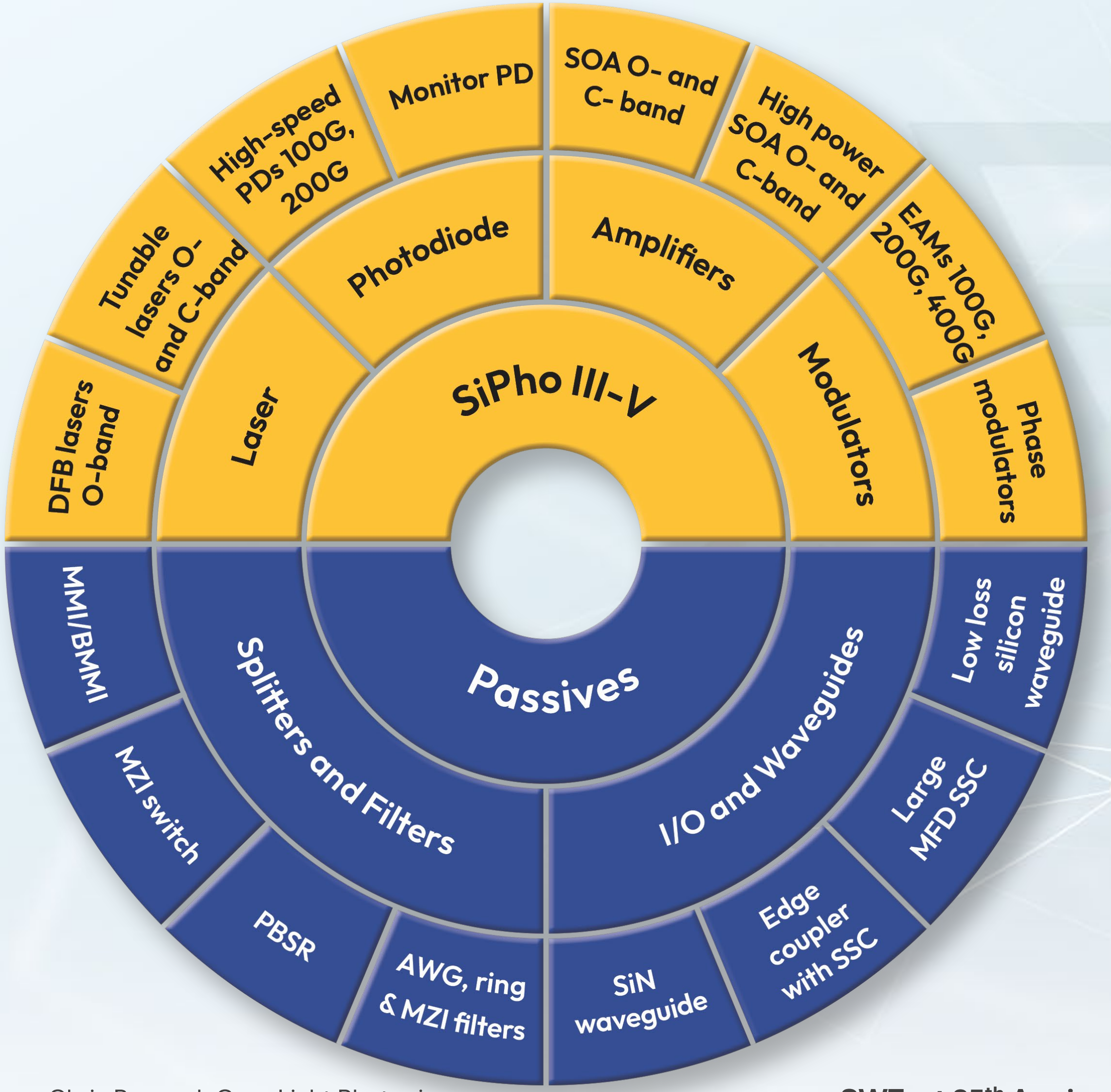
Heterogeneous SiPh wafer

Device cross section



OpenLight Process Design Kit (PDK)

Full component library for photonics ASIC design

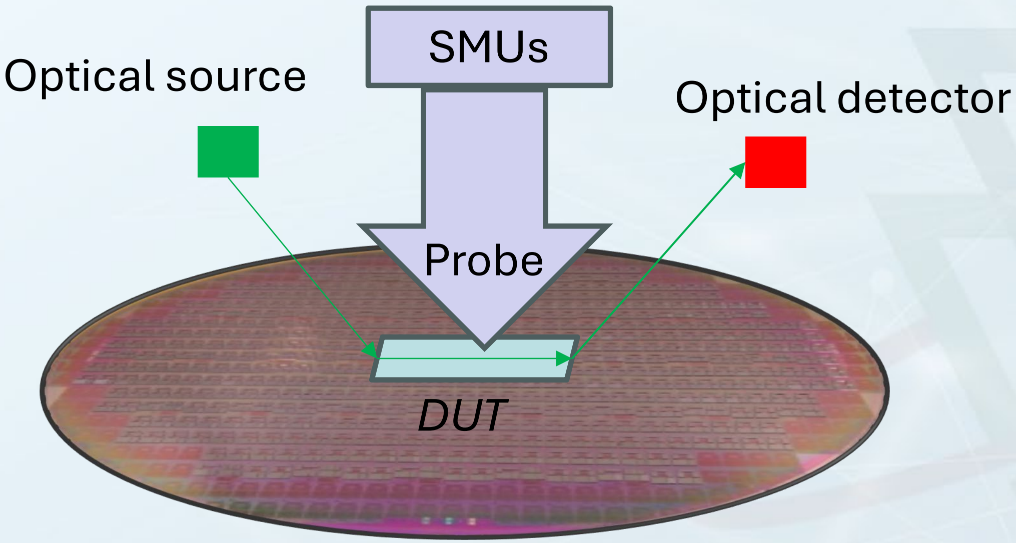


Summary

- PDK enables our customers to design PASICs for diverse applications (Datacom, AI/ML, OXC, laser banks, LiDAR, medical sensing)
- 8" wafers via commercial CMOS foundry
- Test gratings and wafer bumps are on the top side for (single-side probing)
- Flip-chip or wire-bonding packaging
- More than 25 customers designing PASICs on this platform
- OpenLight provides test services at the die, wafer, and package level with full PASIC testing on an ATE using integrated light sources

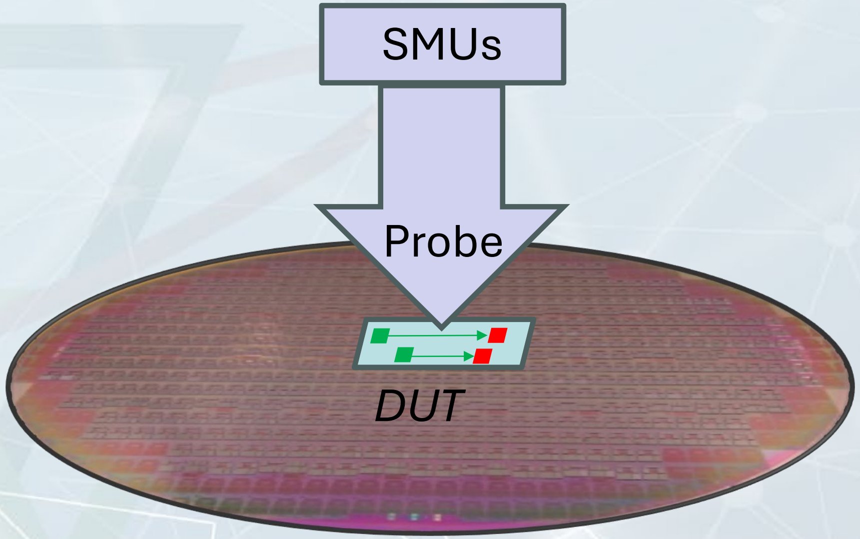
Wafer Optical Test Comparison

Without integrated sources and detectors



- Requires active optical positioners (hexapods)
- Difficult to calibrate optical losses
- Test coverage limited by I/O ports
- Tunable laser provides loss vs. wavelength

With integrated sources and detectors



- Test coverage limited to source and detector layout
- Many source to detector paths can be tested in parallel
- Zero added cost for testing with integrated devices
- Wavelength dependence requires integrated tunable laser

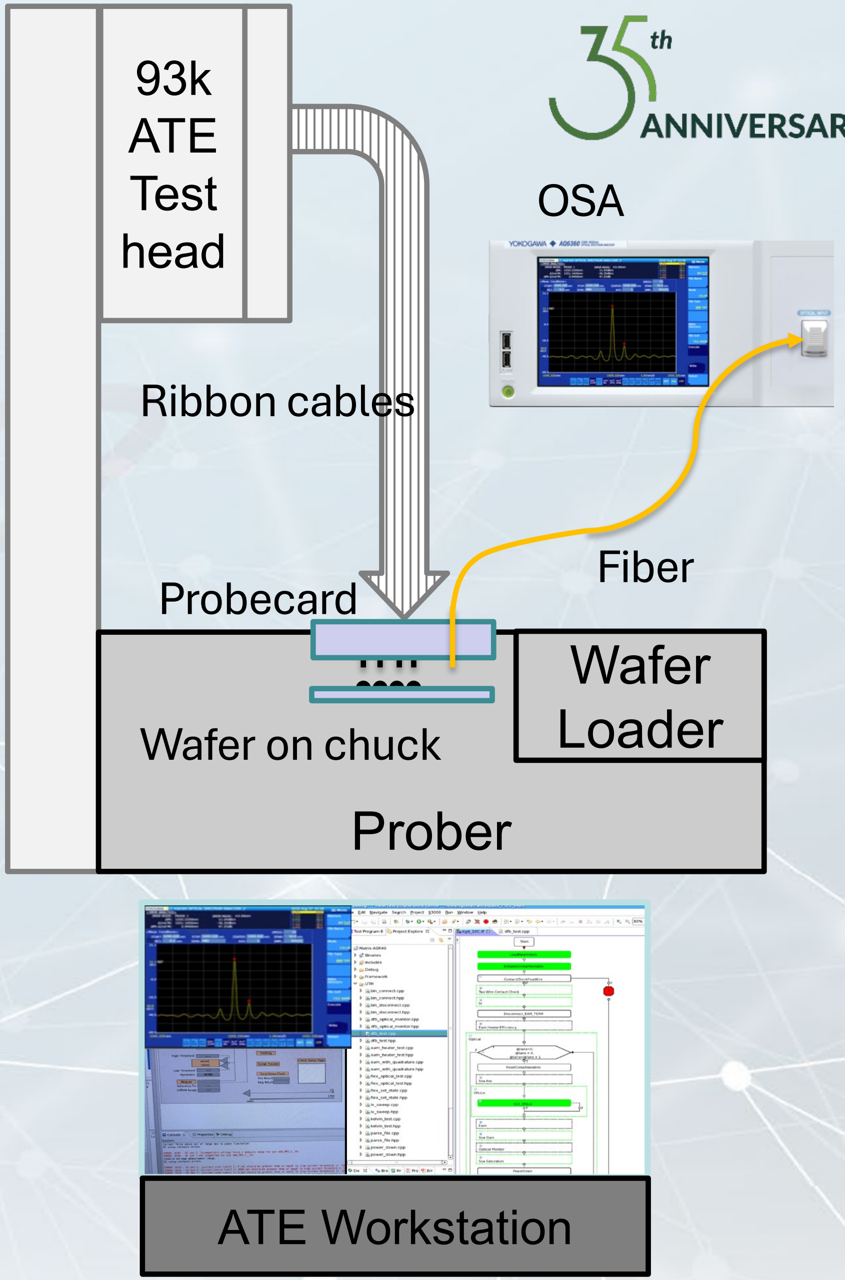
Integrated Light Sources

Source	Max AVI64 (200 mA) Power	Spectrum
Distributed Feedback Laser (DFB)	35 mW	Single mode at grating wavelength
Tunable Ring Laser (TRL)	30 mW	Single mode tunable over 35 nm
Fabry-Perot Laser (FPL)	25 mW	Multimode
Semiconductor Optical Amplifier (SOA)	0.5 mW	Broadband in both directions

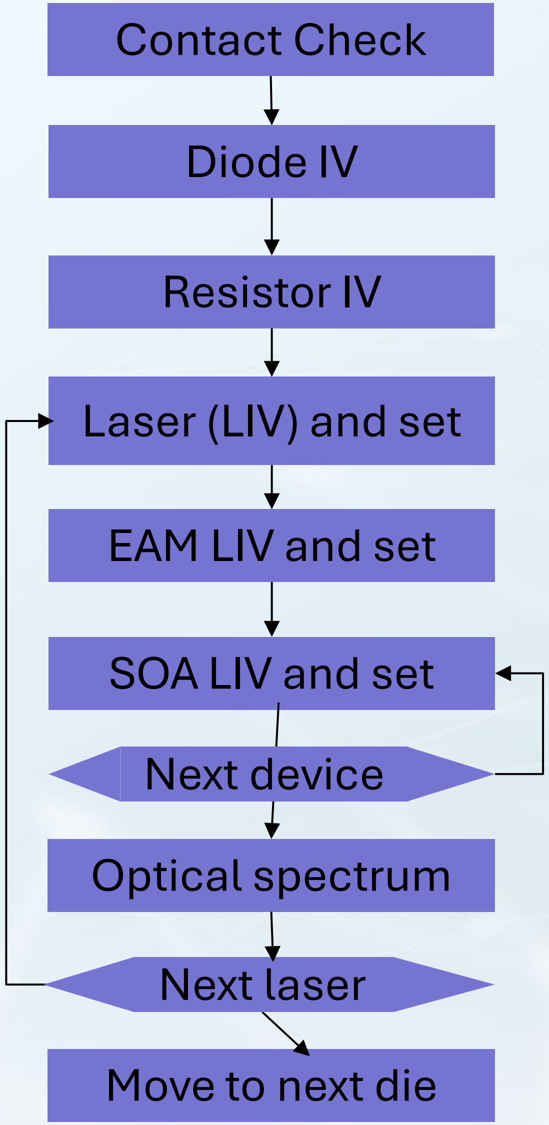
- Source may be integrated into the PIC, or only used for test
- Tap monitor photodiodes measure internal transmission
- SOA can be reversed bias as a photo detector during test
- TRL measures wavelength response of downstream devices

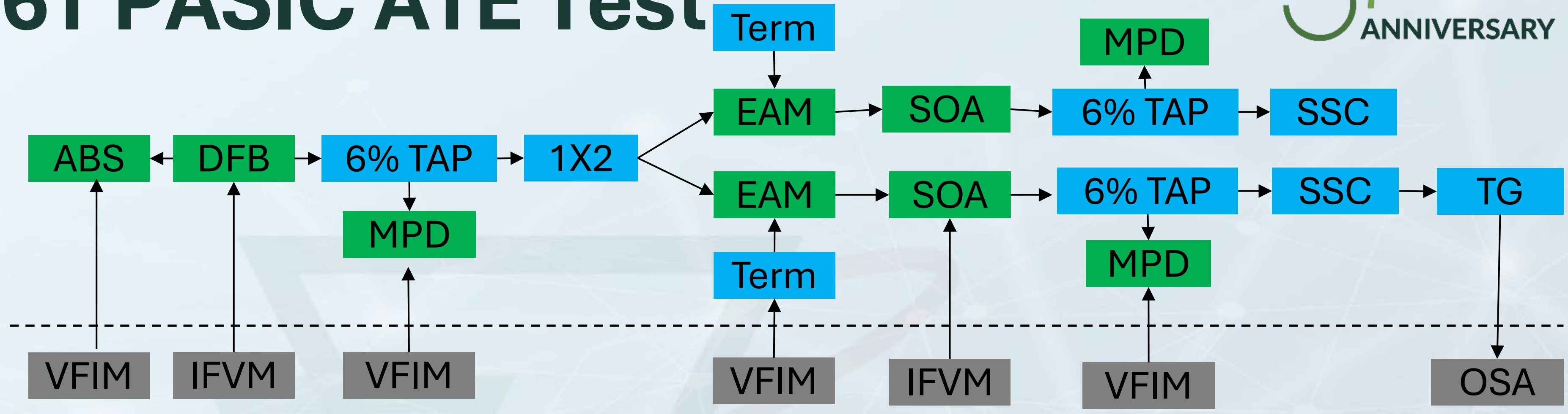
ATE PASIC Wafer Testing

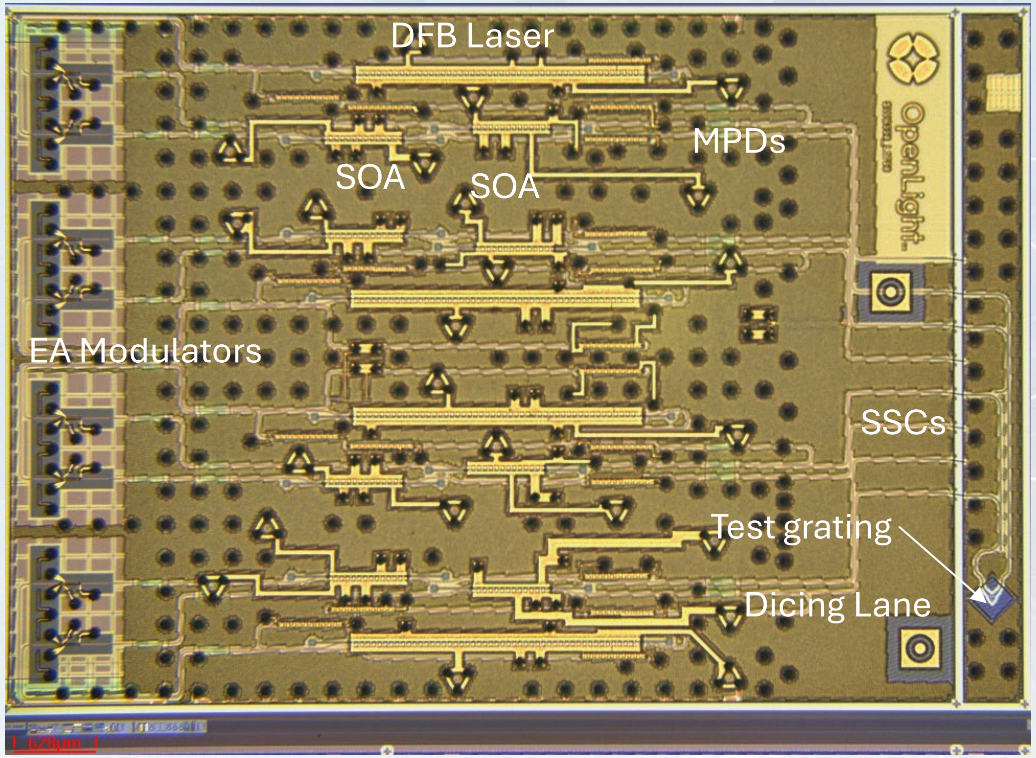
- > 300 devices on the PASIC probed simultaneously
- Optical power and transmission measured with embedded detectors
- Fiber output to OSA measures laser wavelength and SMSR
- Software takes advantage of 93K parallel testing
- Hardware:
  - — Advantest 9300K test head with qty 5 AVI64 cards
    - — Up to 200 mA in IFVM mode
  - — Accretech 8-inch prober with cooled chuck
  - — JEM vertical pin probe card with fiber holder
  - — Yokogawa OSA
- Software:
  - — Advantest SmartTest 7.4.2 with C++ test methods
  - — OSA download integrated into SmartTest software
  - — Offline python analysis



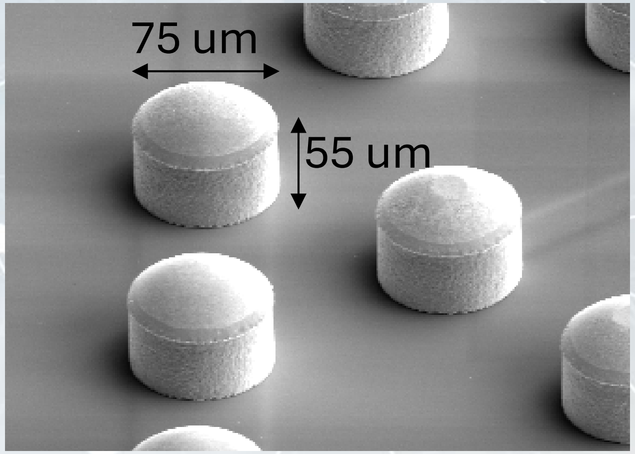
Example 1: 1.6T PASIC ATE Test



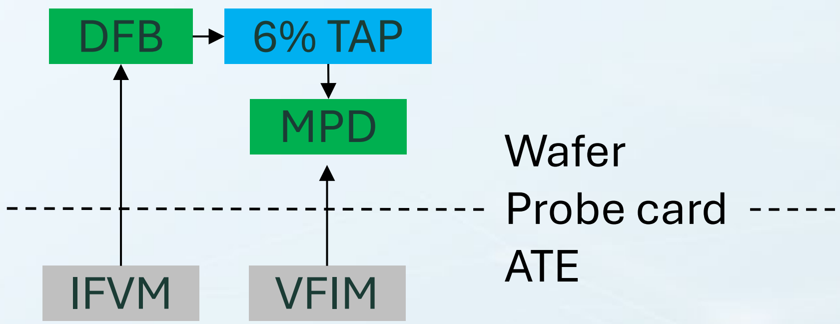


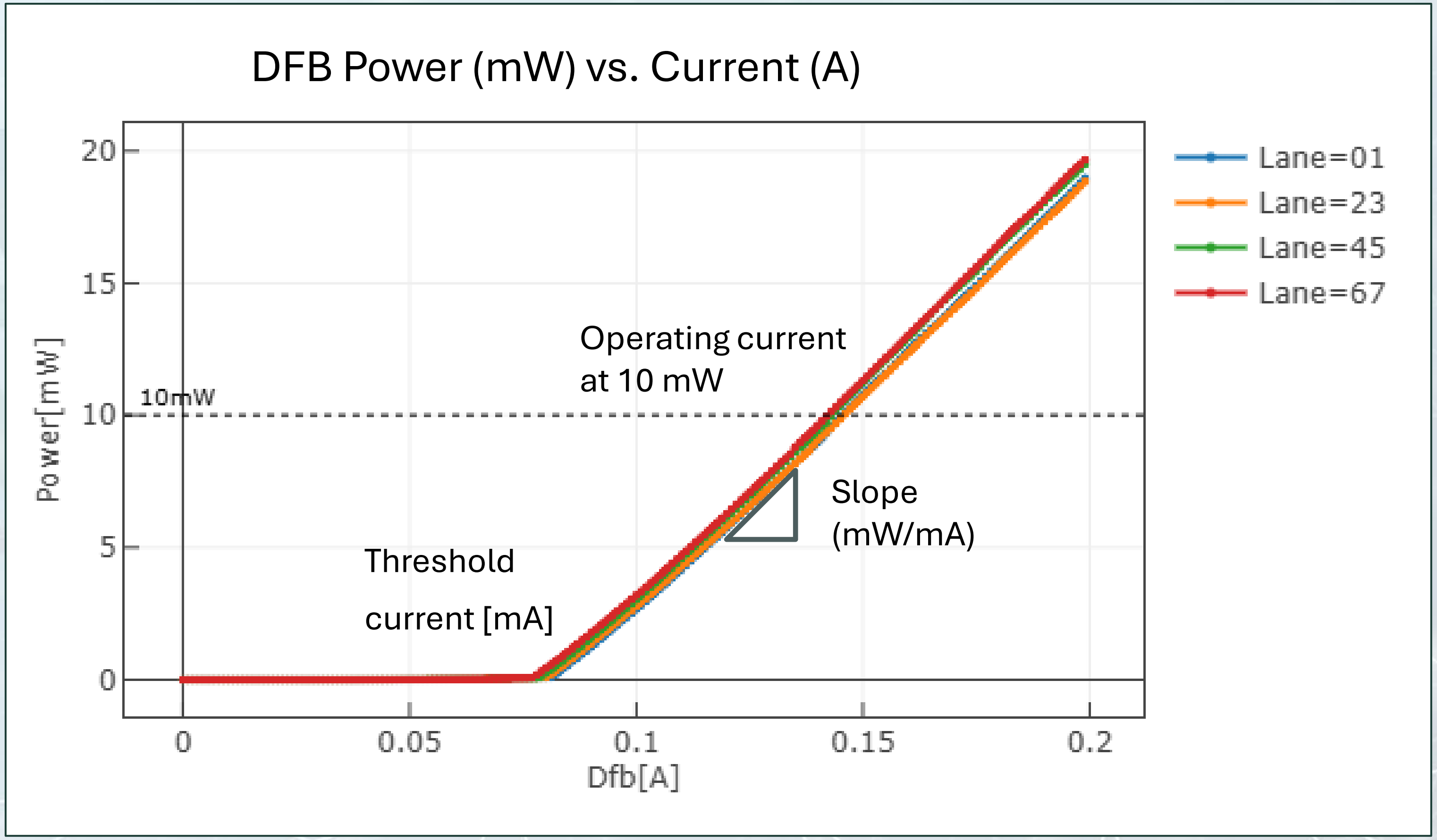


Solder bumps



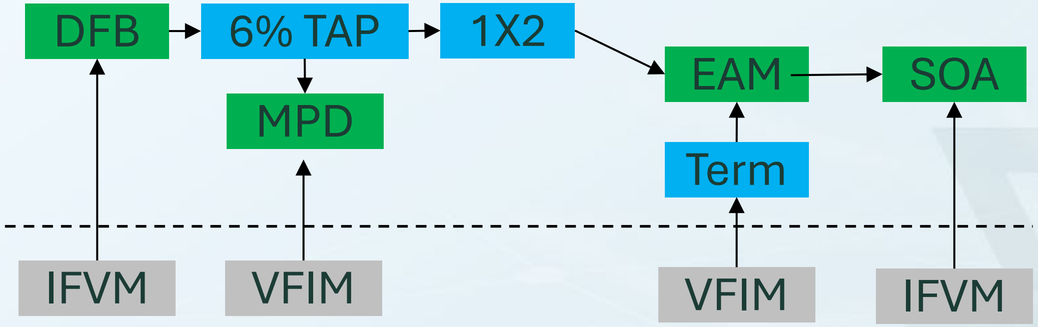
DFB LIV (Light vs. Current and Voltage)

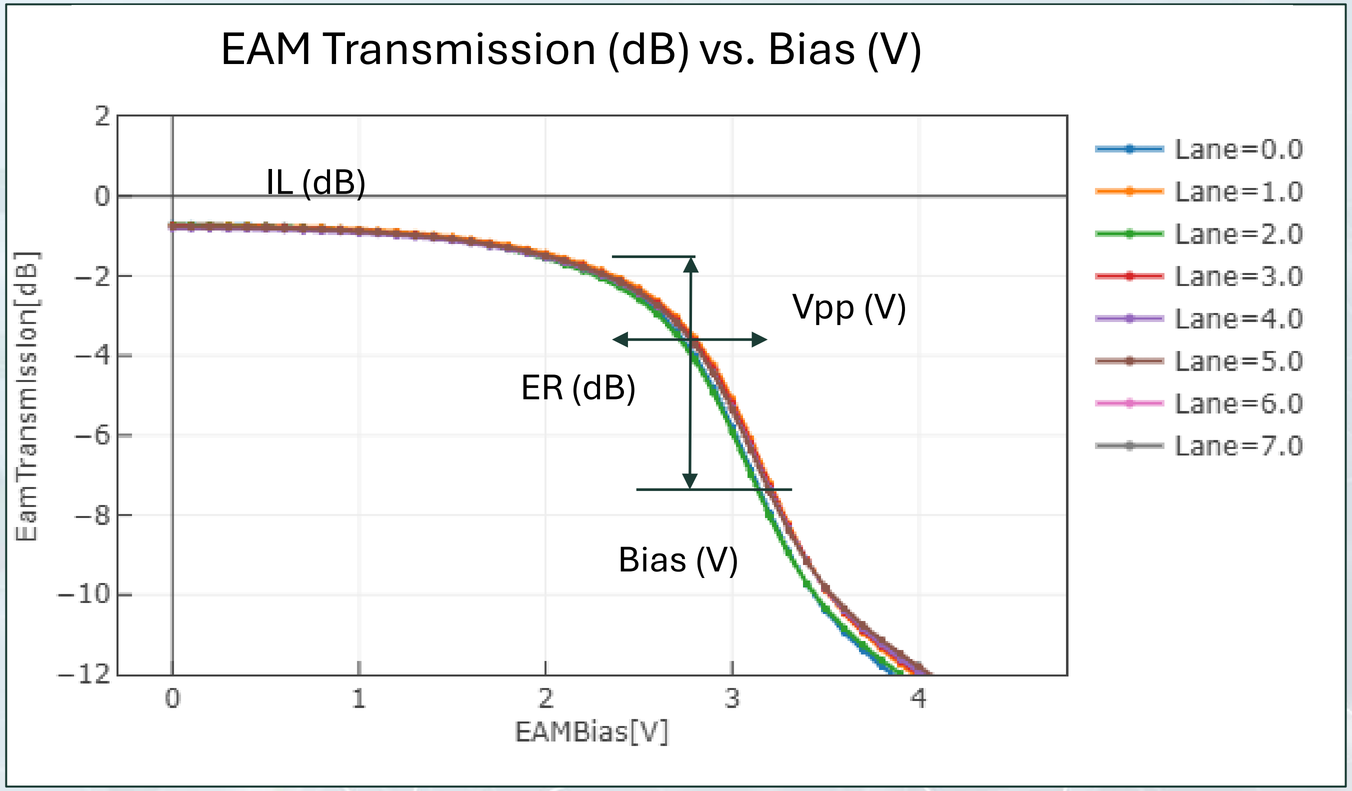




- 1st AVI64 channel provides DFB current drive
- Second AVI channel biases the detector and measures the photocurrent
- Channel ganging to measure up to 400 mA
- Parameter extraction:
  - Threshold current and voltage
  - Slope
  - Operating current and voltage at a target power
  - Wallplug efficiency

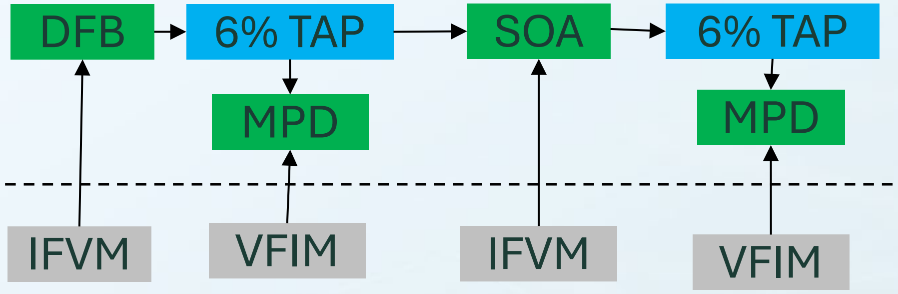
Electroabsorption Modulator



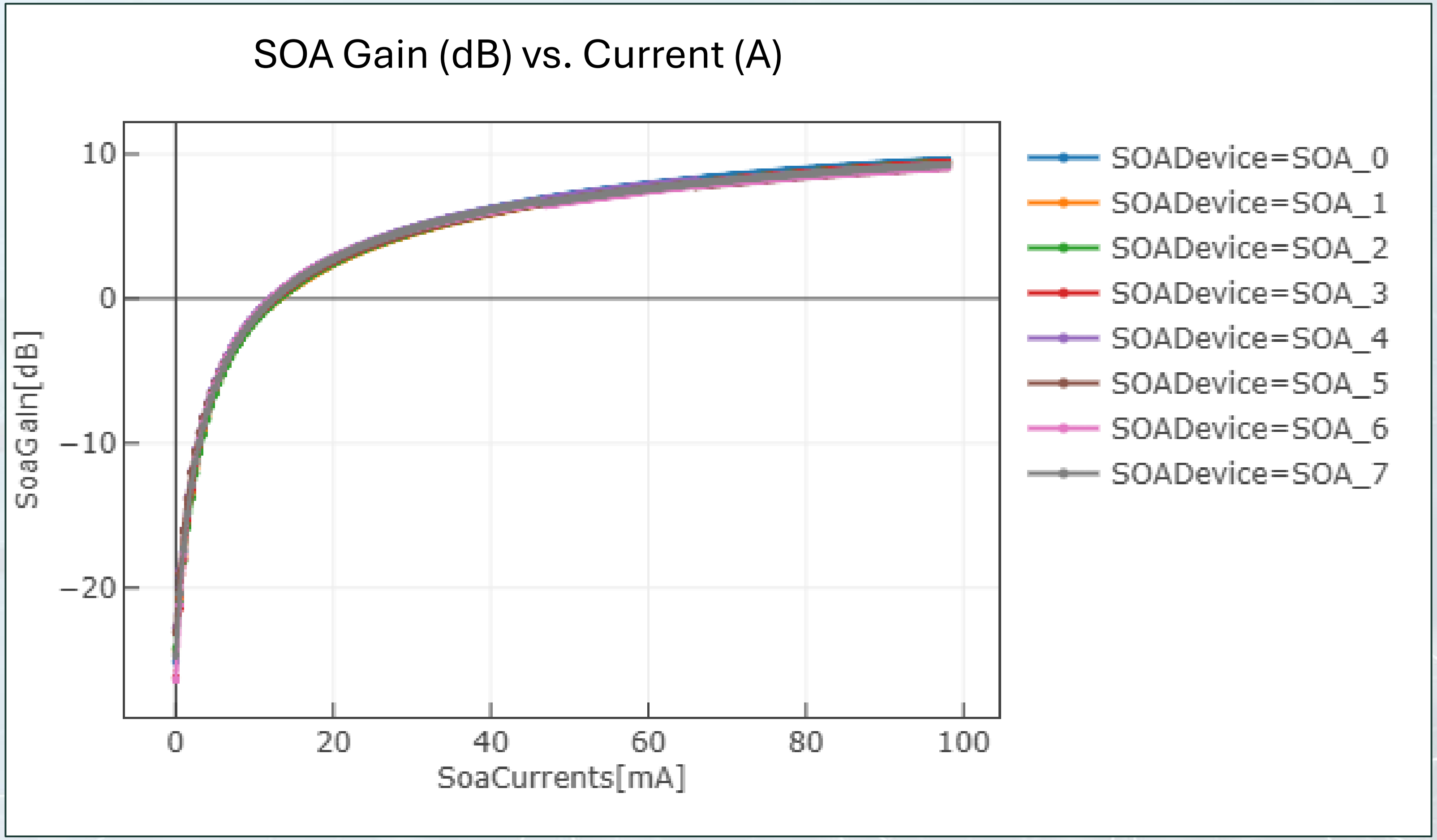


- DFB laser is set to a target power
- SOA is reversed bias to be used as a photodector
- EAM bias voltage applied while photocurrent measured on the SOA and EAM
- Parameter extraction:
  - Insertion loss (dB)
  - Optimum bias point (V)
  - Extinction ratio as a function of Vpp
  - Optical modulation amplitude of Vpp

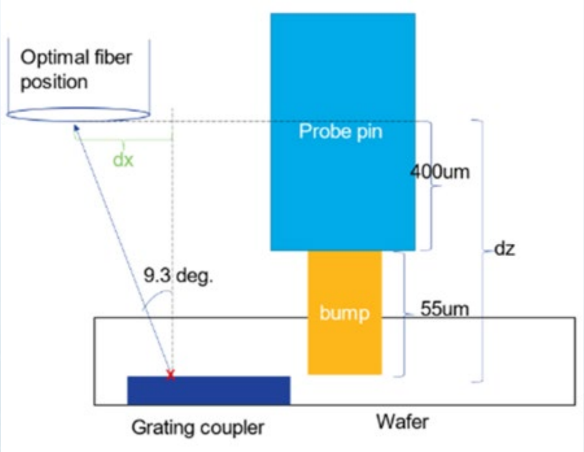
SOA Gain



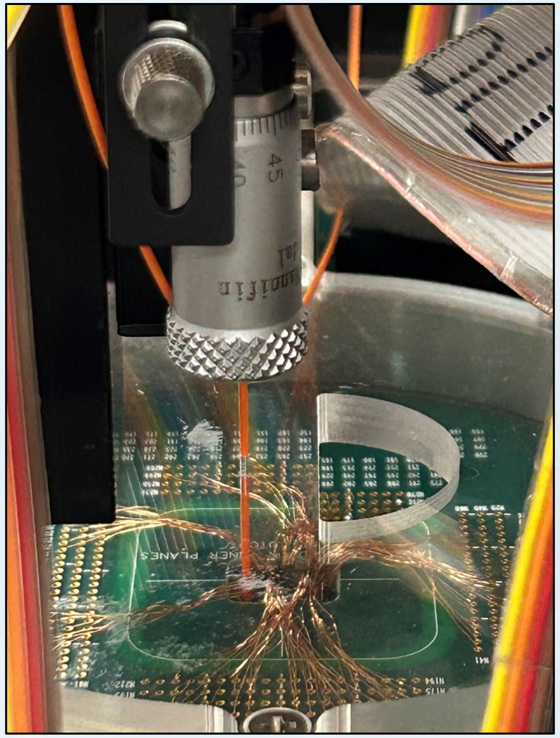
- DFB laser is set to a target power
- SOA input power measured in reverse bias
- SOA bias current while measuring gain with the output MPD
- Parameter extraction:
  - Maximum gain
  - Maximum output power
  - 1 dB saturation power
  - On/off extinction ratio



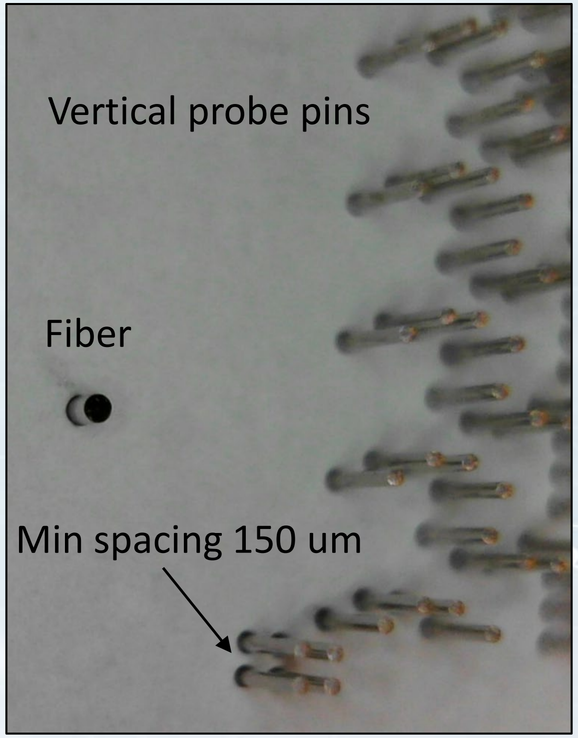
ATE Probecard with Vertical Fiber



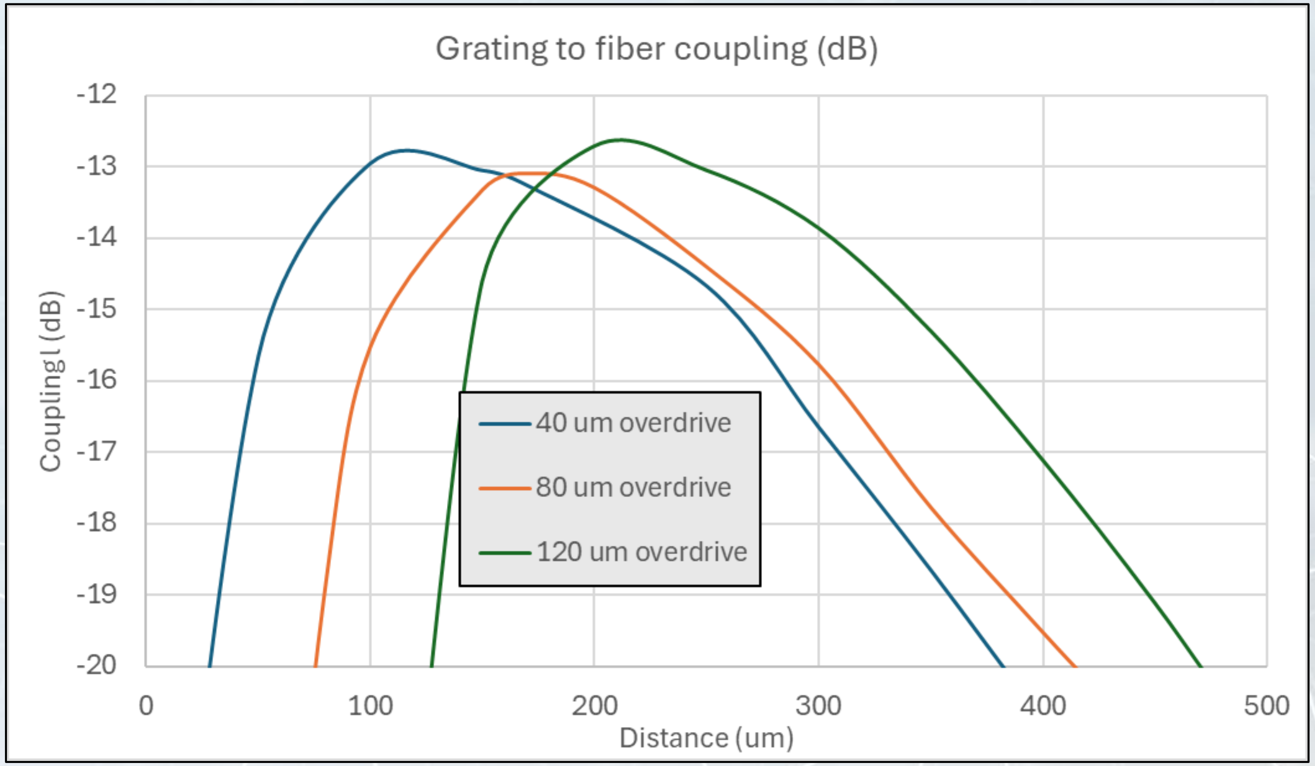
200 um tolerance for 1 dB variation in coupling loss → passive positioning is acceptable



Fiber vertical positioner

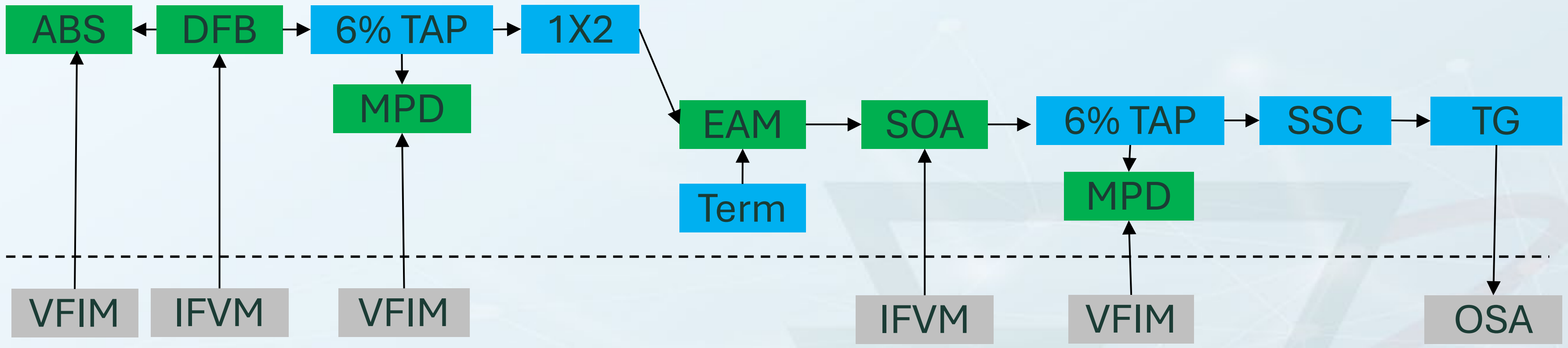


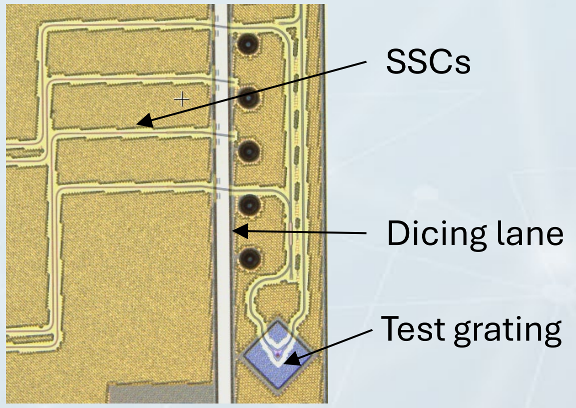
Probe tips with fiber

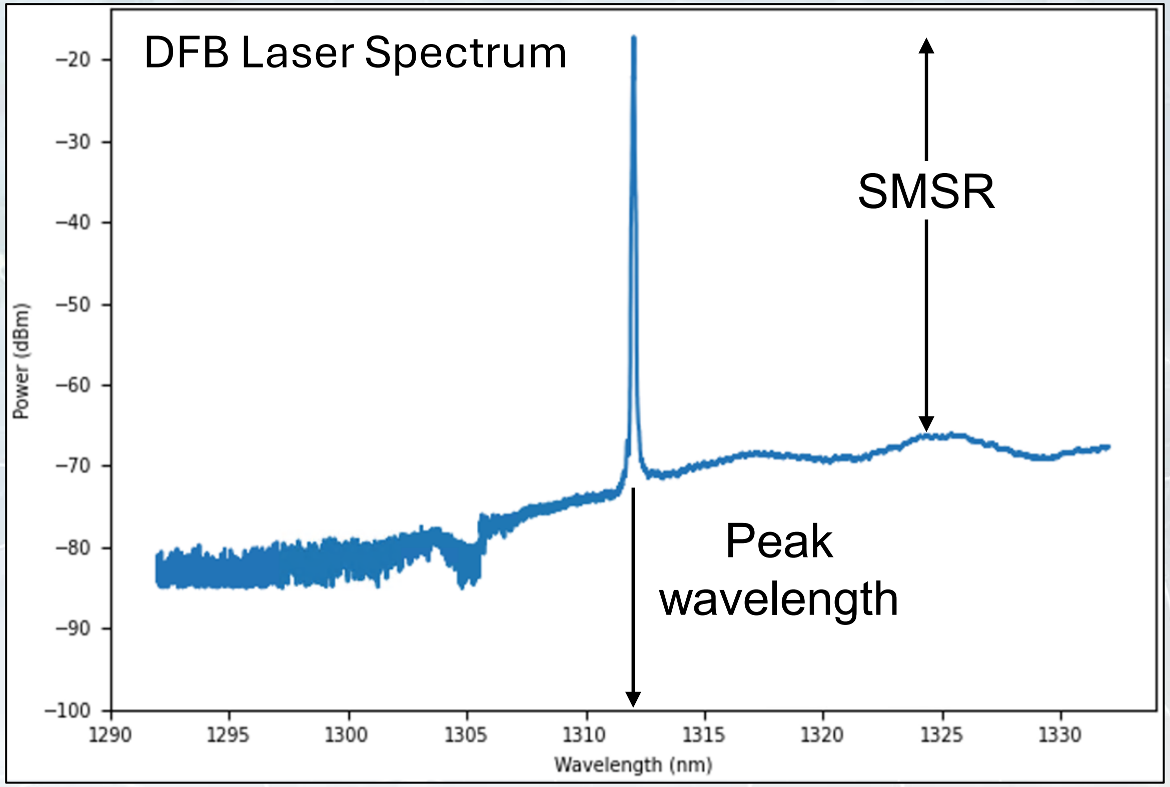


Loss to fiber vs relative fiber position

OSA Measurement

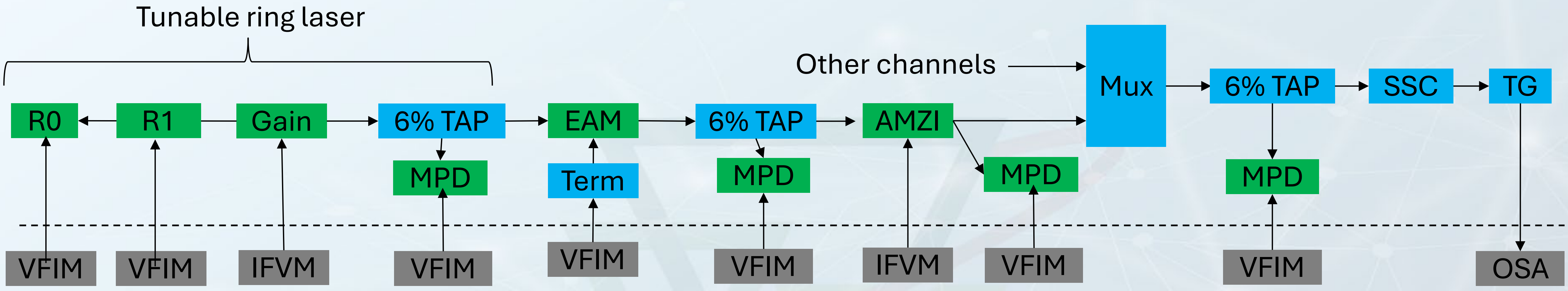






- Optional grating to OSA to measure:
  - DFB Laser wavelength
  - DFB Laser Side Mode Suppression Ratio (SMSR)
  - Tunable laser wavelength
  - Device loss vs. wavelength

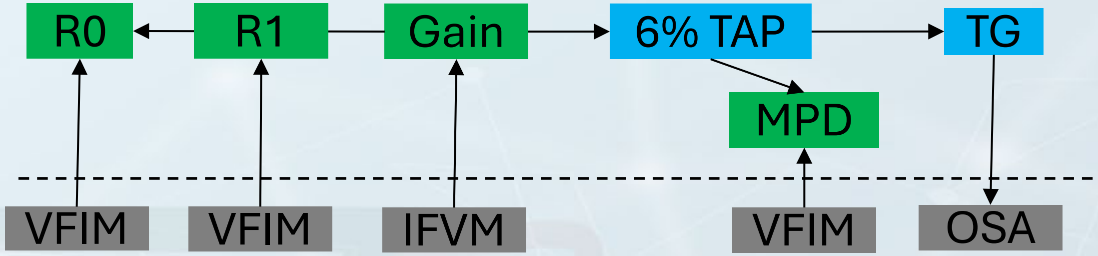
Example 2: CWDM TRL Transmitter

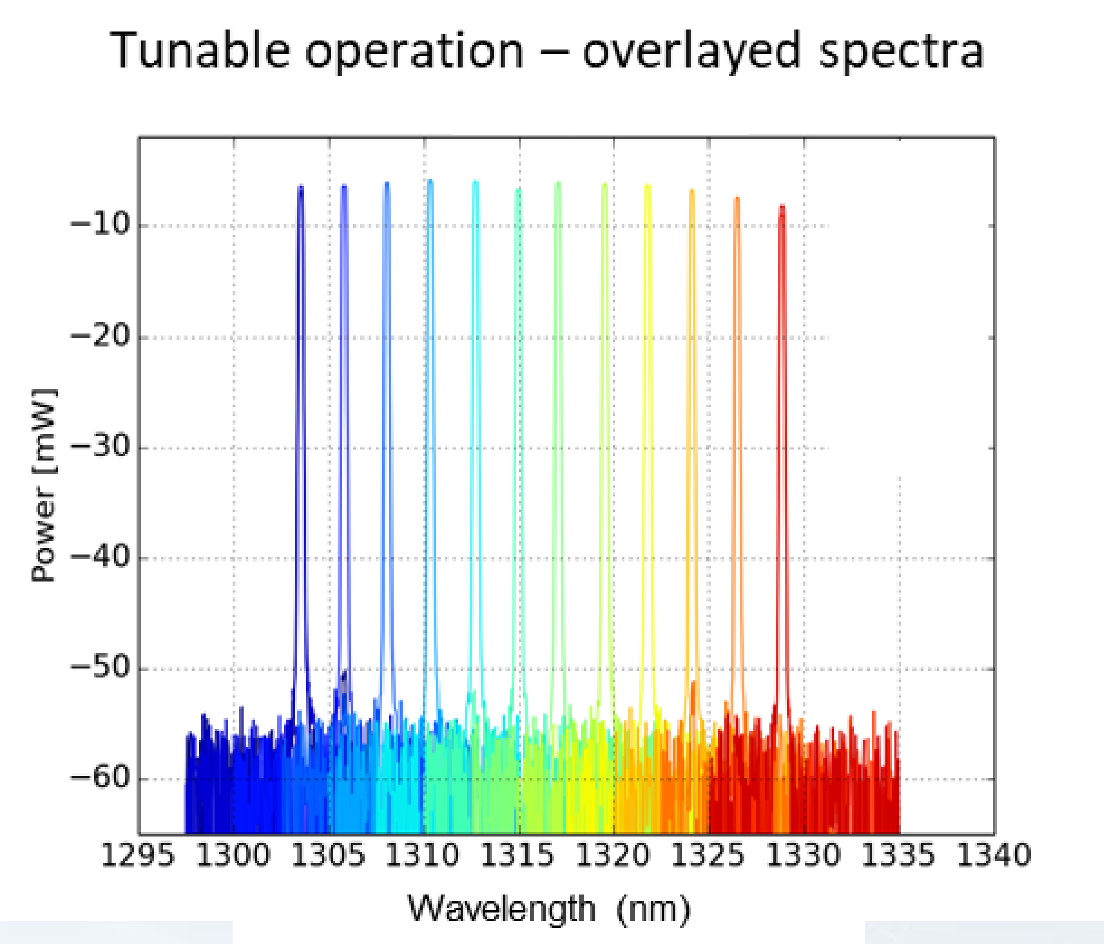


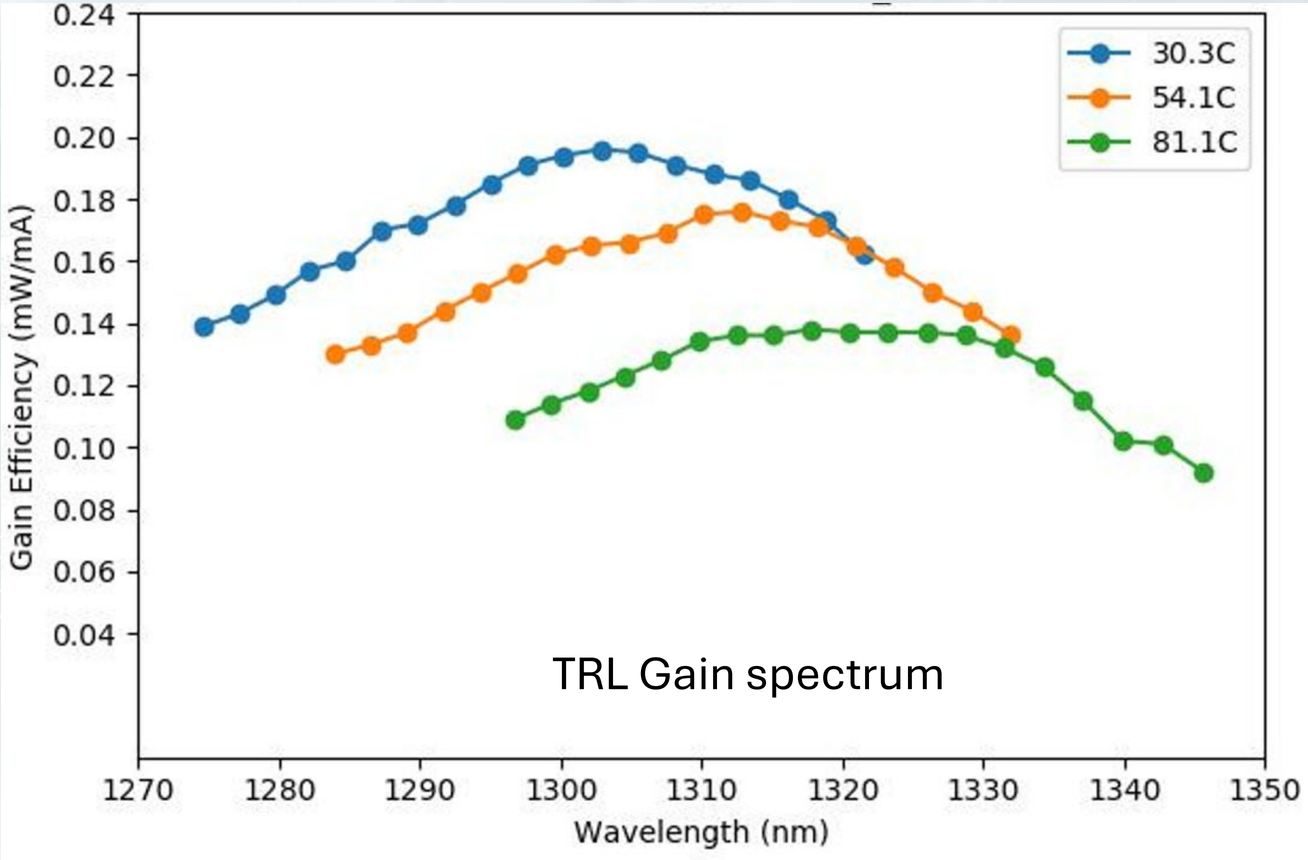
- Tunable ring laser (TRL) laser is set at the target wavelength of each channel
- OSA is used to measure TRL wavelength and component loss vs. wavelength

TRL Wavelength Measurement

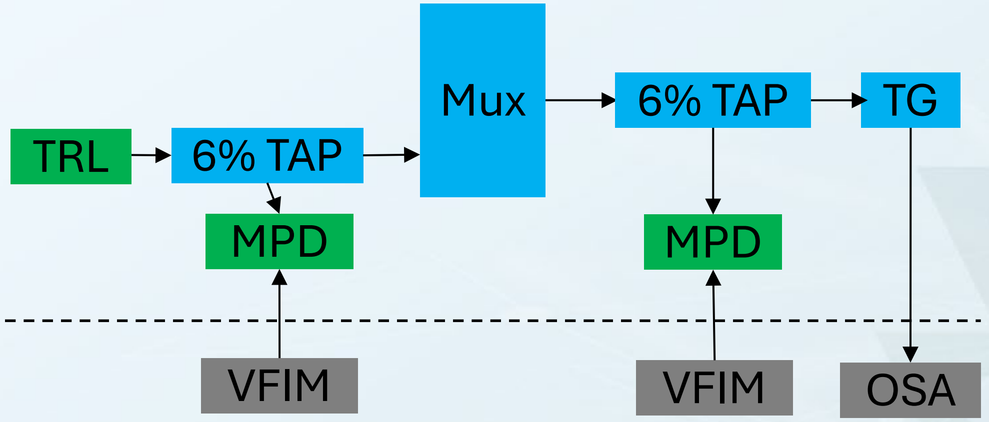
- OSA measures the laser spectrum and gain profile

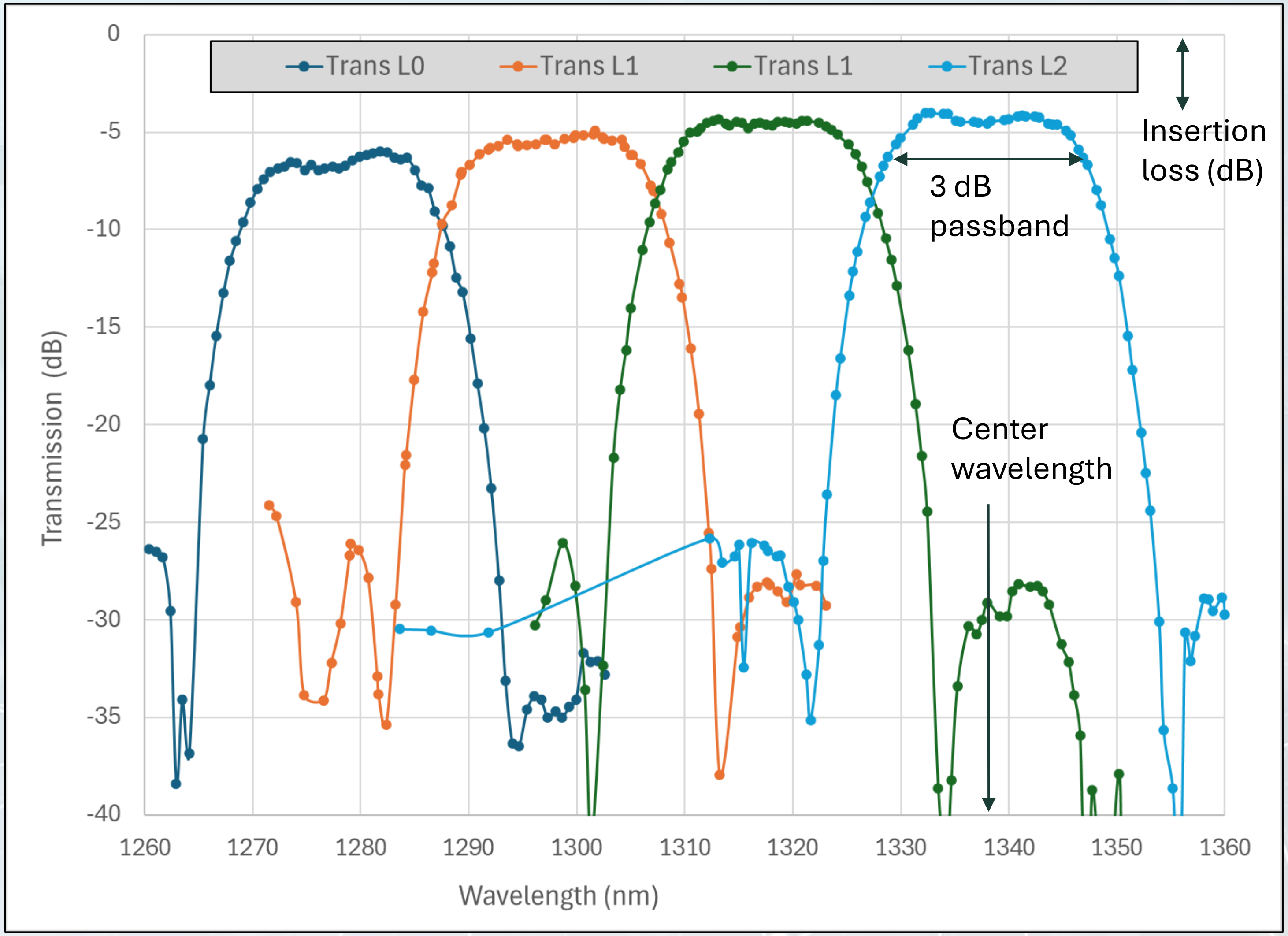






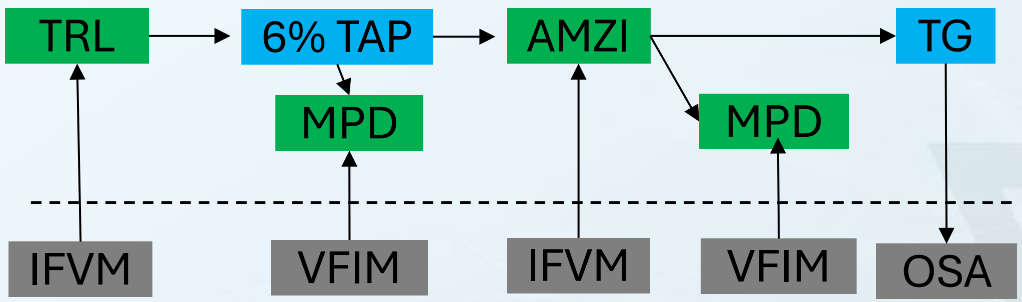
Multiplexer Transmission vs. Wavelength



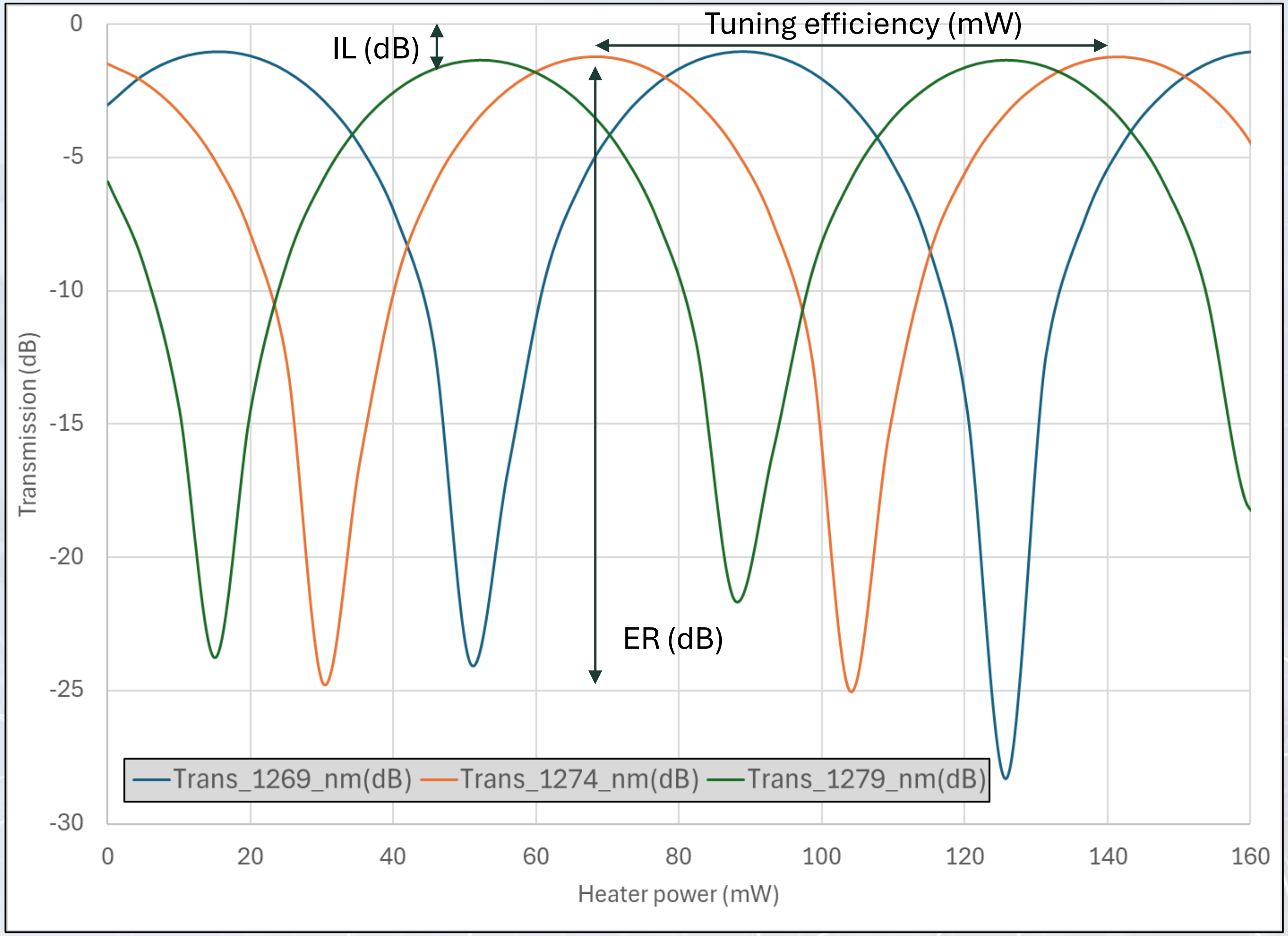


- TRL is tuned across the MUX passband
- OSA reads TRL wavelength
- Ratio of MPD signals measures the Mux transmission vs wavelength
- Analysis determines:
  - Insertion loss
  - Center wavelengths
  - 3 dB passband

AMZI Filter/Switch Transmission

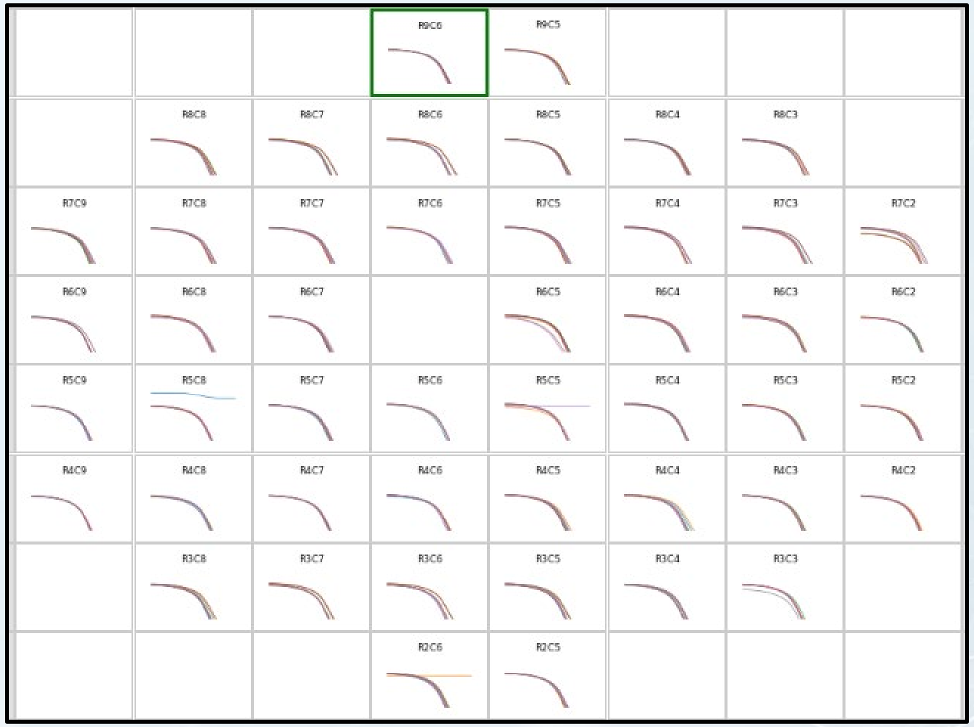


- TRL wavelength is set with the OSA reading
- Asymmetric Mach Zehnder Interferometer heater power is swept while measuring ratio of MPD signals
- Analysis determines:
  - Insertion loss
  - Extinction ratio
  - Heater tuning efficiency
  - Max/min bias points
  - 3 dB passband
  - Free spectral range



Full Wafer Test

- Automated test runs on wafer lots of 5-25
- Specifications applied to the extracted parameters for die pass fail
- Binning SINF files sent to dicing partner



Wafer grid of EAM transmission

Binning wafer plot

Summary

- Standard ATE and prober equipment enables volume production
- Integrated sources and detectors enable parallel electrical wafer testing
- Tunable laser enables device transmission spectra testing
- Passive coupling to OSA provides wavelength and SMSR

Acronyms and Abbreviations

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2D = Two Dimensional
AI/ML = Artificial Intelligence/Machine Learning
AMZI = Asymmetrical Mach-Zehnder Interferometer
ATE = Automated Test Equipment
AVI64 = 64-channel Analog Voltage Current SMU from Advantet
CMOS = Complimentary Metal-Oxide Semiconductor
dB = decibels
dBm = decibel-milliwatts
DFB = Distributed Feedback
DUT = Device Under Test
EAM = Electro-Absorption Modulator
EPI = Epitaxy
I/O = Input/Output
IFVM = Current Force/Voltage Measure Mode (IFVM)
JEM = Japan Electronic Materials Corporation
LIDAR = Light Detection and Ranging
LIV = Light Current Voltage
mA = MilliAmperes
Max/Min = Maximum/Minimum
MPD = Monitor Photo Diode
OSA = Optical Spectrum Analyzer
OXC = Optical Cross Connect Switch
PASIC = Photonic Application Specific Integrated Circuit
PDK = Process Design Kit
SiPh = Silicon Photonics
SINF = Simplified Integrator Nested Format
SMSR = Side Mode Suppression Ratio
SMU = Source Measurement Unit
SOA = Semiconductor Optical Amplifier
SSC = Spot-Size Converter
TRL = Tunable Ring Laser
um = Micrometers
VFIM = Voltage Force/Current Measure Mode (VFIM)
Vpp = Peak to Peak Voltage

Thank You !

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