



Silicon Photonic On-Wafer Test



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Overview

- **About CompoundTek and STAr Technologies**
- **Need for Silicon Photonics (SiPh) Wafer Test**
- **Silicon Photonics Wafer Test Solution**
 - Prober Layout and DUT Layout
 - Types of Optical Coupling
 - GRnR Results
 - Typical SiPh Test Items
 - Video Demonstration
- **Summary**

Our Commitment



Deliver leading edge Open-Source silicon photonics platform





Accelerate time-to-market




Founded by Industry Experts.


“Virtual fab business model” with proprietary technology

- 

2017 Operations began with patented manufacturing technology running in our fab partner
- 

> 20 Commercial Customers in 9 different countries are served by our cutting-edge SiPh foundry capabilities
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>25 International leading Research Institutes/ Universities are a part of our global SiPh ecosystem
- 

70 provisional filing/know-how in FY20 forms our large IP bank, capabilities are heavily promoted via media/press (22 releases, FY20) for differentiated branding
- 

1st globally embarking on a 8" & 12" agnostic SiPh commercial testing hub

Asia's 1st SiPh Foundry Agnostic Wafer Test Hub. Testing Centre of Excellence Operation

- Backed by CompoundTek's strategic partnerships with leading industry test equipment players (prober and instruments)
- 8" and 12" & O and C band ready
- Ideal for EO components, 400Gbit/s and higher
- State-Of-The-Art equipment (up to 67GHz LCA for e.g)
- Powered by in-House proprietary proven test executives
- Patented software coding with AI, big data analytic, up to 40% throughput improvement vs market benchmark
- Managed by team with proven track record

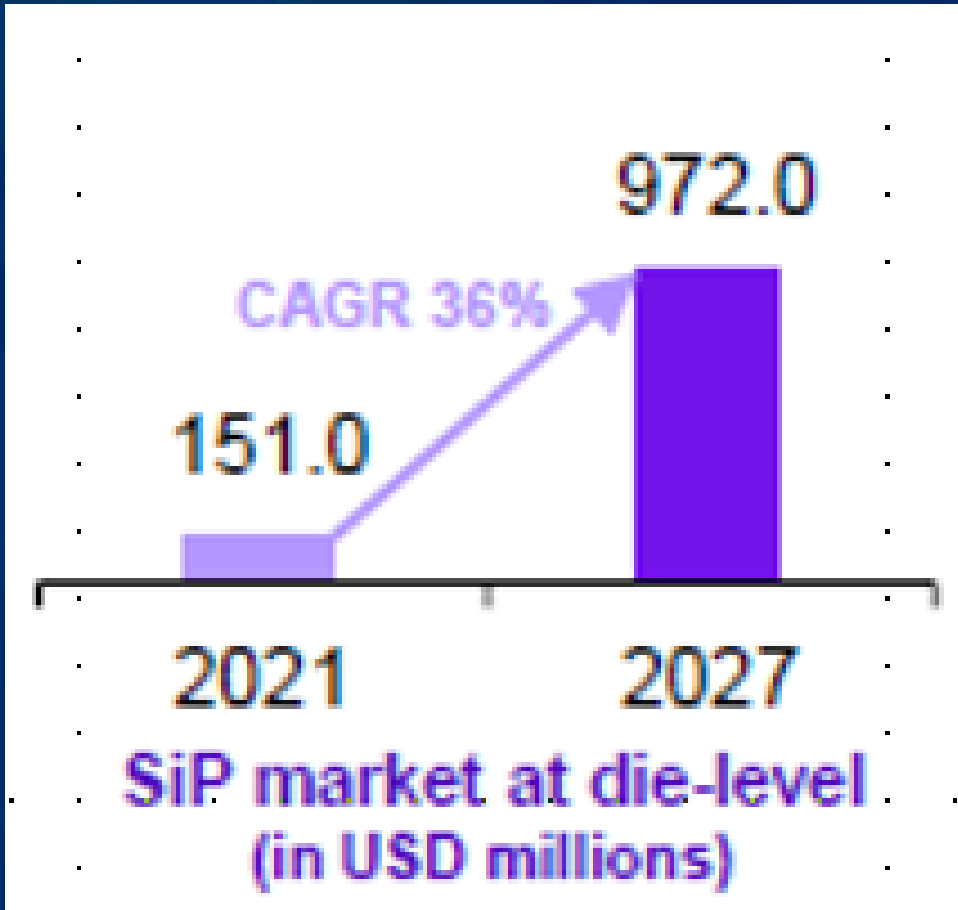


NEWS.

STAr Technologies Overview



SiPh Market Size



- **Increase predominantly driven by**
 - Data Communication such as transceivers,
 - Photonics Processing Applications
 - Smart Sensors such as LiDar
 - Consumer health applications, such as silicon photonics based biosensors in wearables

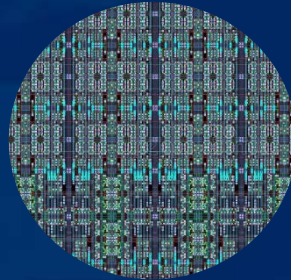
Source: (1) McKinsey: Imperatives for photonics companies in the next wave of growth (Jan 23)
(2) Yole: Silicon Photonics: To SOI and beyond (Aug 22); Yole: Silicon Photonics 2021 Market Technology report

SiPh Wafer Test Challenges



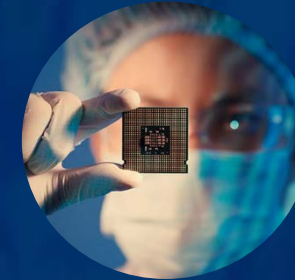
High technical complexity required

- Optics Testing unknown to existing OSATs
- Complex hardware/prober design for both Optical & Electrical test.
- High precision alignment of $<1\mu\text{m}$ a must, for optical light coupling in/out of Device-under-Test (DUT).
- No cost effective wafer test with edge coupling solution in market
 - Test done at vertical light coupling but actual application is edge coupling, mismatch between test & actual application can limit test coverage



Special layout rules and guidelines

- Recommend for new products to ensure Design for Testability
- Enforced during design phase. Designer to layout optical grating and electrical pads according to guidelines to ensure testability



Long test time, high test costs

- Long alignment time needed for optical coupling. Fast and repeatable optical coupling needed to ensure cost effective production testing

SiPh Wafer Test Solution



- 8"/12" wafer compatible.
- Vertical Coupling and **Edge Coupling** fiber array.
 - **CompoundTek Edge Coupling fiber array design coupled with STAR's Patented Edge Coupling Alignment SiPh Solution**
- Full O-band, C-Band and L-Band.
- Optical/electrical testing/RF Testing
- Suitable for mass volume production & cost-effective testing.

4th Annual SWTest Asia | Hsinchu, Taiwan, November 2-3, 2023

STAr SPT System Overview



- **Objectives**

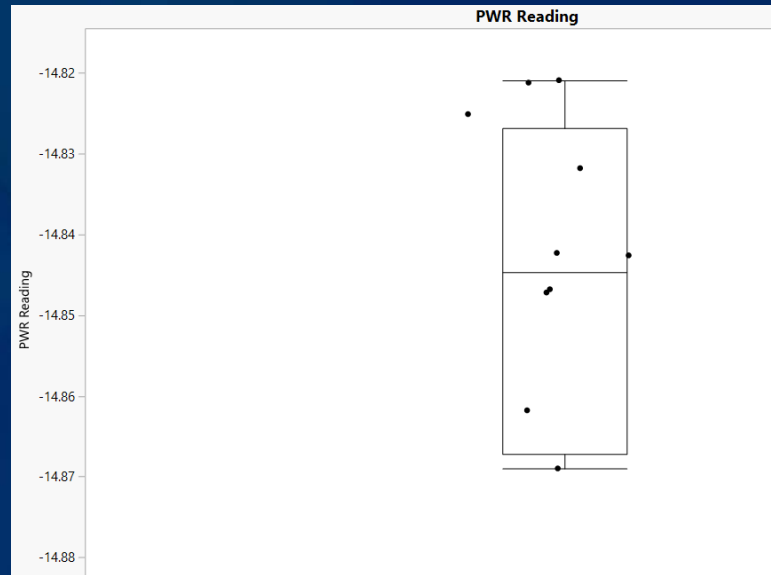
- To provide a cost effective semi-automated or full automation wafer-level test system for characterization and acceptance tests of silicon-photonics devices

- **System Capabilities**

- Characterization & Technology Development
- WAT/E-tests/Inline PCM
 - All E-tests parameters including process monitor control, device parameter test, statistical process control, etc.
 - Optical components for process control and monitor

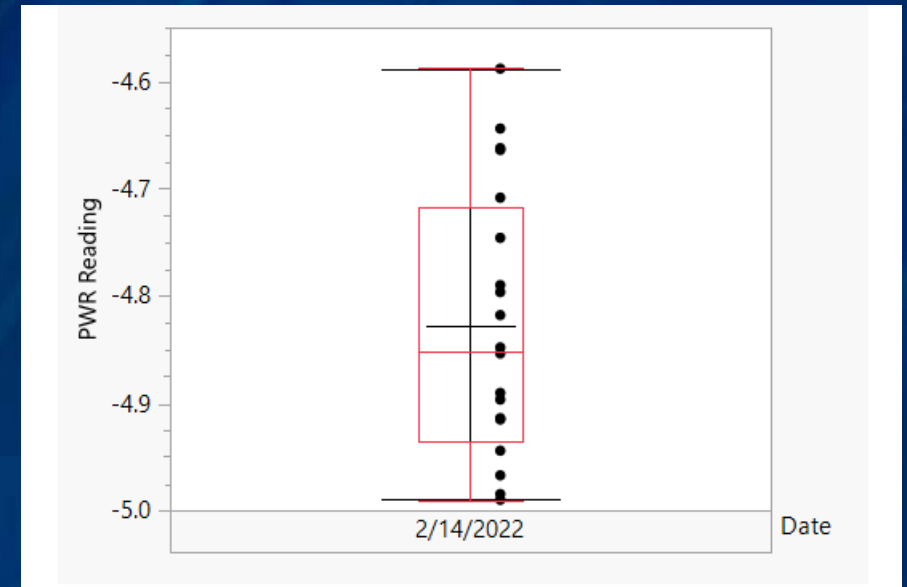
Optical Coupling GRnR Results

Vertical Coupling GR&R



Vertical Coupling GRnR: 0.06 dBm

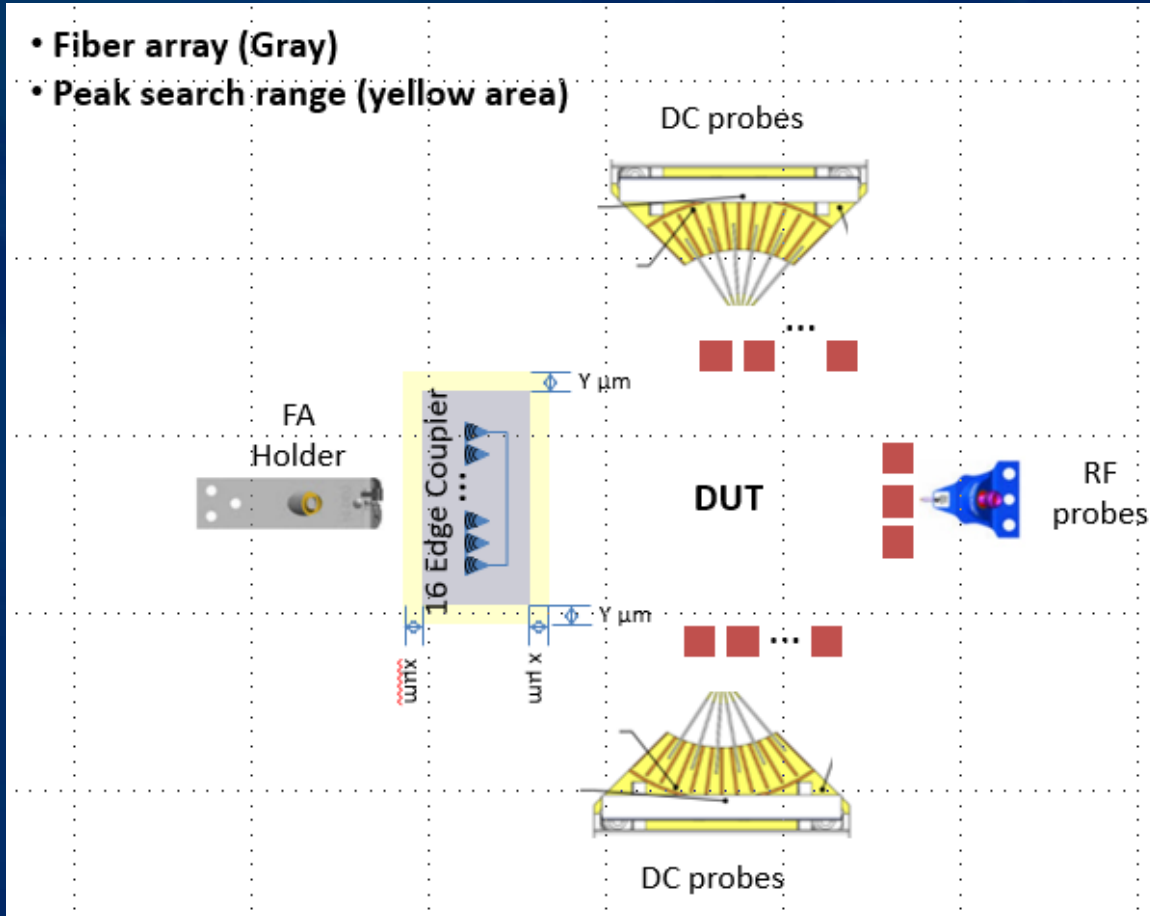
Edge Coupling GR&R



Edge Coupling GRnR: 0.17 dBm

Worse GRnR at edge coupling due to more stringent precision needed for edge coupling compared to vertical coupling

Test Configuration

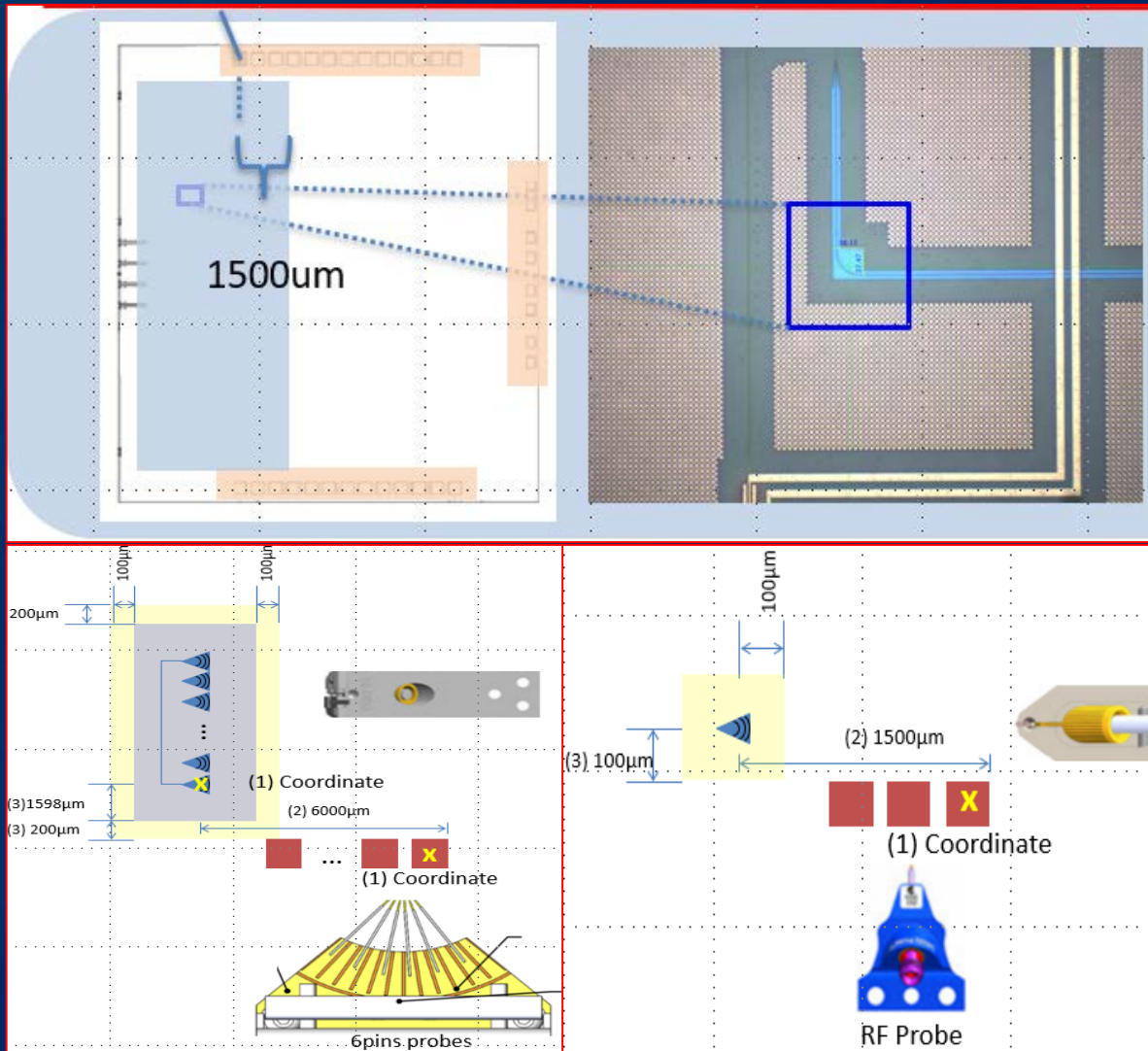


Types of IO	Orientation
Optical Edge Couplers	West
Electrical Pads (DC/RF)	North/South/ East

Flexible orientation possible by rotating the wafer

- O-band and C-band.
- Trench Width: $\geq 80 \mu\text{m}$ (zero change of existing layout).
- Trench Depth: $\geq 40 \mu\text{m}$
- Number of Edge Couplers: 16.
 - Customization of edge fiber array possible for edge couplers ≥ 16 .
- Edge Coupler Pitch: 127/250 μm .
 - Edge Couplers on same side of die.
- Electrical Pad (DC and RF) size: 80 x 80 μm (recommended)
 - Pitch 100 μm .
 - RF Pads configuration GSG, GSGSG.

Design Rule Layout



- CompoundTek wafer test design rule layout for both vertical and edge coupling available to customers during chip design **to ensure wafer can be tested after Fab out**
 - Consists of keep out area for pads, edge couplers/vertical gratings
 - Dimensions and design of deep trench

Typical SiPh Wafer Test Items

Electrical Test

- Photodiode Dark Current
- Optical Modulator terminator, VOA, heater etc active structure IV (resistance) measurement.

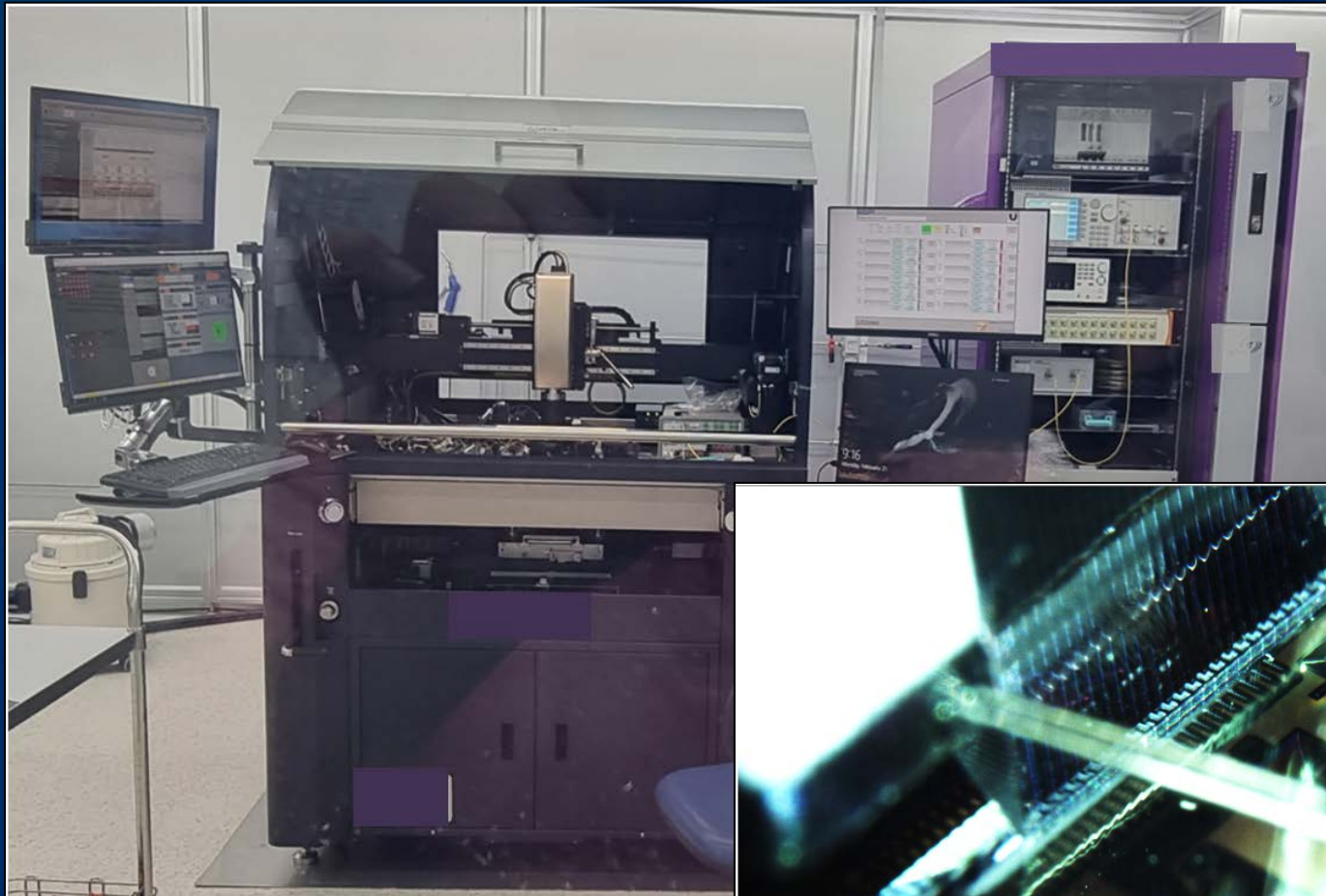
Optical Test

- Passive device parameter including IL, PDL, WDL etc
- Waveguide Propagation Loss
- Tap Coupler Coupling Strength

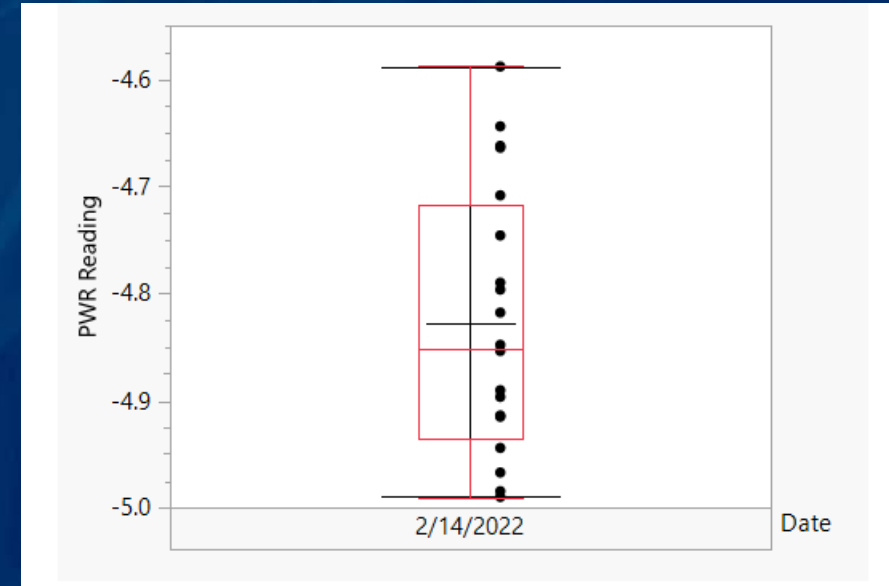
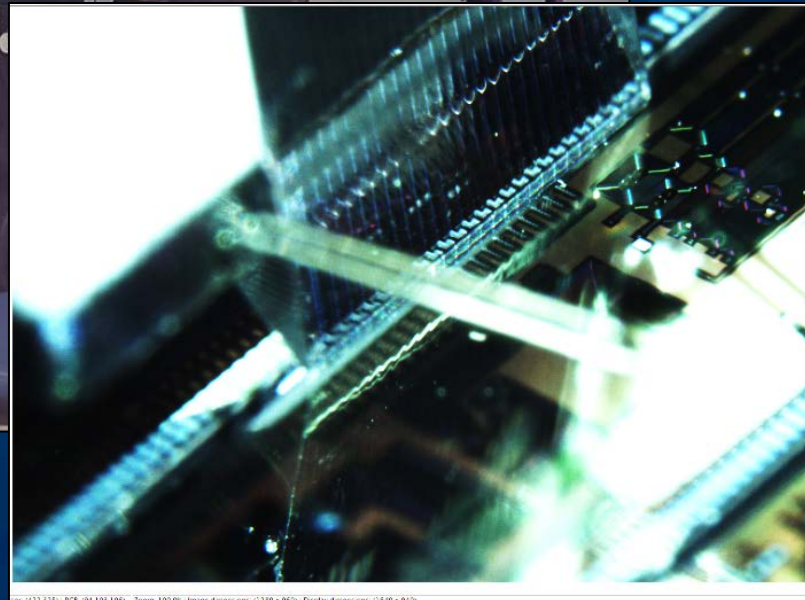
Opto-Electrical Test

- Photodiode Responsivity
- Photodiode Bandwidth
- Modulator Extinction Ratio
- Modulator Bandwidth

SiPh Wafer Optical Edge Coupling



On-wafer fiber array edge coupling on CompoundTek's Gen#1 suspended edge coupler



Edge Coupling Performance

Trench Top Width	> 80 μ m (No change in layout)
Coupling Loss	~4.8 dB/facet (Depending on MFD mismatch)
Std Deviation	0.17dB

Integration with LCA for Bandwidth Measurement

Capable to perform Edge Coupling + Optical Bandwidth Measurements



No significant bandwidth difference as compared to customer diced chip measurement

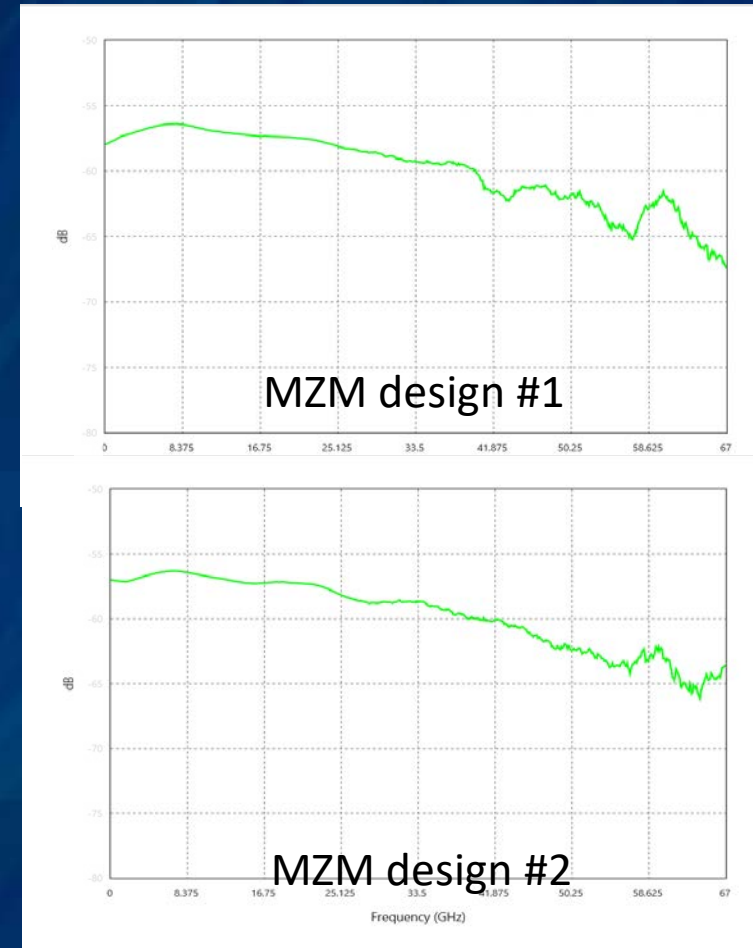
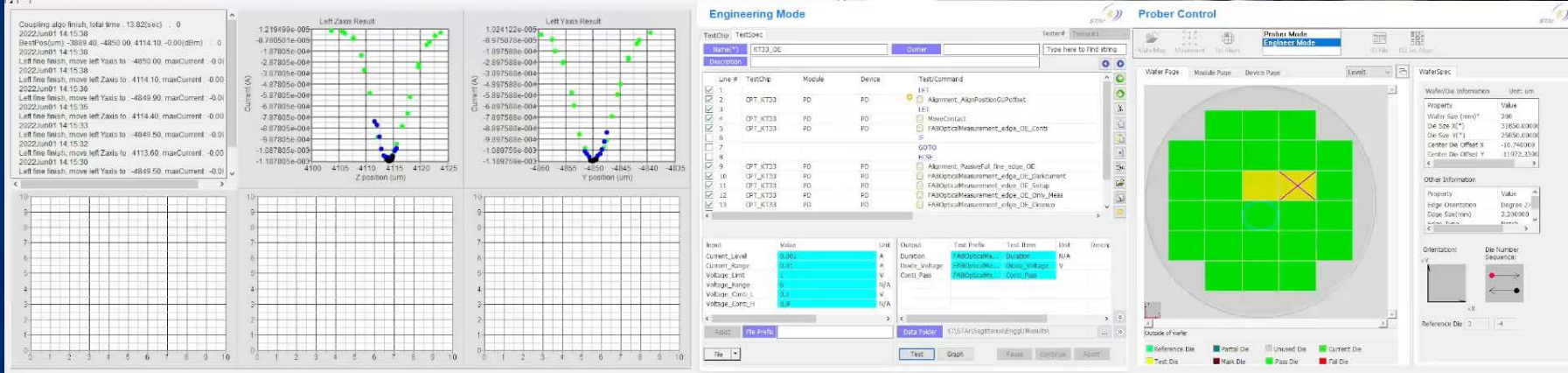
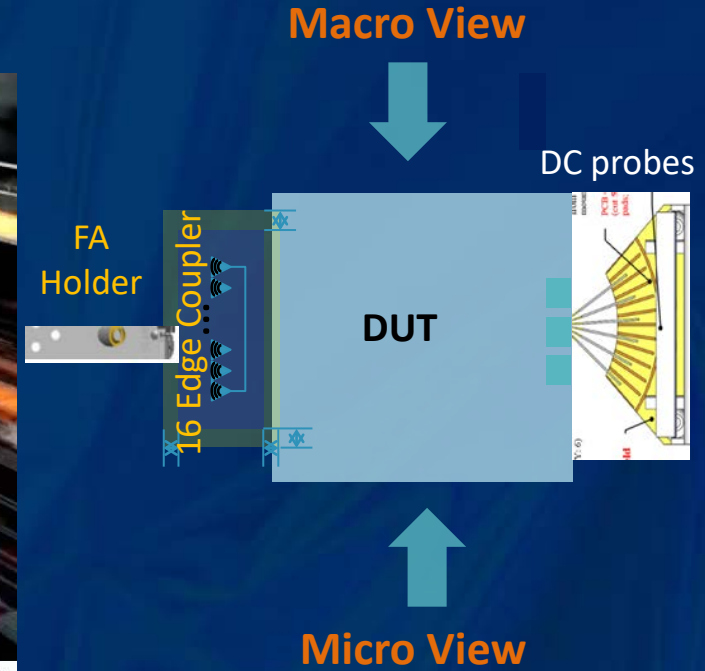
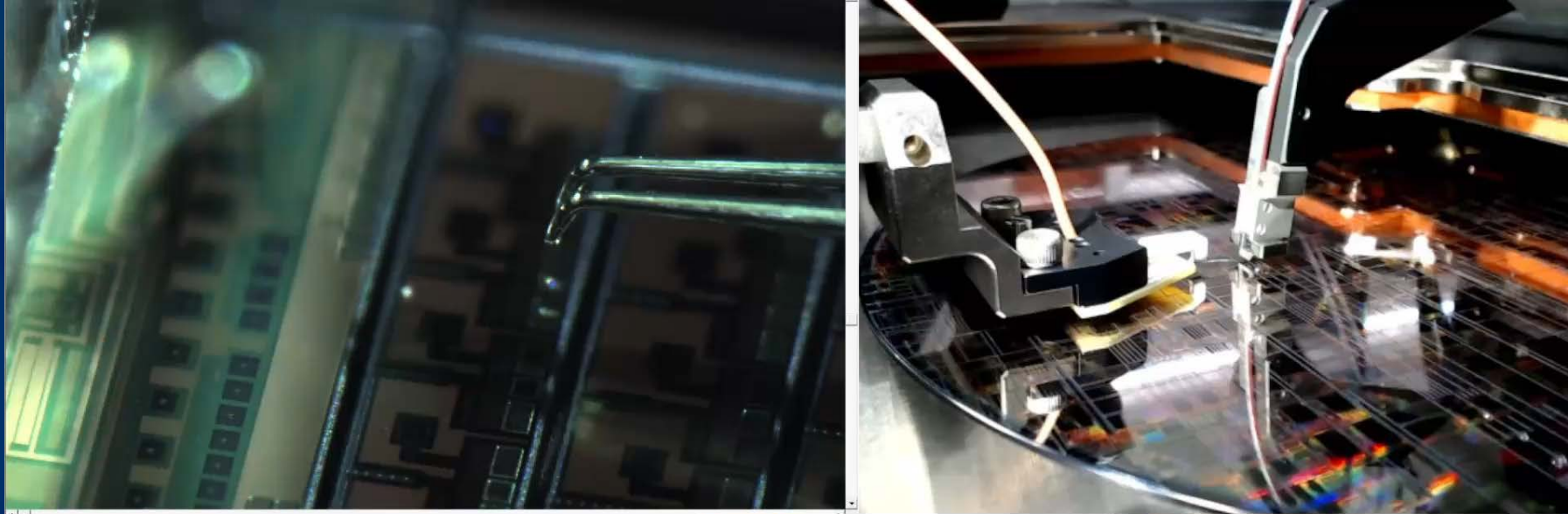


Photo Diode Test Video



Video Demo on Edge coupling OE Testing on PD. 2 dies tested in video

- 1) Optical Input at West
- 2) Electrical probes at East

Edge Coupling Performance

Key Features

1.	Coupling Loss	CT average between 4 to 5 dB per facet
2.	GRnR	Excellent GRnR, 0.17dB @ 1 sigma
3.	Trench Width	> 85 um
4.	Trench Depth	> 40 um
5.	Coupler Pitch	127 um/250 um

Enable fast yield and performance feedback on wafers by up to 3 months compared to chip level test. Saving up to a year for full product development cycle (assuming 4 iterations)

Summary

- **Need for SiPh wafer test solution to address market needs as SiPh volume ramps up in the next 5 years**
- **SiPh Wafer Test solution with both vertical and edge coupling designed for high volume wafer test.**
 - CompoundTek Wafer edge coupling fiber array coupled with STAr Technologies wafer prober solution
- **Solution proven with customer production SiPh wafers.**
 - Optical Passive Test
 - Opto-electrical Test
 - High Speed Bandwidth test