KEYSIGHT WORLD2018

Silicon Photonics Wafer-Level Test & Measurements

晶圆级硅光测试与测量

Technical Consultant / FormFactor Inc.

Dr Sia Choon Beng 謝春明 博士

Bio Data

- Support Customer Applications & Production Solutions, Marketing
- 10 Years with Cascade Microtech Inc. prior to Formfactor Inc. Merger
- Ph.D. in RF Device Design and Modelling
- Worked with International Semiconductor companies, foundries as well as renowned Research Institutes & Universities in the world
- IEEE MTT-11 Microwave Measurement Committee
  - Measurement Best Practices, Emerging Technologies & IEEE Workshop
- IEC TC47 – Technical Expert representing Singapore
  - Sponsored by Singapore Standards, Productivity and Innovation Board
  - Leading Wafer-level Device Reliability Tests & Standards
- EECE Technical Committee, Institution of Engineer Singapore (IES)
- Research Interests:
  - DC, AC, 1/f noise, Power Device Characterization
  - Wafer-Level Optical Measurements, THz Calibration & Characterization of Devices

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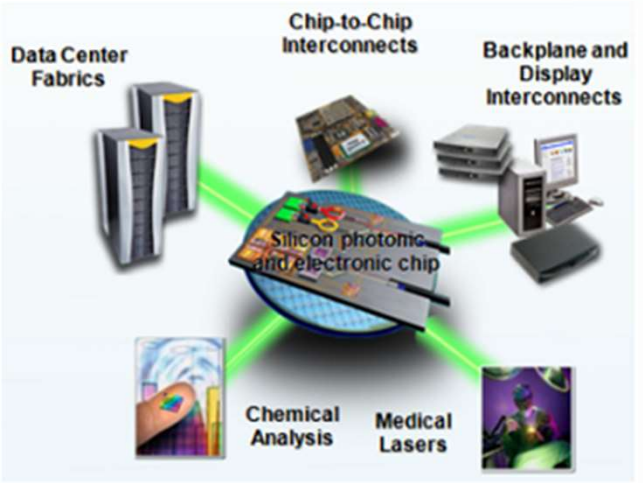
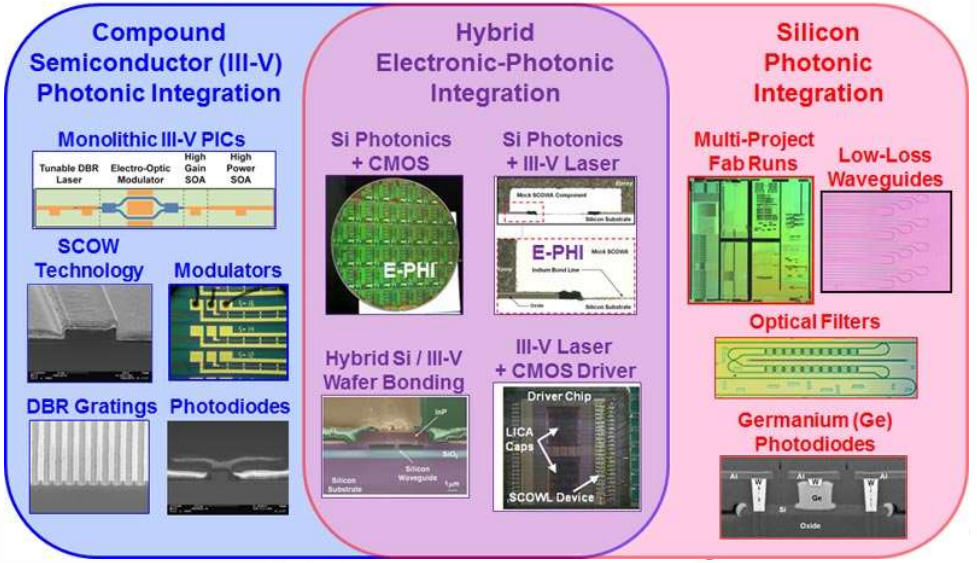
Agenda

- Why Silicon Photonics?
- Why Wafer-level Photonics Test?
- FormFactor Integrated Wafer-Level Photonics Probing Solution
- Key Advantages of FormFactor's Photonics Solution
- RF Wafer-Level Solutions to Support Optical-Electrical Tests
- Conclusions

Why Silicon Photonics?

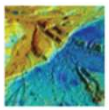
- Demands for high bandwidth & big data
- Improvements in Thin Film technologies
  - Overcoming lattice mismatch
  - Very High Quality III/V semiconductor material on Silicon substrate
- Exploiting Silicon Technologies
  - High Volume Production = Low Cost
  - 300mm wafers
  - Ultra Low Power Logic devices
  - High Performance RFCMOS devices
  - Higher Integration
    - Higher interconnect density/Layers
    - More embedded functionalities



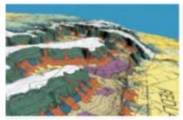


Other Photonics Applications
LIDAR (Light Detection and Ranging)

Leddar Tech



Military
Payload
>1K Units



Geographical
Survey
>20K Units

Robotics
>100K Units

Construction
& Industry
>250K Units

Autonomous
Navigation
>1M Units

Low Volume

High Volume

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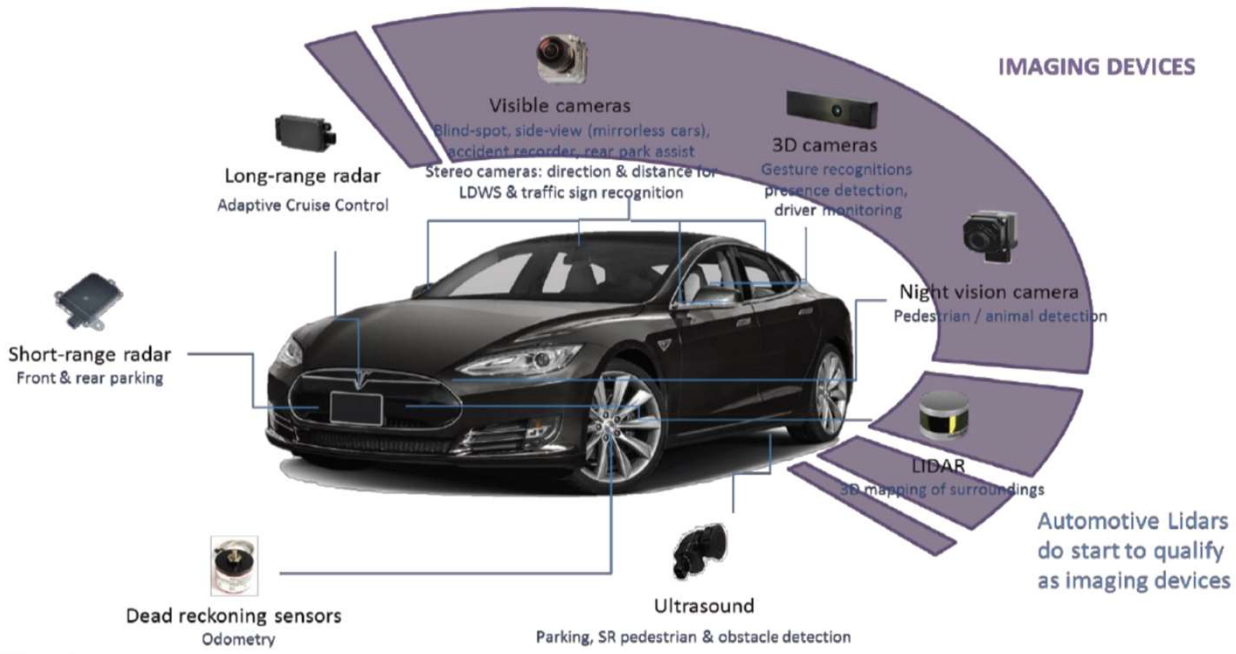
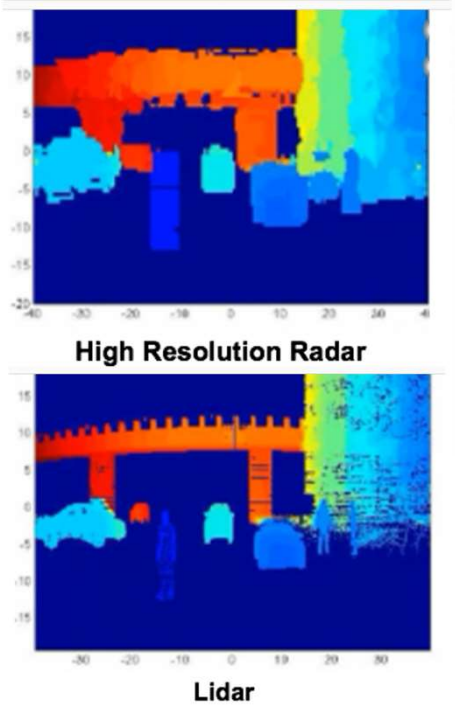
Imaging for Automotive Applications

- LIDAR will become key sensors for autonomous vehicles





High Resolution Radar vs LIDAR (NXP)

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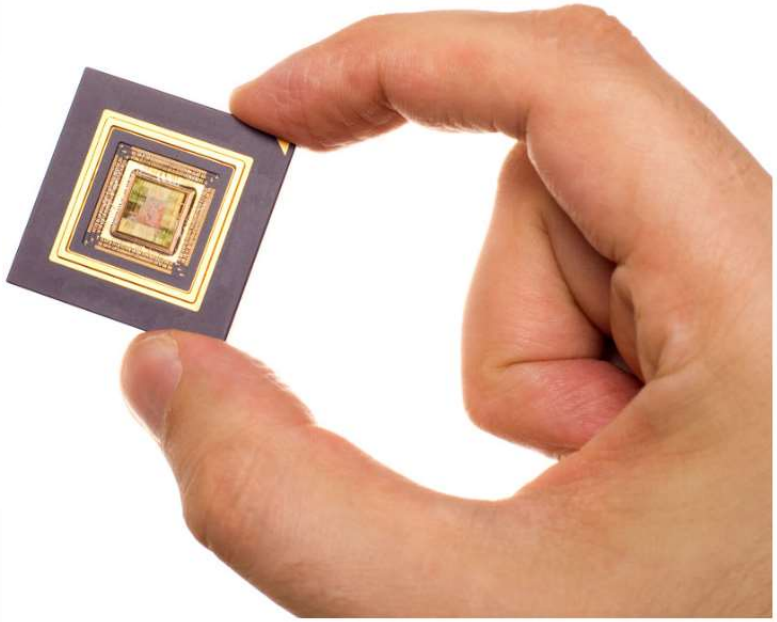
Imaging for Automotive Applications – Solid-State LIDAR

LiDAR



ANALOG PHOTONICS

Analog Photonics is developing the next generation chip-scale Light Detection and Ranging (LiDAR) sensor solutions using proprietary and patented *silicon photonics* and *optical phased array* technology.

Advantages

- Miniaturized
- Low-cost
- Aesthetic
- Eye-safe
- Chip-scale
- Lens free
- No moving parts

Applications

- advanced driver assistance systems (ADAS)
- autonomous driving
- parking assistance
- cabin monitoring
- Laser mapping
- robotics
- mobile-device

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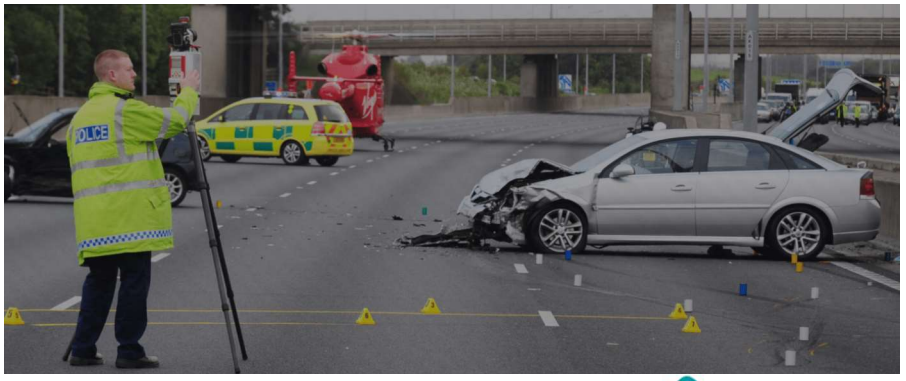
LIDAR on UAV

- Solid-State LIDAR
  - Higher Imaging Precision
  - Lighter Payload
  - Longer Time in the Air
- Applications
  - Environmental & Coastal 3D Mapping
  - Agriculture Precision Forestry
  - Civil Engineering & Surveying
  - Defence & Emergency Services
  - Highway & Road Networks
  - Logistics – courier services



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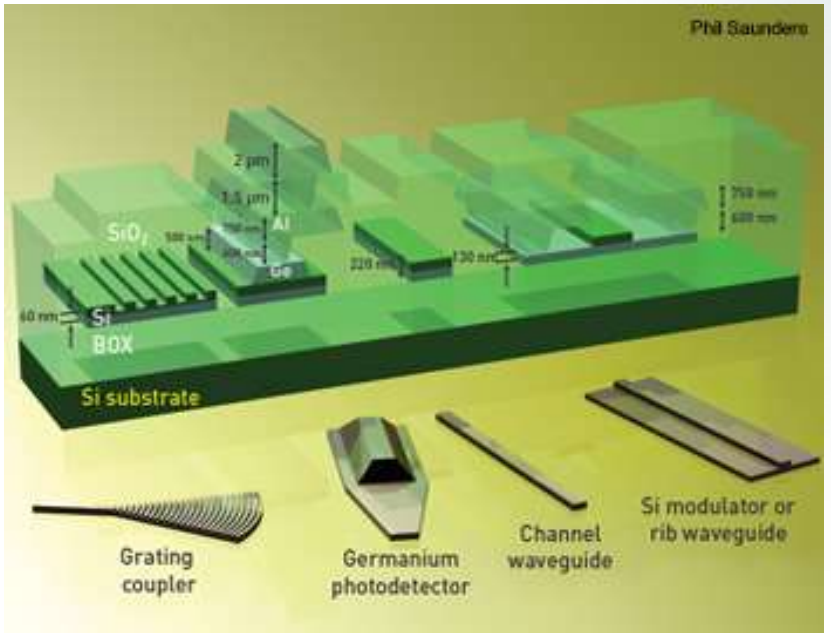
General Photonics Devices

- Passives
  - Low loss waveguides
  - Splitters
  - Wavelength selective combiners/splitters
  - Isolators/Circulators
  - Comb generators
- Actives
  - Lasers (single frequency, tunable, mode locked)
  - Modulators
  - Switches
  - Amplifiers
  - Photodetectors



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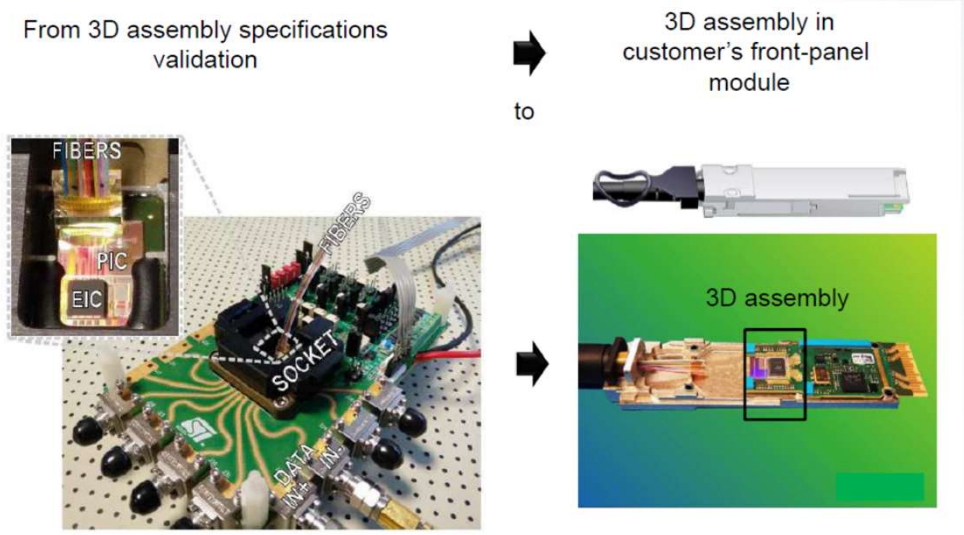
Why Wafer-Level Photonics Test?

- R&D
  - Process Development
  - SPICE Model Development
- Production
  - Wafer Acceptance Test
  - Known Good Die Test
- Reduce Development & Production Costs
- Faster Time to market



Source: ST Microelectronics, ICMTS2017

Design → Wafer Fab → Parametric Tests → Chip Sort Tests → Packaging → Final Test

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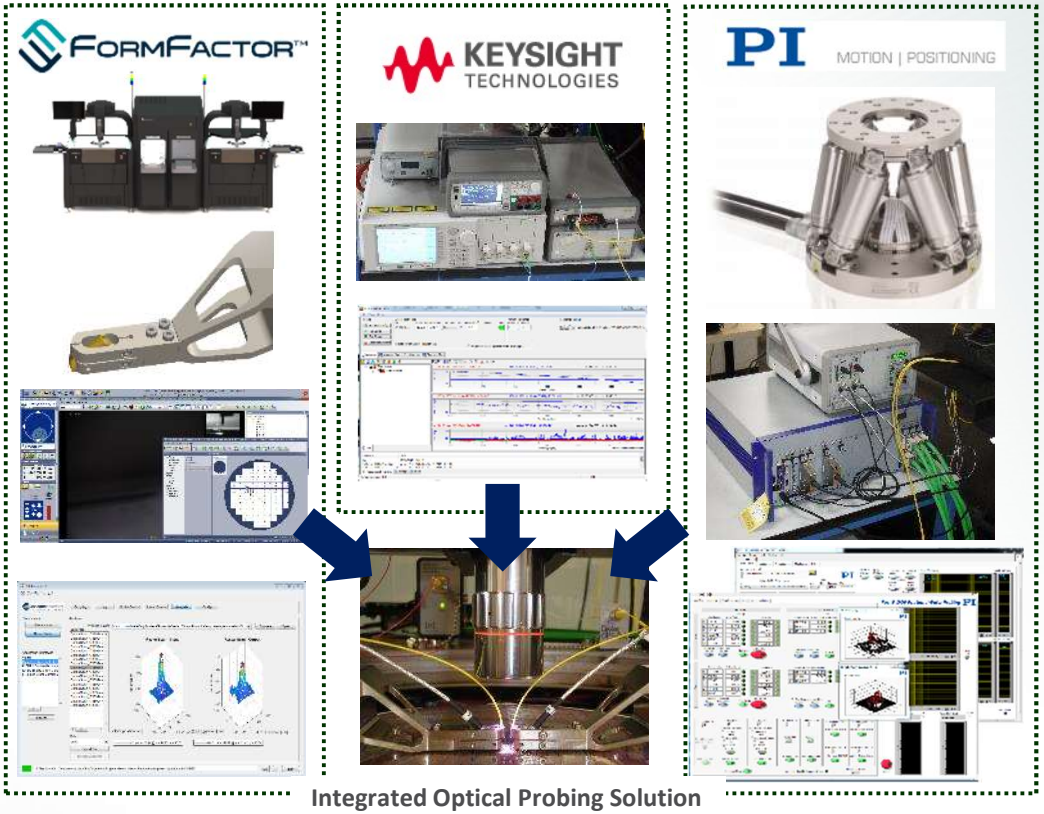
FormFactor Integrated Wafer-Level Photonics Test Solution

- Joint partner integration between
  - FormFactor (formerly Cascade Microtech)
  - Keysight
  - Physik Instrumente
- Integrated solution provides optical alignment and measurement capability



Integrated Optical Probing Solution

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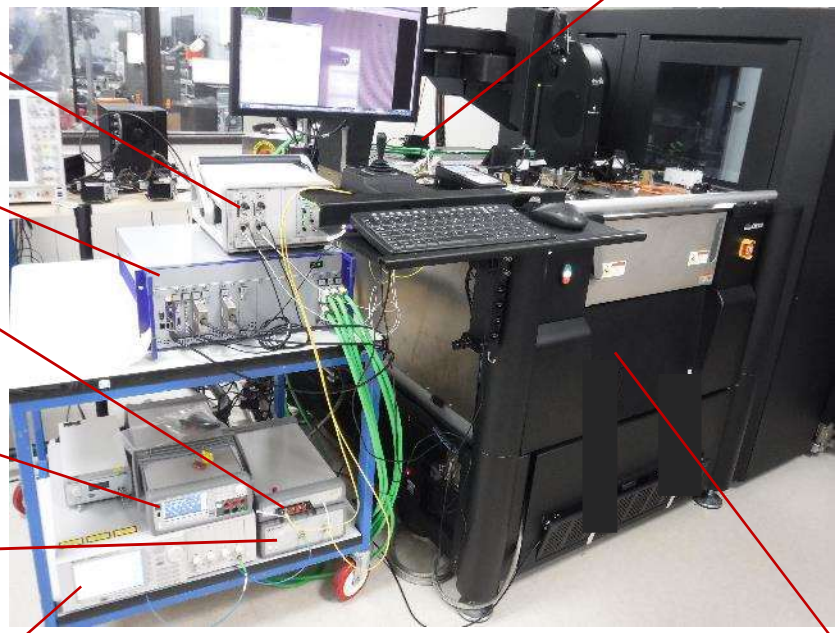
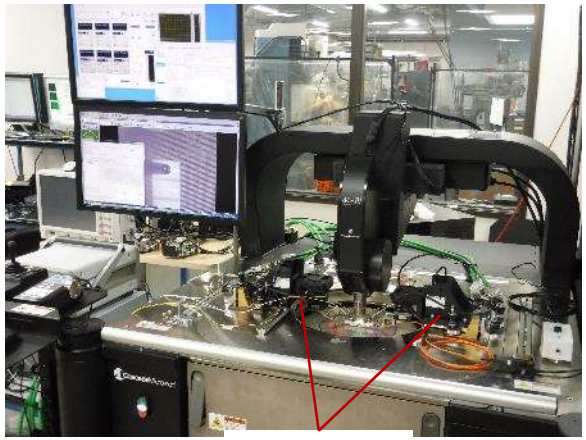
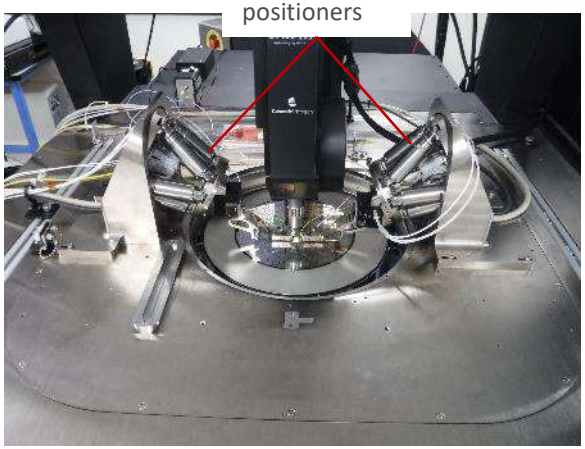
Optical Probing System





Optical probe positioners



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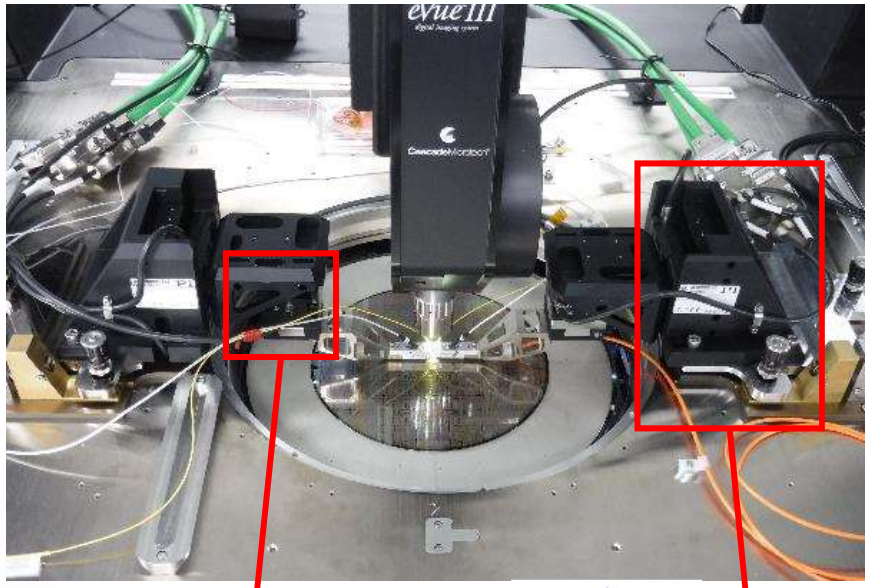
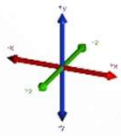
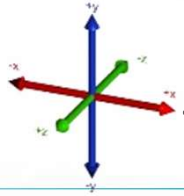
Optical Positioning Systems

XYZNano Positioners



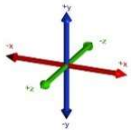


Fine Align



Long Travel

HexNano Positioners



Precision Align

Long Travel Angular Align

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Fully Automatic Wafer-level Photonics Test Solution with CM300

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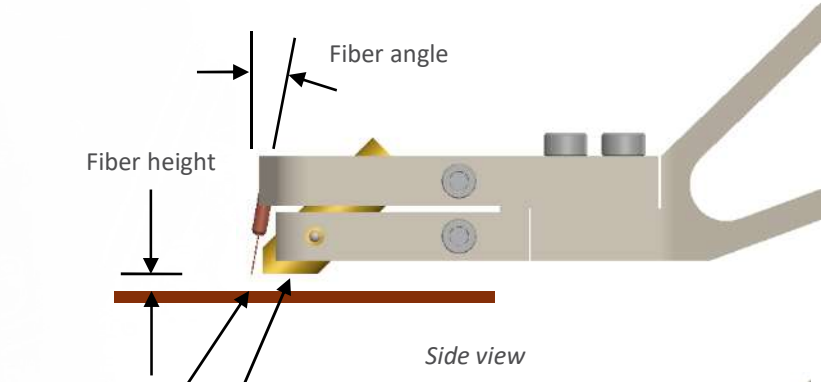
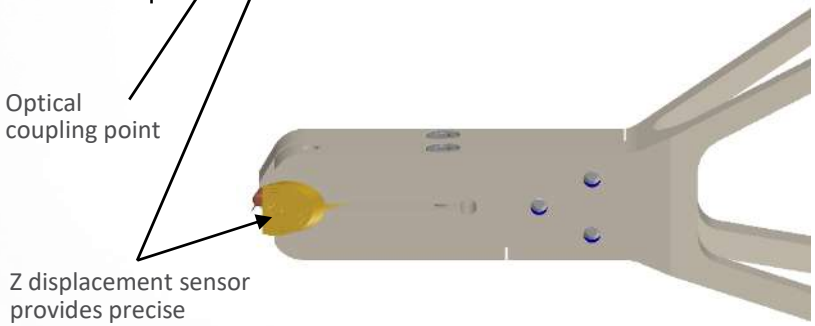
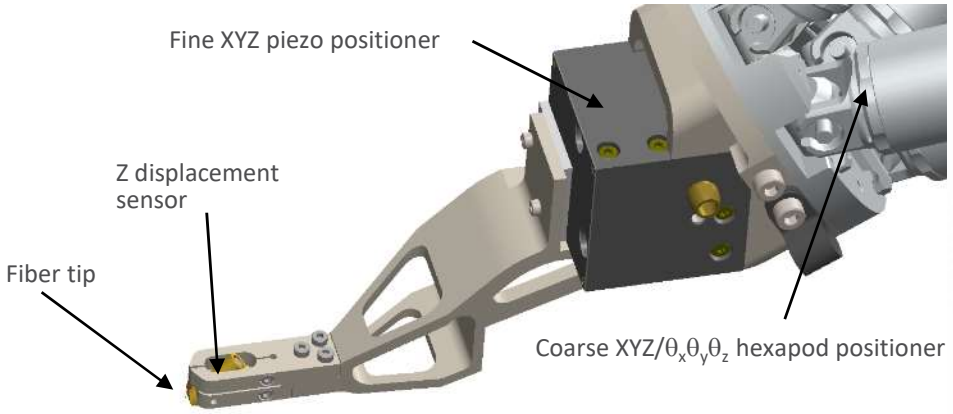
Probe Design

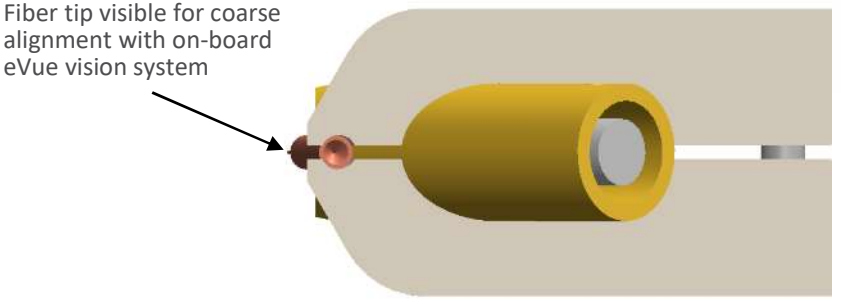


Side view



Bottom view





Top view

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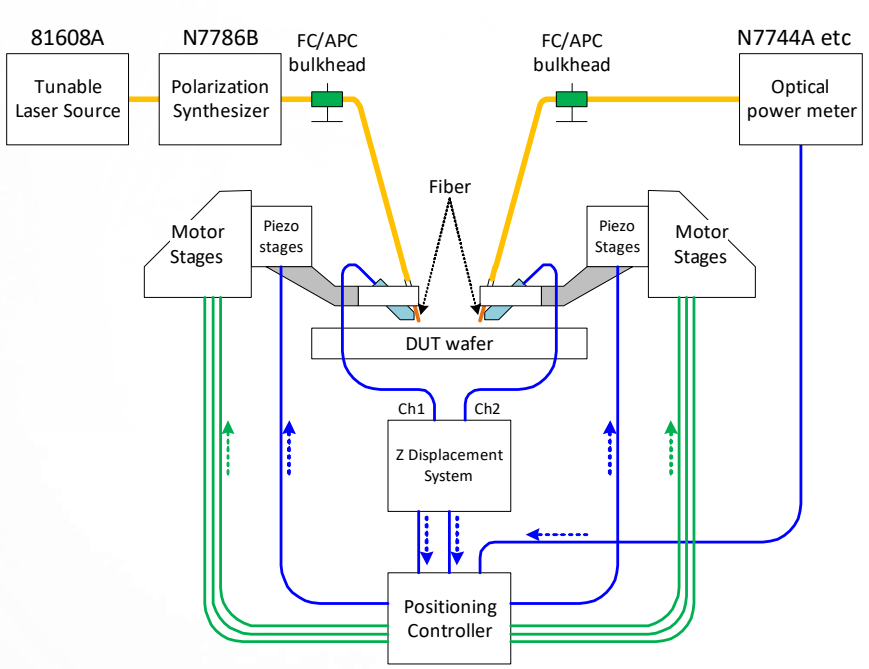
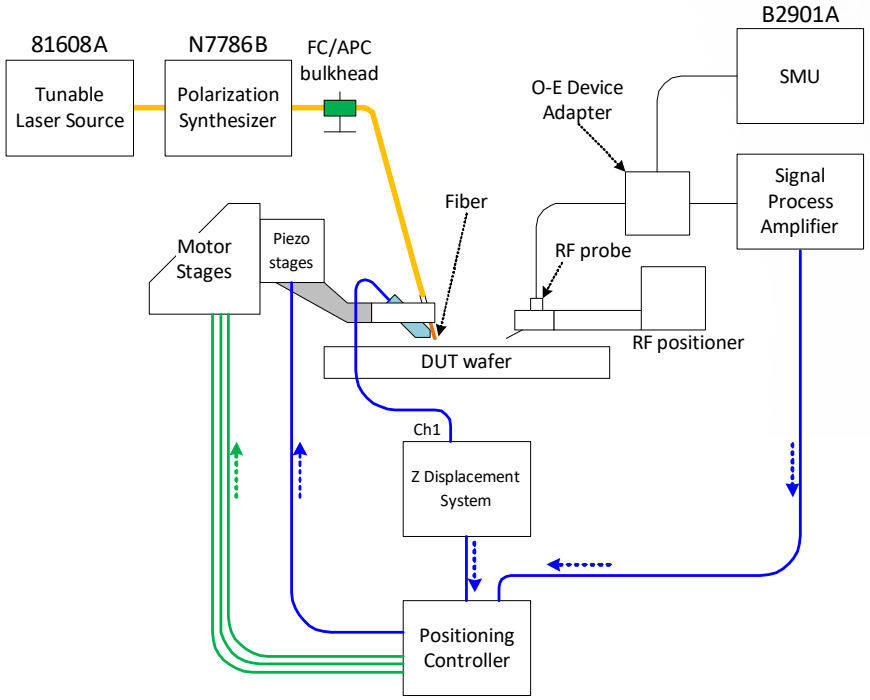
Mixed Signal Probing

- Optical-Optical (O-O)



- Optical-Electrical (O-E)



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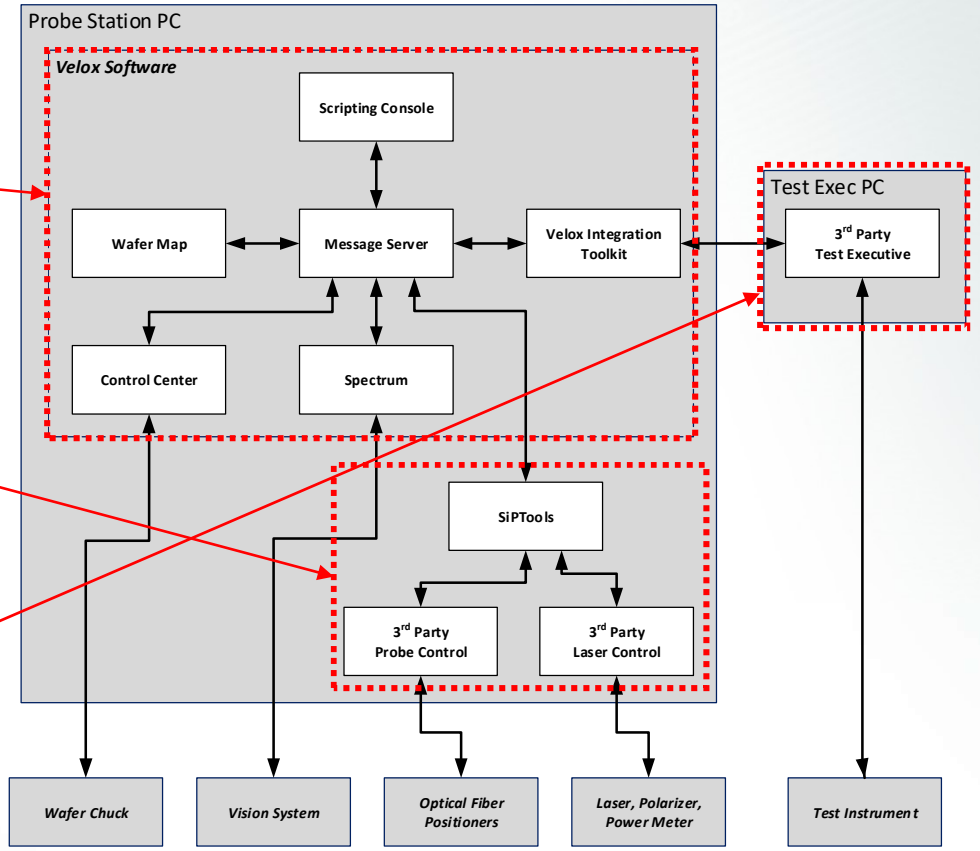
Software

- Standard *Velox* probe station software controls Wafer Chuck and Vision System
- FormFactor developed *SiPTools* application bridges the gap between Velox and 3rd party applications such as Keysight Photonics Application Suite, also running on Probe Station PC
- Data flows through central Message Server hub through a single interface to end user's Test Executive (e.g. Keysight *Test Automation Platform*)



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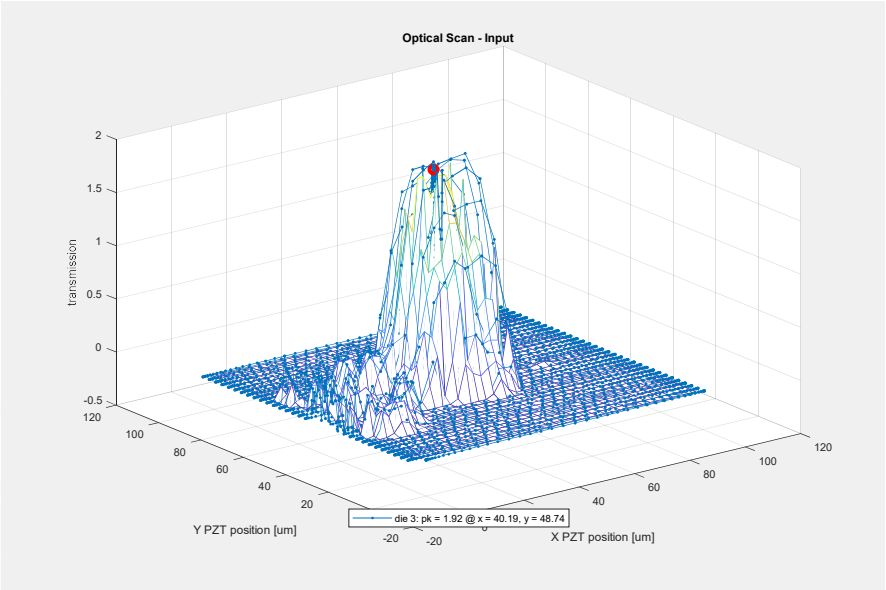
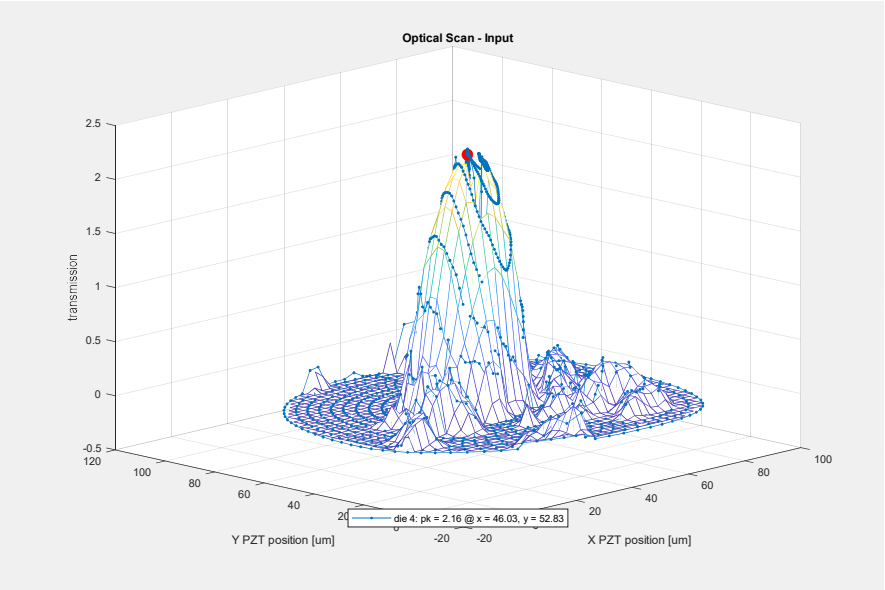
Optical Scans to find Coupling Points

Sinusoidal Scan

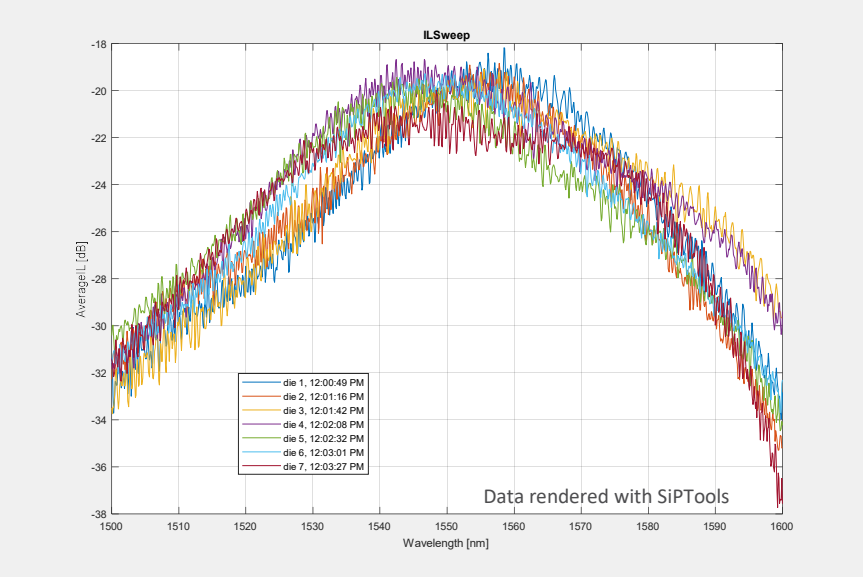


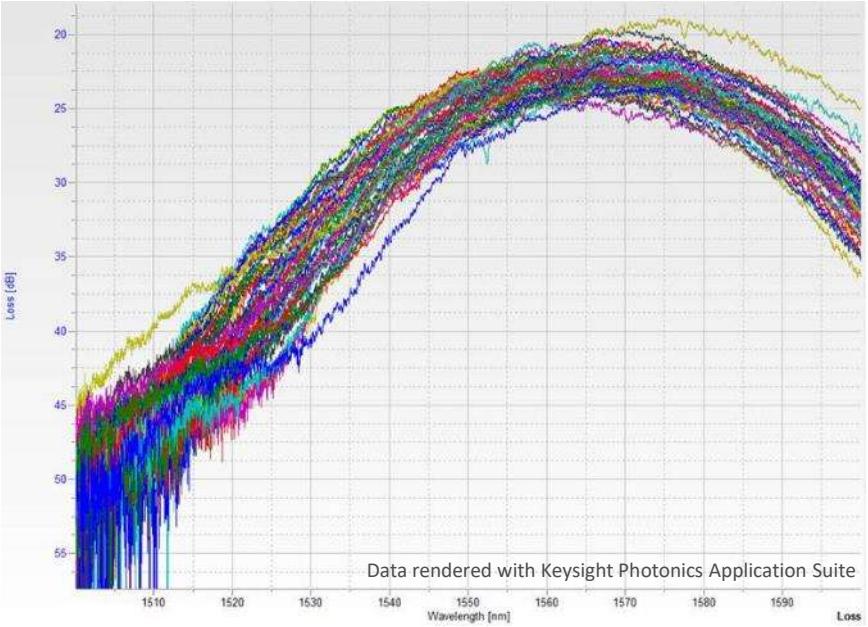
Spiral Scan



- XY axes represent XY position of piezo (fine) positioner during scan, 0-100um range
- Z axis represents optical power meter signal transmitted through DUT
- Coordinates of optical “coupling point” is defined by the peak of this surface

Insertion Loss Measurements





- IL Measurements
  - Insertion loss vs. wavelength
  - Fixed polarization
- IL/PDL Measurements
  - Insertion loss vs. wavelength
  - Variable polarization

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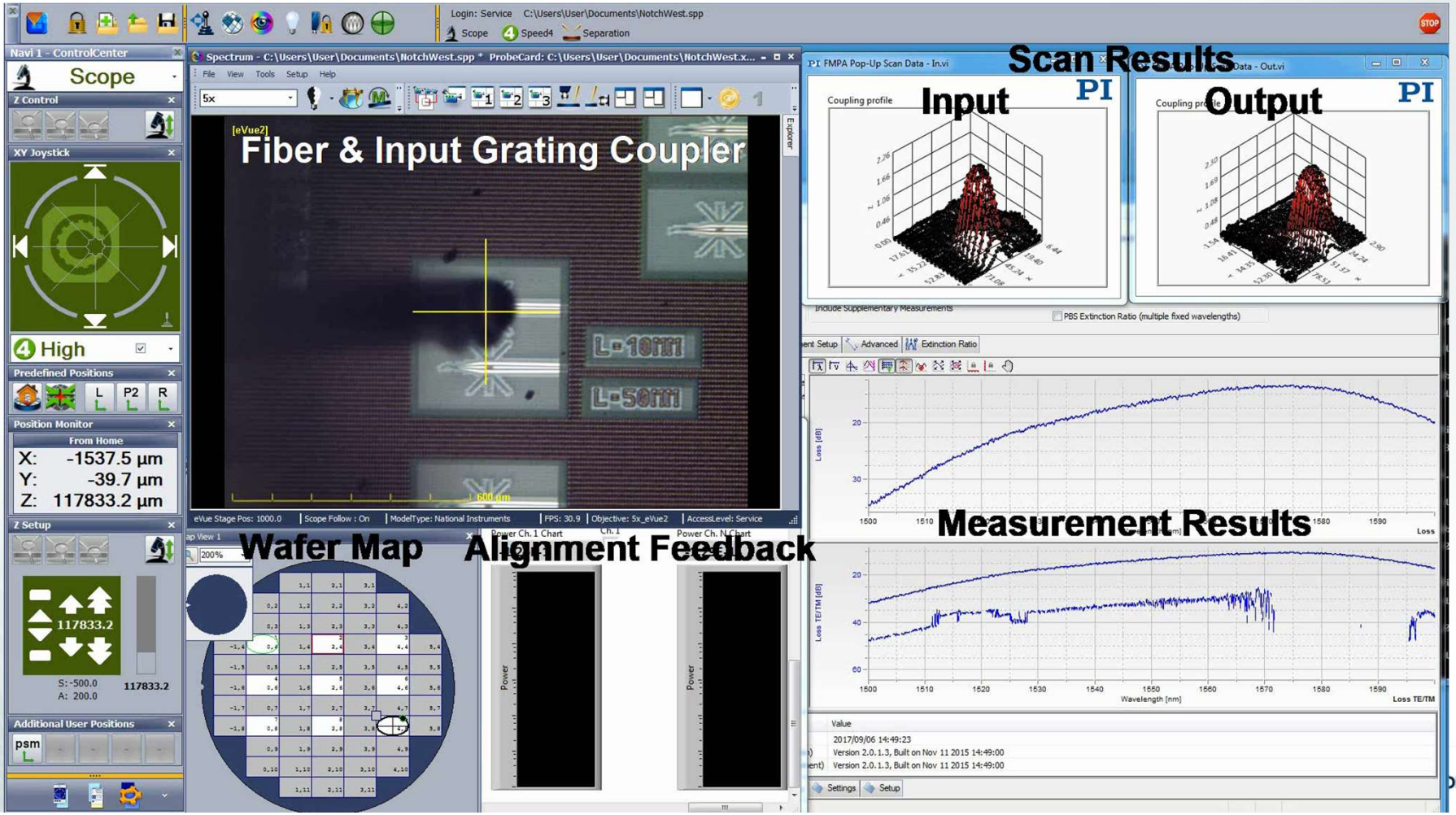
Silicon Photonics Command Set

- AlignOpticalProbes
- CalibrateCapSensor
- CalibratePositioner
- GetLaserPower
- GetPolarizationState
- GetProbeControlVal
- GetWavelength
- ILPDLSweep
- ILSweep
- MeasureFiberAngle
- MoveOpticalProbe
- MoveOpticalProbeZ
- MovePZT
- OpticalScan
- OpticalTracking
- PolarizationSearch
- PolarizationStabilize
- ReadBiasCurrent
- ReadFiberHeight
- ReadOPCPower
- ReadOpticalProbePos
- ReadPowerMeter
- RotateOpticalProbe
- SetBiasVoltage
- SetFiberHeight
- SetLaserPower
- SetOpticalProbeHome
- SetPivotPoint
- SetPolarizationState
- SetProbeControlVal
- SetWavelength
- SetWorkingFolder
- StopSiPTools
- TrackFiberHeight

Alignment & Measurement Demonstration



Key Advantages of FormFactor's Photonics Solution

- **Designed for Flexibility from Engineering to Production.**
- **Easy to use, Fast & Flexible firmware driven Alignment Algorithms implemented in Controller Hardware.**
- **Closed-loop control to hold Position Stably without Needing to Track to stay Coupled.**
- **Know-how to Determine, Calibrate and Set Fiber Height Accurately.**
  - **Planarity of Chucks today cannot handle 10µm Fiber Hover Height**
- **Integrate Seamlessly with Keysight Optical Instruments for IL and IL/PDL Measurements**

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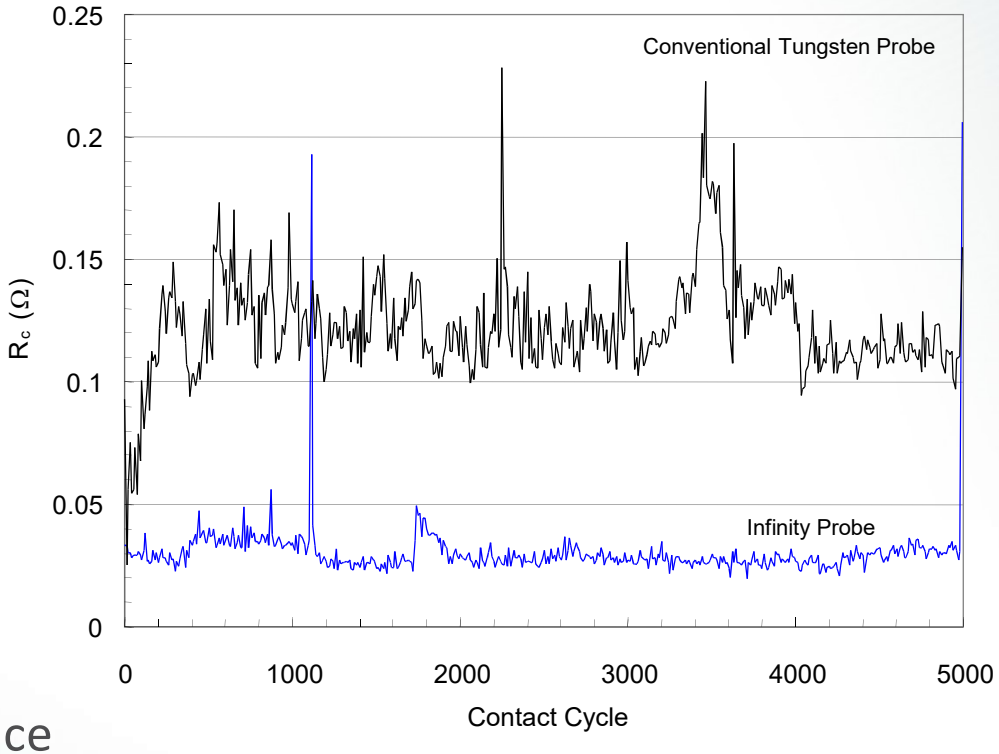
RF Wafer-Level Solutions to Support Optical-Electrical Tests

Infinity GSG, GSSG, GSGSG RF Probe

- Best Electrical Performance
- Thin Film Microstrip
- Nickel Alloy Tips
- Low & Stable Contact Resistance



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InfinityQuad, Multi-Contact Probe

- Configurable Probe Family
- 4 to 25 Probe Tips
- Any Tips can be configured as:-
  - Ground, Power, 500 MHz logic, 20 GHz RF
- Any 4 Tips can be configured as:-
  40, 50, 67 or 110 GHz
- Small Test Pads, 30x50um
- Low Probe Contact Resistance
- >250,000 touchdown lifetime

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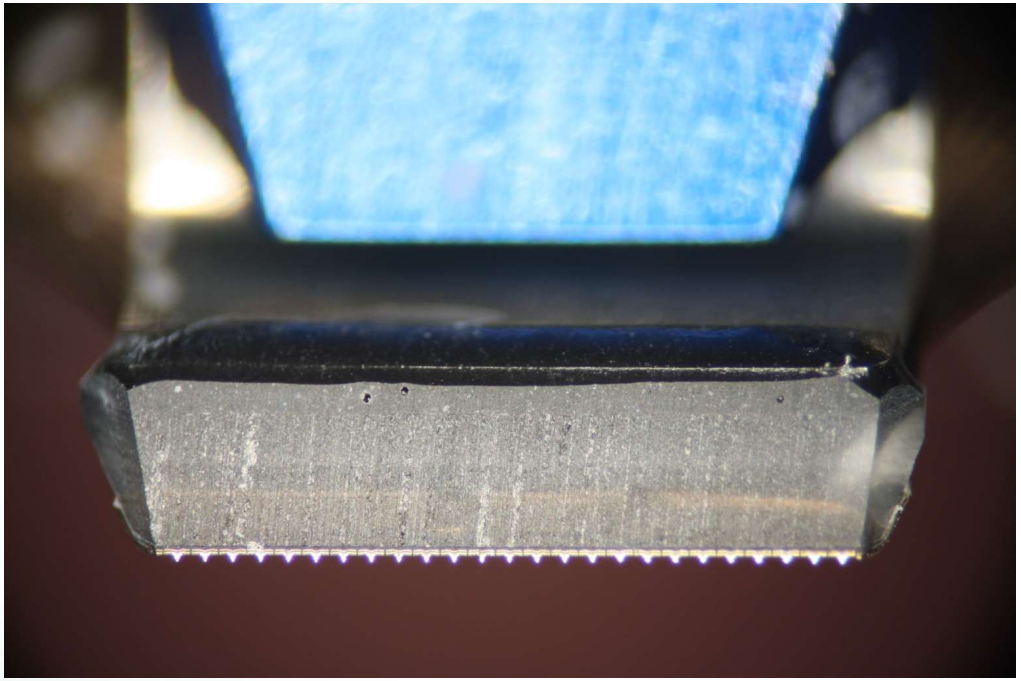
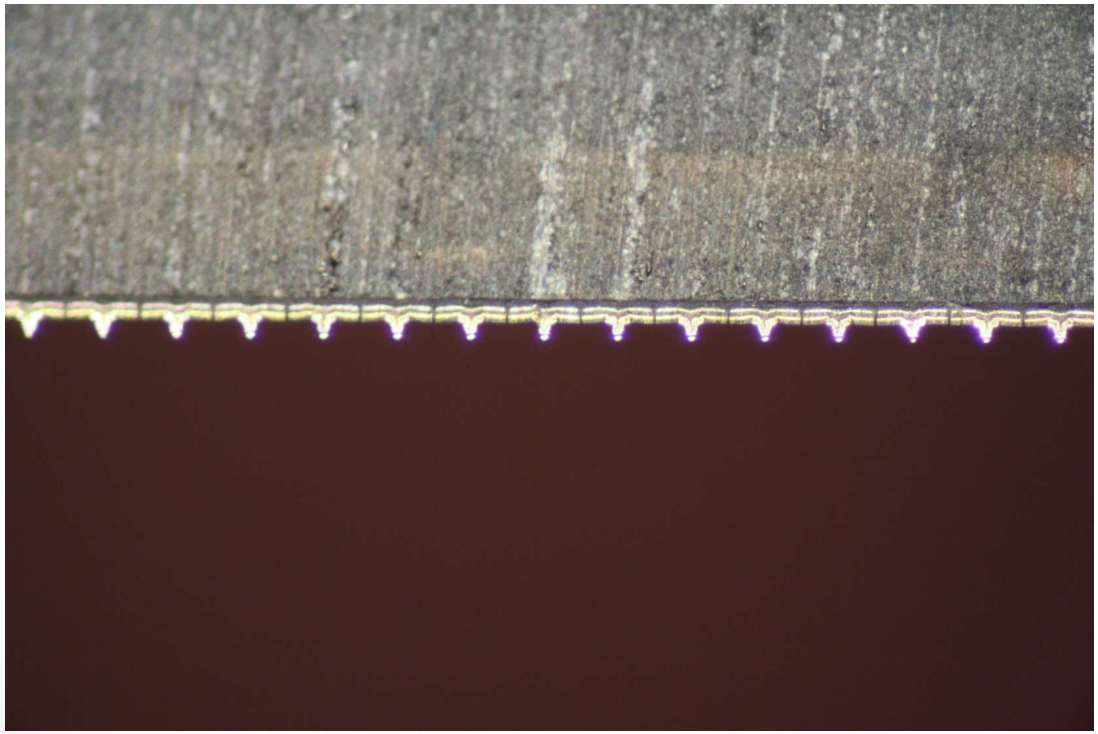
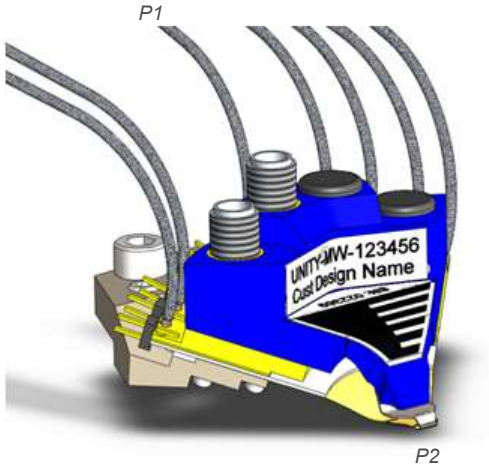
Tip Construction

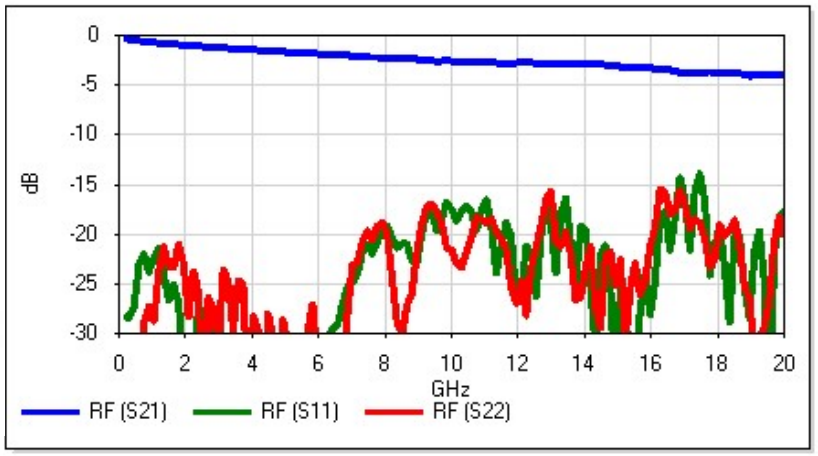


Tip Construction



RF Performance





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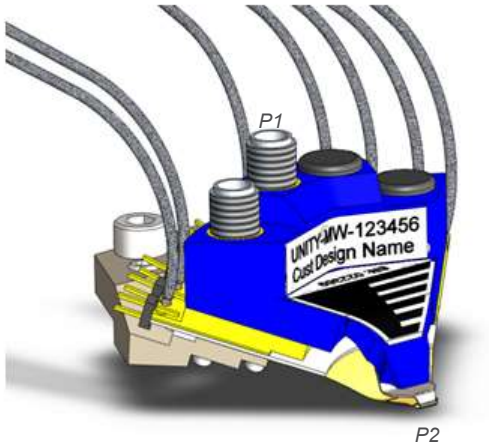
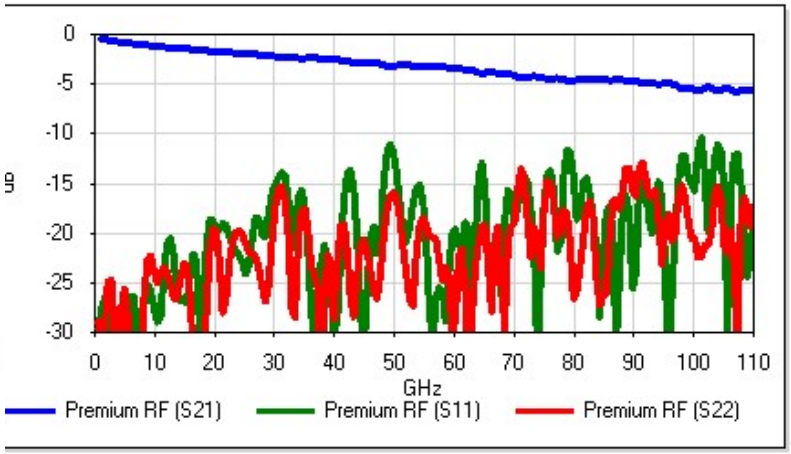
Premium RF Performance





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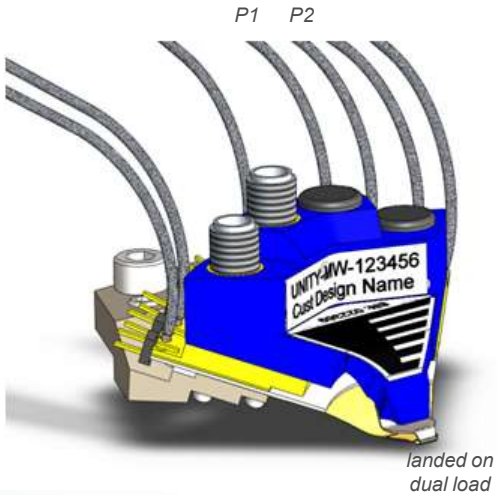
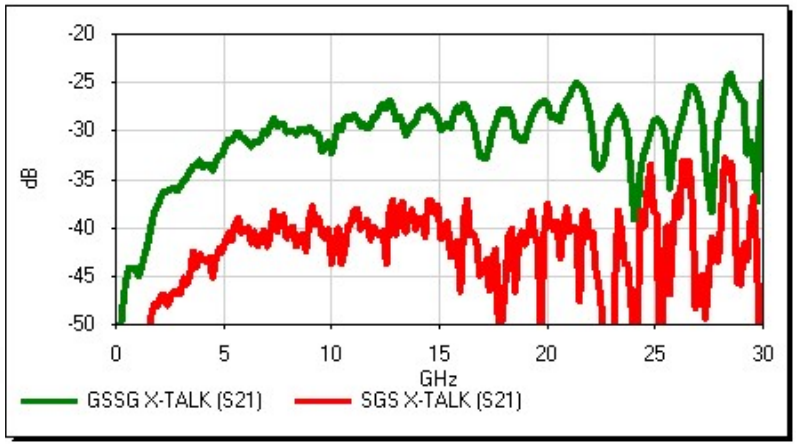
X-Talk Performance



landed on dual load



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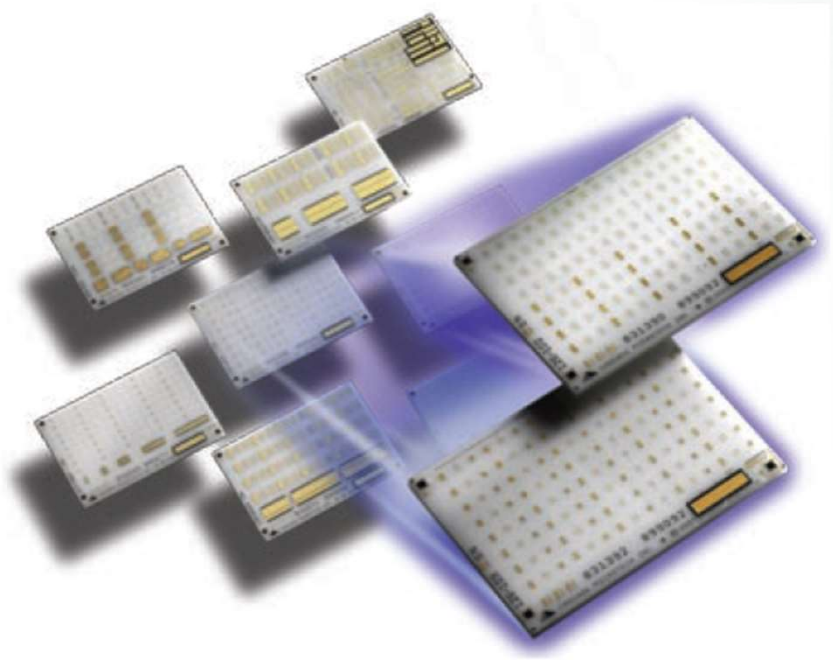
Calibration Software & Calibration Substrates



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Conclusions

- Strong Demands for Photonics Integrated Circuits on Silicon Technology.
  - High Bandwidth, Big Data
  - Solid-State LIDAR
- FormFactor provides a Market-Leading, Proven, Photonics Wafer-level Test Solution through Seamless Integration with Keysight & PI.


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Thank You!
Questions?

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