



Testing automations of high speed silicon photonic transceivers for data center interconnect applications

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October 4th - 7th | 2021



Session: Data center interconnects, 5 October 2021

MASSTART & AUTH Contribution



MASSTART objective

MASSTART aims to provide a holistic transformation to the **assembly** and **characterization** of **high-speed photonic transceivers** towards bringing the cost down to €1/Gb/s or even lower in **mass production**.

AUTH contribution



- ❖ New fabrication, assembly
- ❖ Enhancement of automated PIC testing
 - **Wafer level testing** for reduced time during characterization (x10) and yield analysis (>90%).
 - Development of an **automated die testing platform** for transceivers.

Automated Die Tester Platform

Automation for various characterization tasks by:

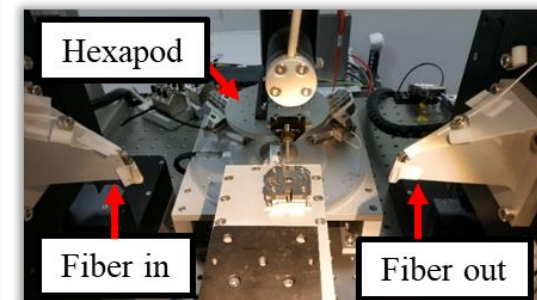
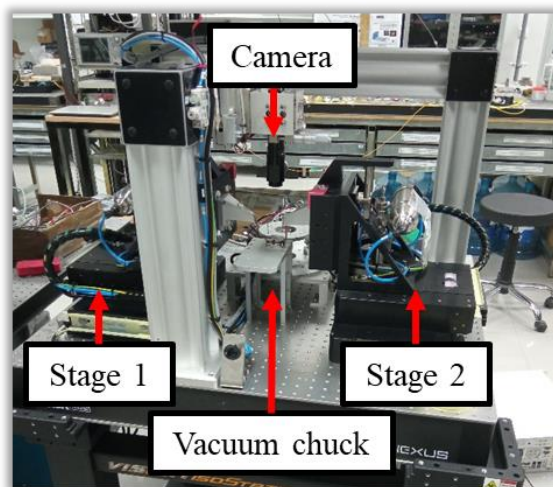


Automated die tester probe setup by:



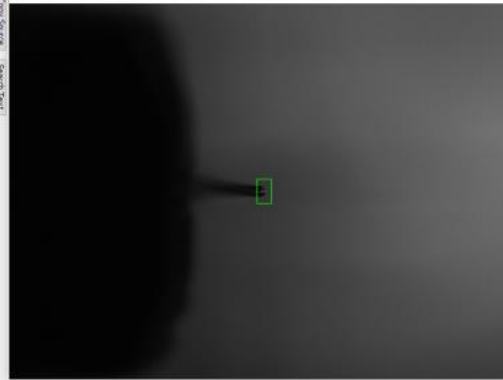
Die tester components

- Two mechanical XYZ-stages of 20 cm travel for fiber probing
- Top view camera
- Hexapod of 41 mm travel in XY and 21 mm in Z-axis for RF probing
- Vacuum chuck for die stabilization



Fiber to Fiber (F2F) Alignment Automated Process

Process I: Fiber calibration on grating couplers

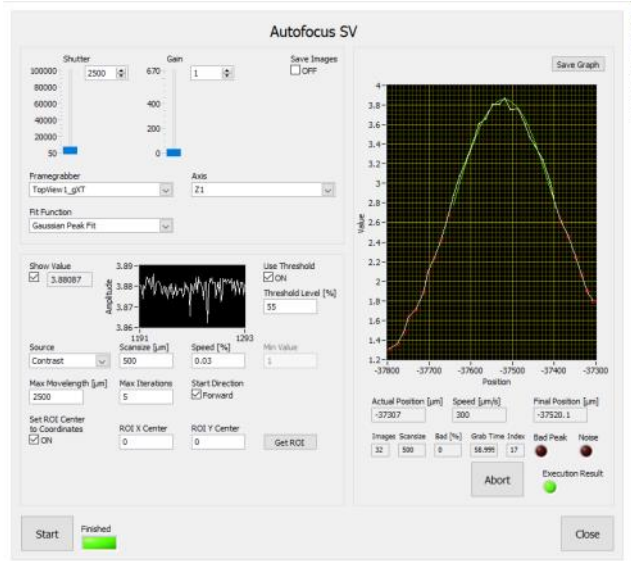


Steps:

1. Fibers to camera field of view
2. Positions hardcoded
3. Stages' height variation by Autofocus tool
4. Fiber's height computation by fixed focus of the camera

Fiber to Fiber (F2F) Alignment Automated Process

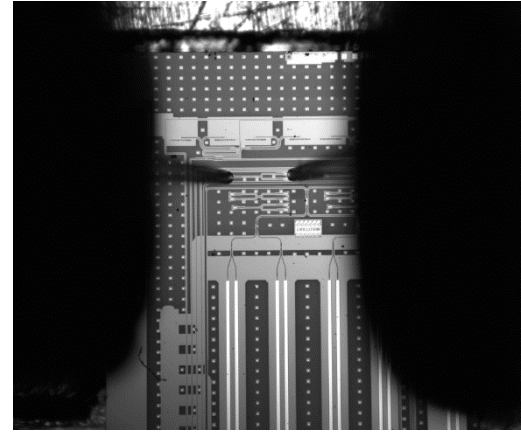
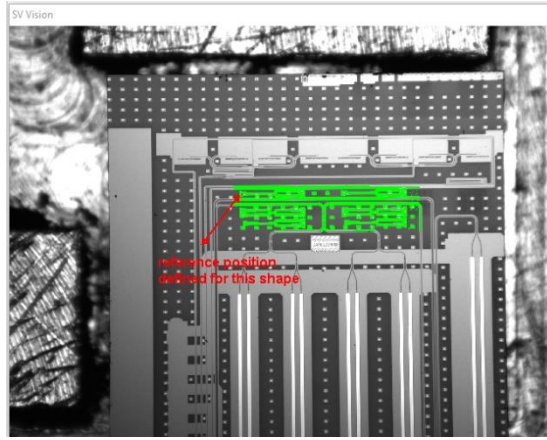
Process II: Chip calibration



Steps:

1. Camera to the chuck-focus position
2. Chip focus by Autofocus tool.
3. Chip's height calculation by fixed focus of the camera
4. Fibers on chip in the camera center
5. Calibrate fibers' X and Y positions .

Process III: Find initial alignment positions

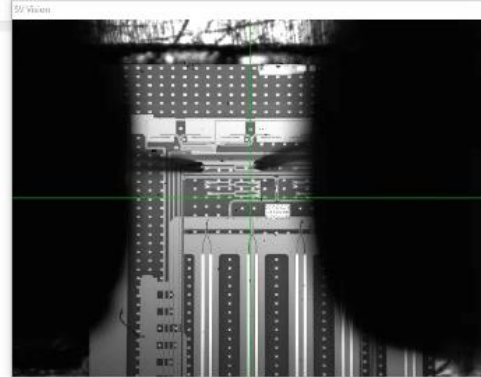


Steps:

1. Through the shape editor, a shape containing all grading couplers is recognized.
2. Move to chip focus position and detect the shape with all couplers.
3. Move the input fiber to the reference position.
4. From the chip's mask, hardcode the distance of the output couplers from the input one, estimate their relative positions and move the output fiber there.

Fiber to Fiber (F2F) Alignment Automated Process

Process IV: Find optimum F2F link



Steps:

1. Read the power-meter as analog input channel.
2. Move to initial alignment positions.
3. Use several area scans to find an optimum link.

Results:

1. Link with 11dBm losses in less than 2 minutes

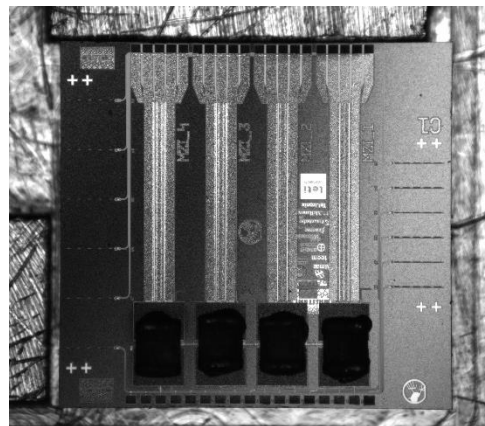
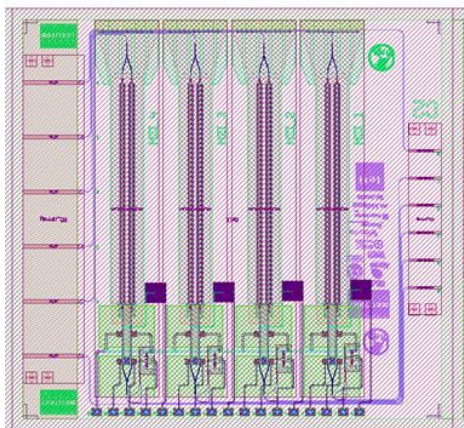
RF Probe Calibration



Steps:

1. RF tip to camera field of view
2. Positions hardcoded
3. Focus on RF tip by altering camera height with Autofocus
4. Focus on chip by altering camera height with Autofocus
5. Distance for the RF tip on chip calculation using the difference of the two focus positions
6. Calculation with some tens of μm deviation has been achieved
7. Automated process for electrical connection will follow

Evaluation of Si photonic transceiver dies



Design by



Fabrication by



Capacitor bonding by



4-channel Si photonic transceiver with MZMs

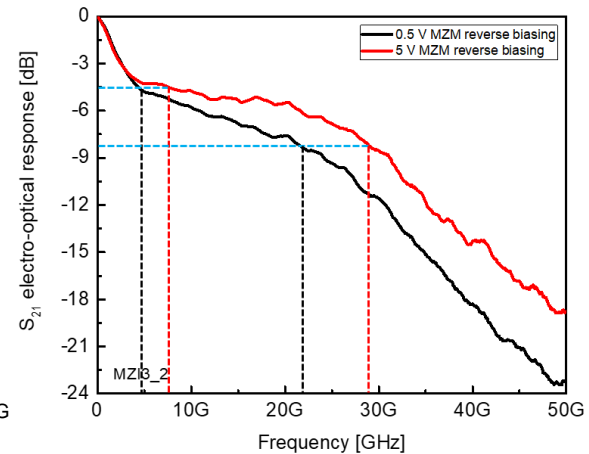
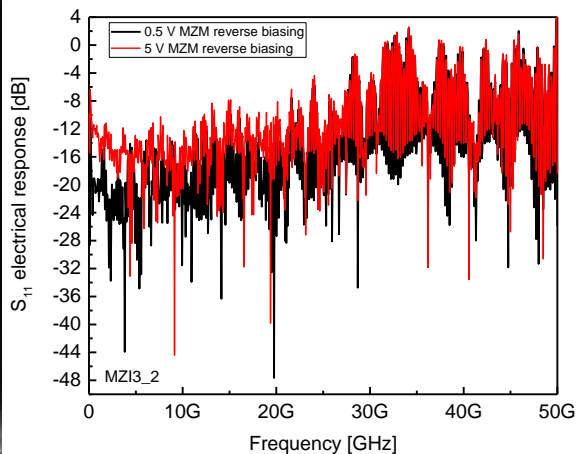
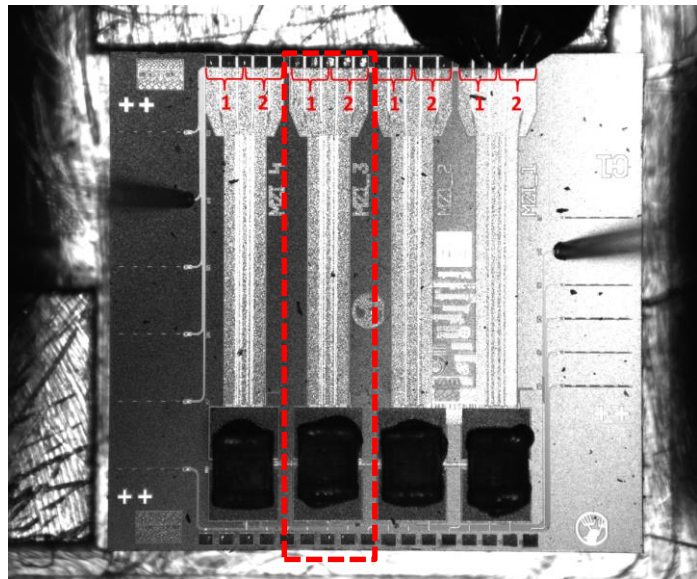
Components of interest:

- ❖ Grating couplers
- ❖ Mach-Zehnder Interferometers (MZI's)
 - Mach-Zehnder Phase Shifters
 - Mach-Zehnder Phase T/O Shifters

Performed measurements

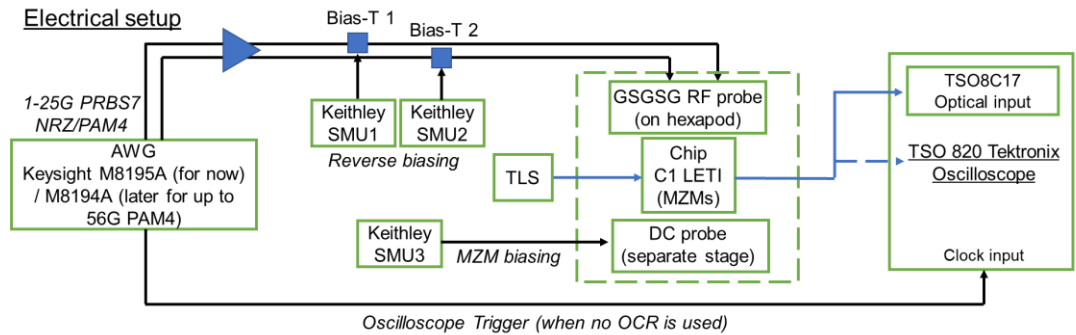
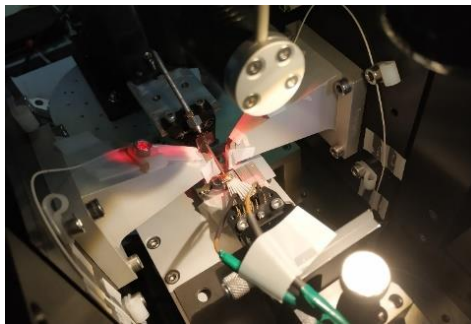
- ❖ **Optical measurements** on grating couplers
- ❖ **Electrical measurements** on MZMs
 - VNA measurements of MZM phase shifters
 - Optical modulation in O-band

S_{11} electrical and S_{21} electro-optical measurements

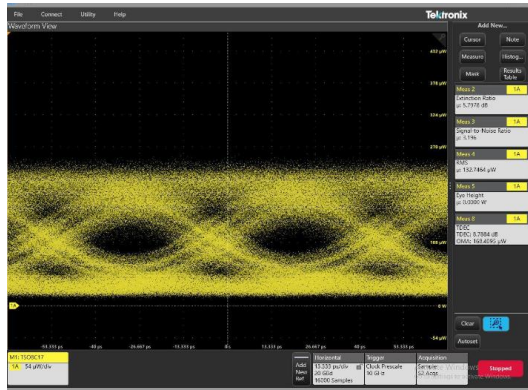


- 3dB bandwidth at 0.5 V MZM reverse biasing ~ 16 GHz
- 3dB bandwidth at 5 V MZM reverse biasing ~ 22 GHz

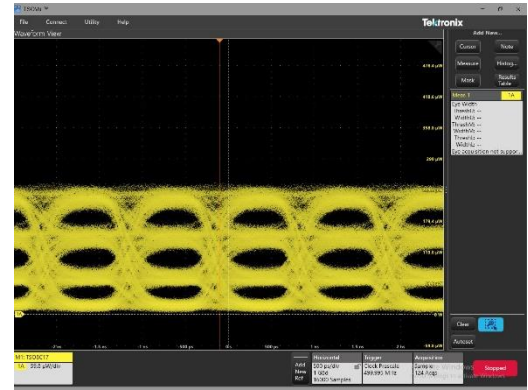
Optical modulation with NRZ & PAM4 signals



20 Gb/s NRZ PRBS7 - Driving RF voltage 3Vpp



1 Gb/s PAM4 PRBS7 - Driving RF voltage 3Vpp



NRZ:
MZM reverse biasing at -2V and
MZM biasing (TO) at 3.2V

PAM4:
MZM reverse biasing at -2V and
MZM biasing (TO) at 3.3V

Overview & Future goals

- ❖ Fiber-to-fiber automated process for die testing optimization
 - ❖ Reduce the optical power losses below 8dBm
 - ❖ Reduce scanning time to less than a minute

How:

- ❖ Scan with the two fibers independently in x- and y- axis.
 - ❖ Use combinatorial scanning shapes such as spiral.
- ❖ Optimization of RF electrical connection
 - ❖ Height calculation for electrical connection with a few μm deviation
 - ❖ Process for electrical measurements on MZMs.

Acknowledgements

Thanks to

MASSTART Consortium



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Grant Agreement Nr. 825109



Website: <http://winphos.web.auth.gr/>

