Introduction of Si Photonics transceiver technology with High temperature operation capability and MMF transmission

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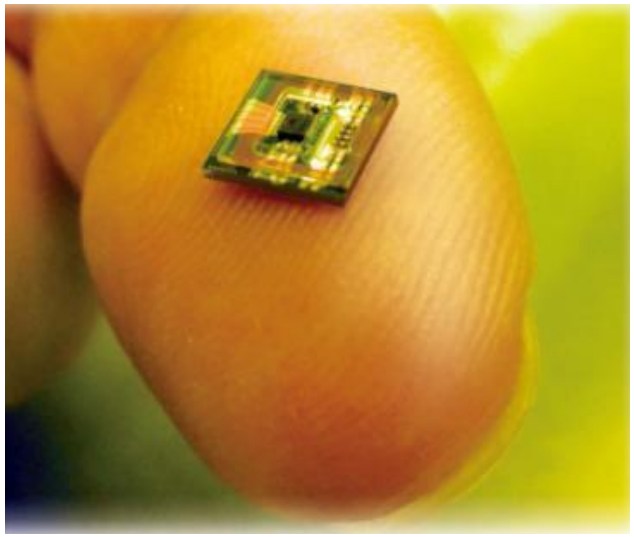
IEEE 802.3 Multi Gigabit Automotive
Optical PHY Study Group

Introduction



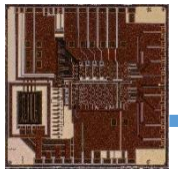
No proposal in this presentation.

Introduction of Si photonics technology possibly applicable to Automobile interconnects.

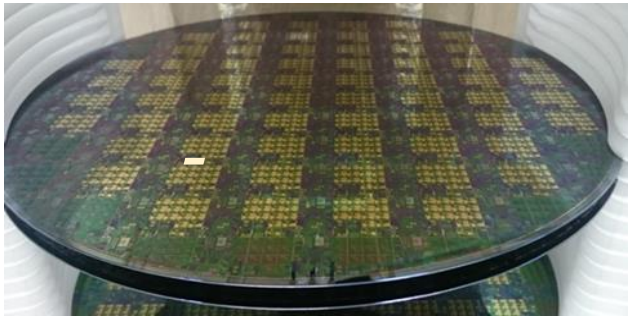
Data-based discussions on high temperature operation, speed and reliability in response to the discussions by Rubén of Sept 2019 Interim in;
“Open discussion on objectives” and
”Technical and economic feasibilities Requirements and methodology for assessment”.

What is Si photonics transceiver？

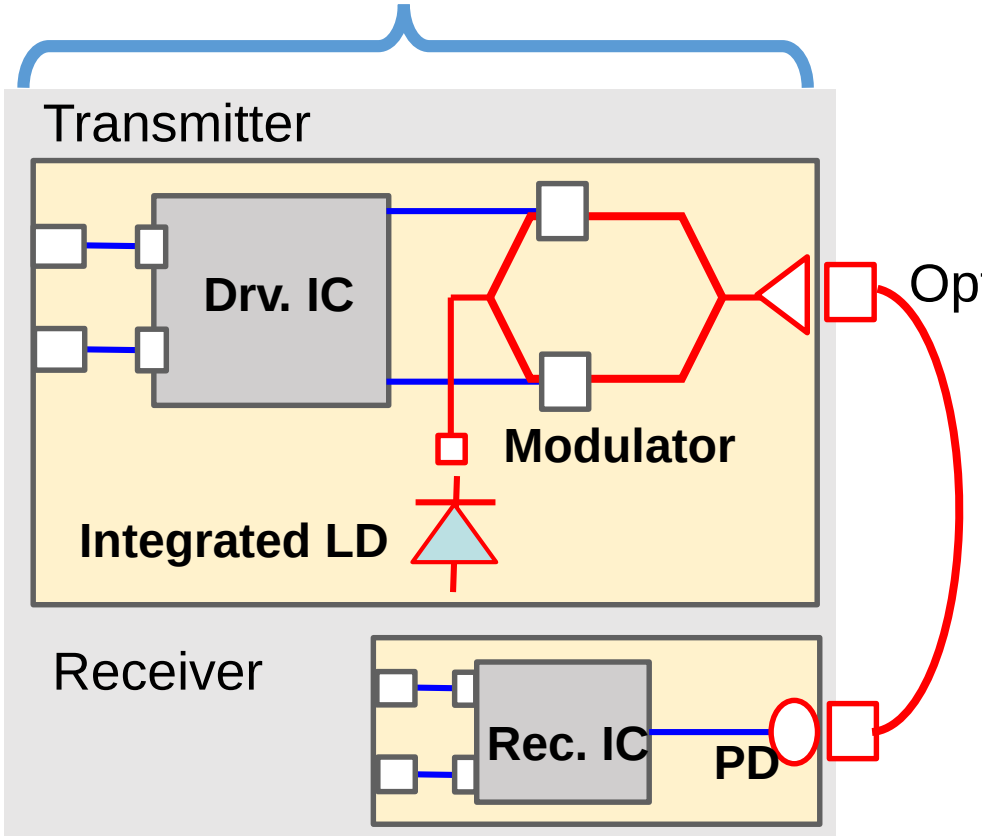
Integrated Si photonics transceiver



Si wafer



One chip integration
Mass-producible

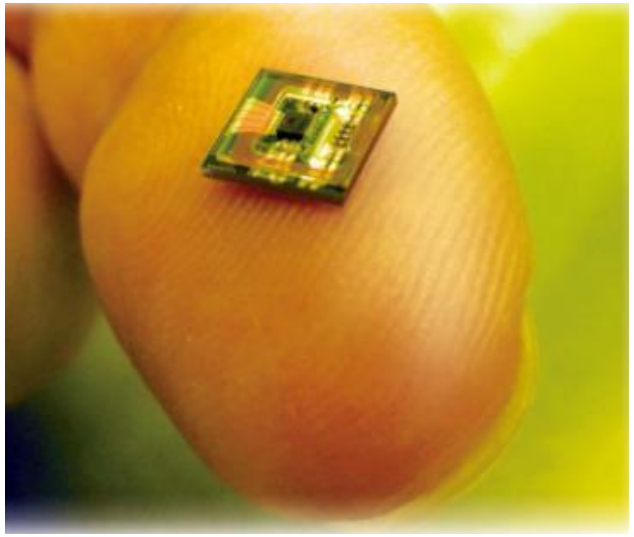


Opt. Connector
/Fiber

Si photonics technology commercially available for short reach interconnect

Optical I/O core chip based on silicon photonics

Item	Specification
Throughput	100G: 25Gx4ch Tx + Rx 300G: 25G × 12ch Tx/Rx
Footprint	5mm × 5mm
Power consumption	5mW/Gbps
Wavelength	1.3μm（O-band）
Media	MMF up to 300m*



* 1310nm-optimized MMF

- High density
- Low power consumption
- User-friendly assembly
- Low cost solution through the combination of
  Si-Photonics and multimode optics with wide alignment margin

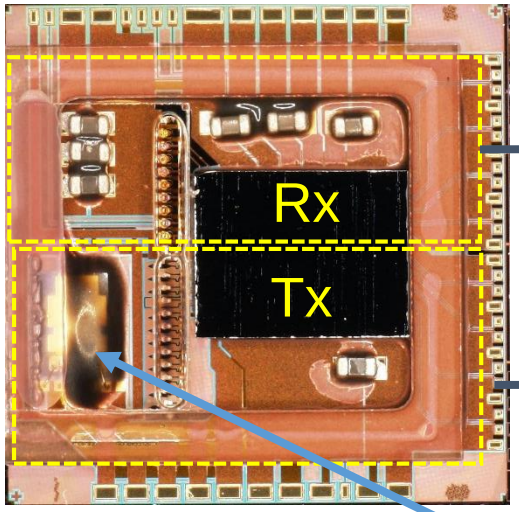
Data-based approach of Si Photonics for High speed, High temperature and High reliability in response to

”Technical and economic feasibilities Requirements and methodology for assessment” by Rubén at Sept 2019 Interim

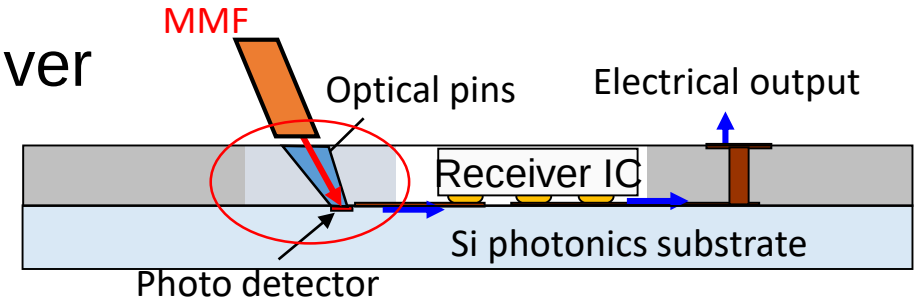
- IEEE Std 802.3 already includes the 10, 25 and 50GBASE-SR specifications that may be considered as starting point to develop multi-gigabit optical PHY specification for automotive applications
  - nGBASE-SR are based on 850nm VCSEL, MM graded-index glass fiber, GaAs PIN diode
  - However, are them really suited for automotive applications?
- Key differences between nGBASE-SR and the Automotive requirements:
  - Ambient temperature grades per AEC-Q100:
    - Grade 2: Ta = -40ºC — 105ºC
    - Grade 1: Ta = -40ºC — 125ºC
    - Grade 0: Ta = -40ºC — 150ºC
  - Grade 2 imposes junction temperature range Tj = -40ºC — 125ºC (power < 1W / port)
  - 15 years operation, 0 ppm failures

Si photonics with QD-laser and MMF optics for short reach incl. automobile

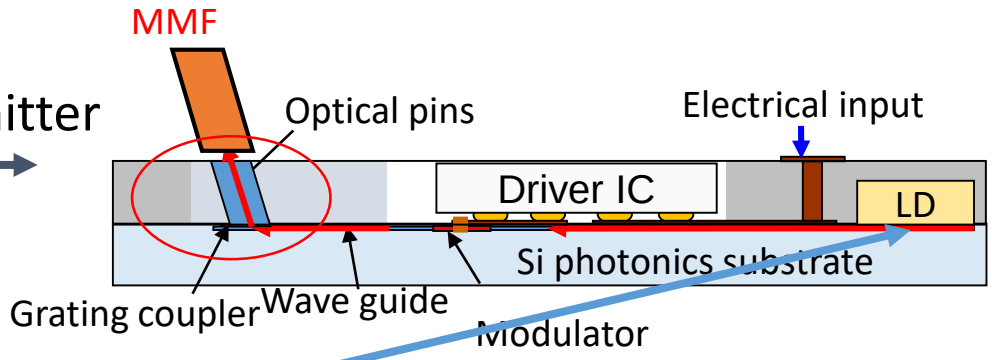
Si photonics one-chip transceiver



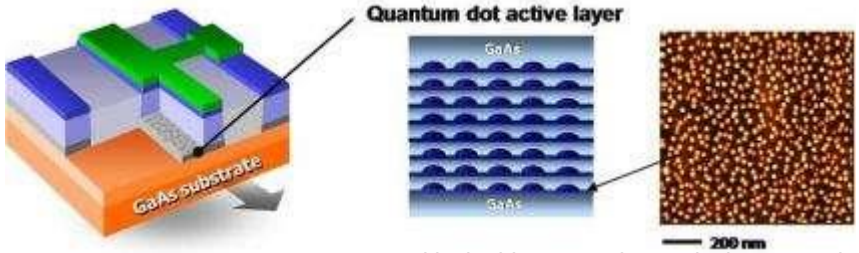
Receiver



Transmitter

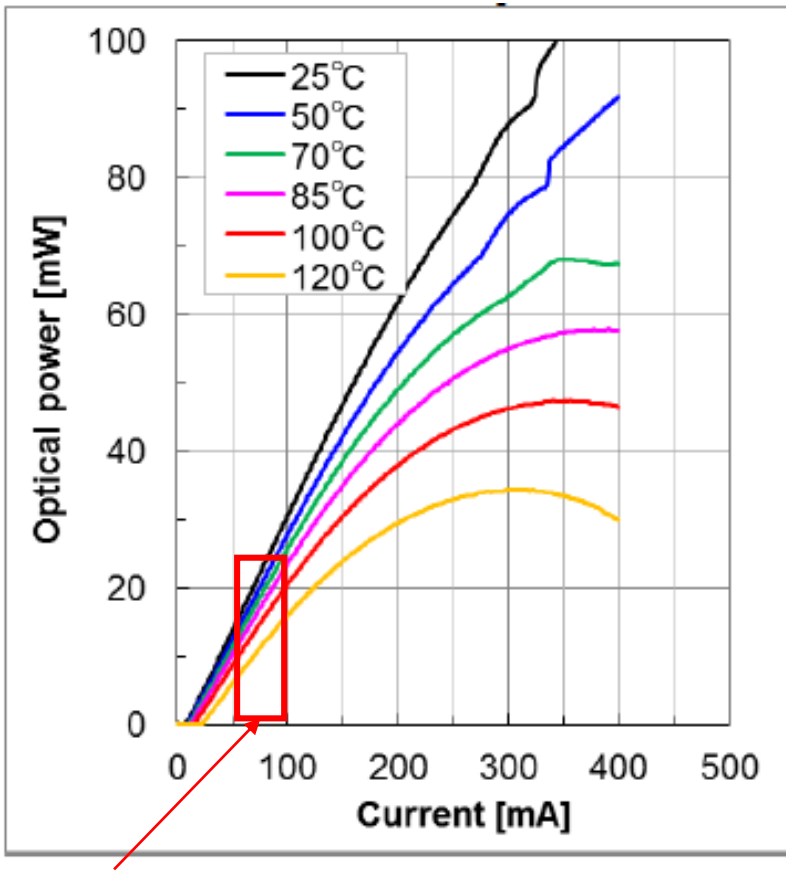


Quantum dot laser light source



High temperature operation of Quantum Dot LD light source

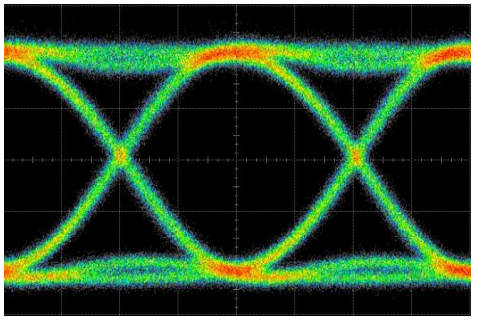
(Temp. range limited by equipment)



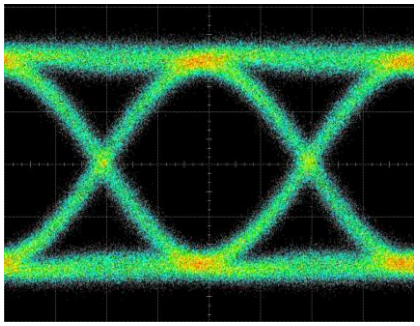
General Operation current

25Gbs Tx waveform

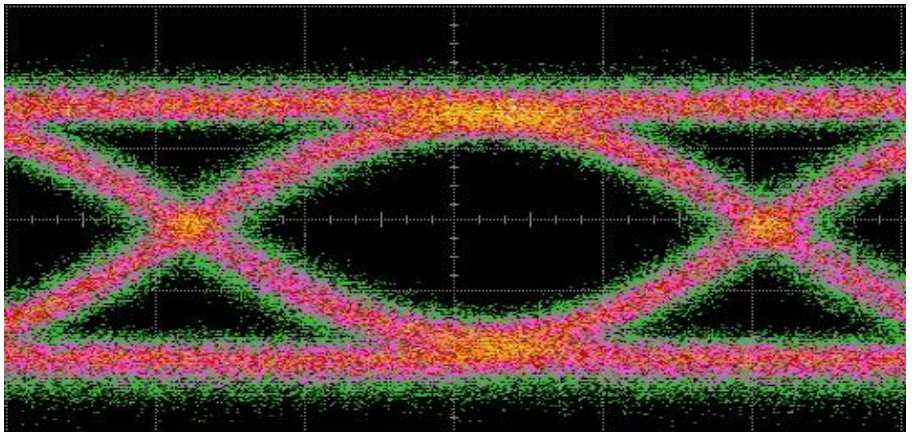
-5ºC



85ºC

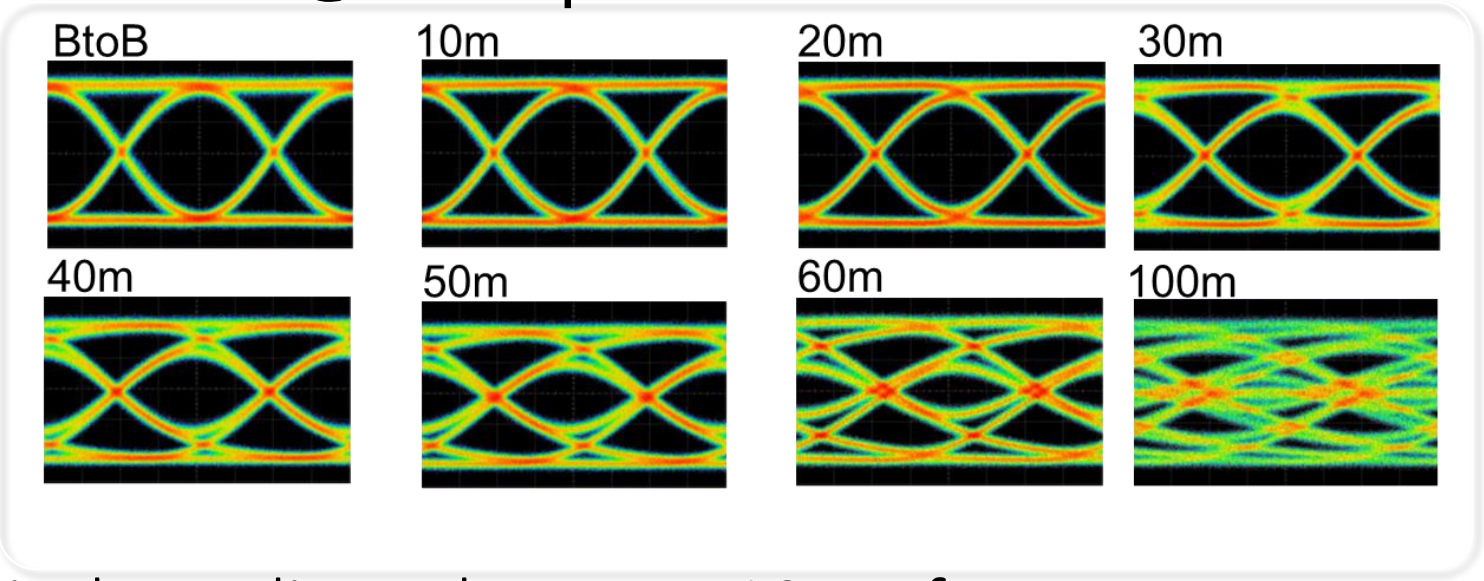


105℃ (W/O LD bias control)



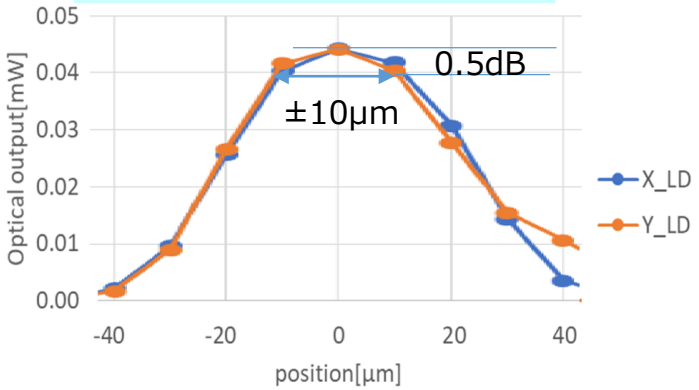
MMF Transmission data for OM3

OM3 >40m@25Gbps

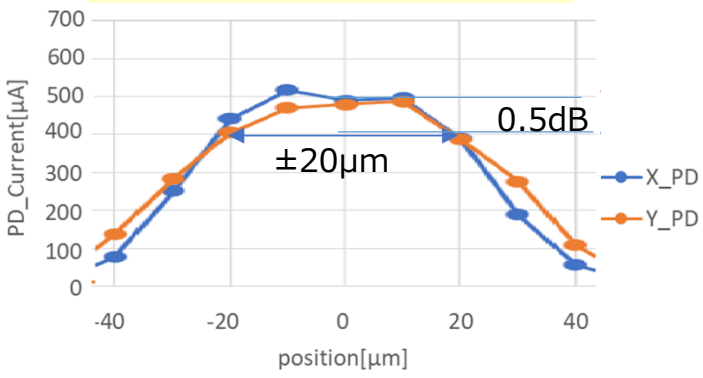


Optical coupling tolerance >10µm for MMF

Tx interface tolerance



Rx interface tolerance



LD lifetime test results (tentative up to 105℃)

Acceleration test (Po=31mW) for QD laser Results in Ea=0.746eV

Arrhenius equation

κ= A* EXP(-Ea/(kB*T))

where κ : rate constant

Ea: Activation energy 0.746eV

kB: Boltzmann Constant(=8.617*E-5 eV/K)

T : Absolute temperature(in kelvins)

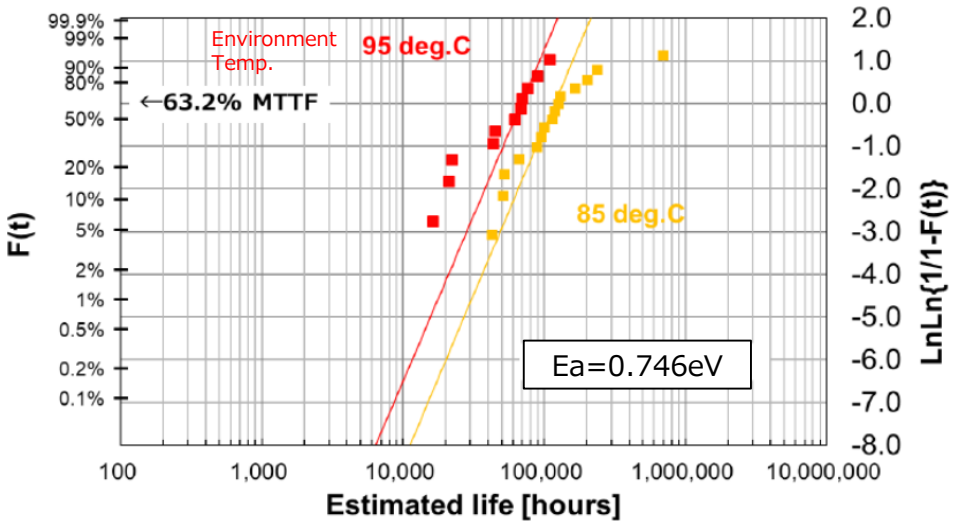
MTTF in actual use at Po=20mW for Ea=0.746eV
Expexted to be 20 years at 105℃

$k = ko * \exp\{Ea/kB * (1/T - 1/To)\} * (\frac{I}{Io})^{-n} * (\frac{P}{Po})^{-m}$

assumed n=2 & m=1

Redundancy (Dual redundancy) will benefit the required reliability for Automobile applications of ~0ppm@15 years

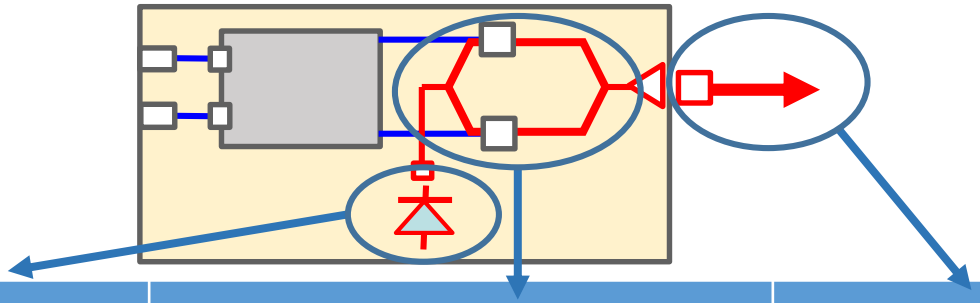
	85°C	95°C
MTTF (Cumulative failure rate, F(t)=63.2%)	134,470 [hours]	63,682 [hours]
Median life (Cumulative failure rate, F(t)=50%)	112,450 [hours]	50,470 [hours]



Actual use condition(20mW@100mA、TO CAN)

Environment Temp.	Junction Temp. Tj(℃)	MTTF of 4 Channels (years)
60℃	68.1	642
85℃	95.0	87.5
105℃	116.8	20.9

Features for automobile applications



Quantum dot laser	Si photonics platform	MMF transmission
High temperature operation	Temperature independent modulator High speed operation High productivity (Low cost/High volume)	Large optical coupling tolerance (>10um) MMF (OM3) for automobile reach (40m)

- Operation temperature up to 105 ℃
- Operation up to 25Gbps (50G-NRZ in future)
- Commercial MMF(OM3) available for 40m reach

Summary

Data-based approach of Si Photonics for Automobile applications for High speed, High temperature and High reliability

- High speed
 25Gbps and higher

- High temperature
 Quantum Dot Laser Source integrated Si Photonics transceiver operates over 105℃

- Reliability
 QD-LD lifetime expected over 20 years and redundancy will benefit high reliability

We would like to contribute and appreciate your feedback