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2D image sensors for LiDAR

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Hamamatsu Photonics

From photonics technology to automotive solutions

A driver in the photonics industry

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"A HIDDEN CHAMPION OF THE 21TH CENTURY"

Hermann Simon, author of the *Hidden Champions of the Twenty-First Century*

10
RESEARCH & PRODUCTION BASES

5,491
EMPLOYEES

$ 1.676 BILLION
1953 ••••••••••••• 2022

SINCE
1953

5.4%
R&D EXPENSE

3 NOBEL PRIZE
CONTRIBUTIONS

15.000
PRODUCTS

1995
ENTRY IN TOKYO **STOCK EXCHANGE**

UNITED NATIONS GLOBAL COMPACT
- HUMAN RIGHTS
- LABOUR STANDARDS
- ENVIRONMENT
- ANTI-CORRUPTION

*Figures taken in 2021/2022

A dedication to the automotive industry

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LiDAR

Automatic air conditioner

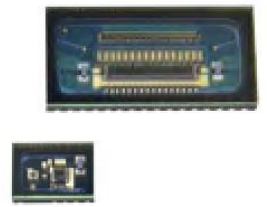
Automatic headlight control

Automatic wiper

In-vehicle network

Semiconductor Failure Analysis

A vast LiDAR portfolio

Parameter	Si PIN PD	InGaAs PIN PD	Si APD	Si APD+TIA	SiPM/MPPC	InGaAs APD	InGaAs APD + TIA
LiDAR Range	Short	Short to Medium	Medium	Medium	*Medium to Long*	Long	Long
Gain	1	1	50-150	50-100	10^6	10-30	10-30
QE @ 905/1550 nm	>92%	>76%	50%	50%	9%	>72%	72%
Operating Voltage	<10V	<20 V	160 V +/- 20 V	160 V +/- 20 V	60 V	65 V	65 V
Readout Circuit	Complex			Simple		Complex	
Array	Suitable						
Operating Temperature	-40/+125°C	-40/+105°C	-40/+105°C	-40/+105°C	-40/+105°C	-40/+85°C	-40/+105°C
Products series							

Customization of photodetectors is possible, please contact Hamamatsu for more information.

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LiDAR sensors: improved technology

PDE (Photon Detection Efficiency)

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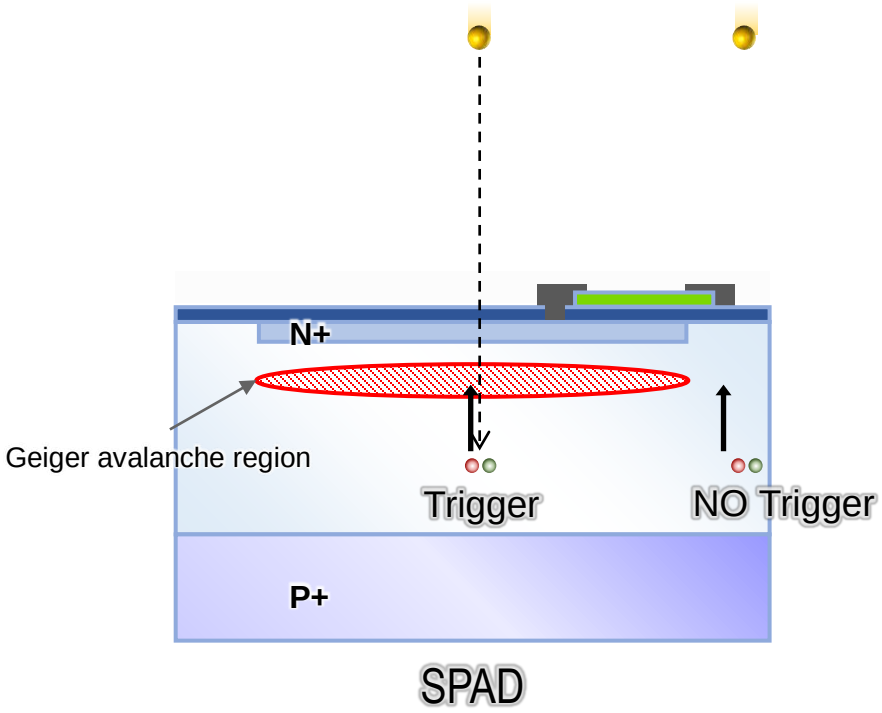
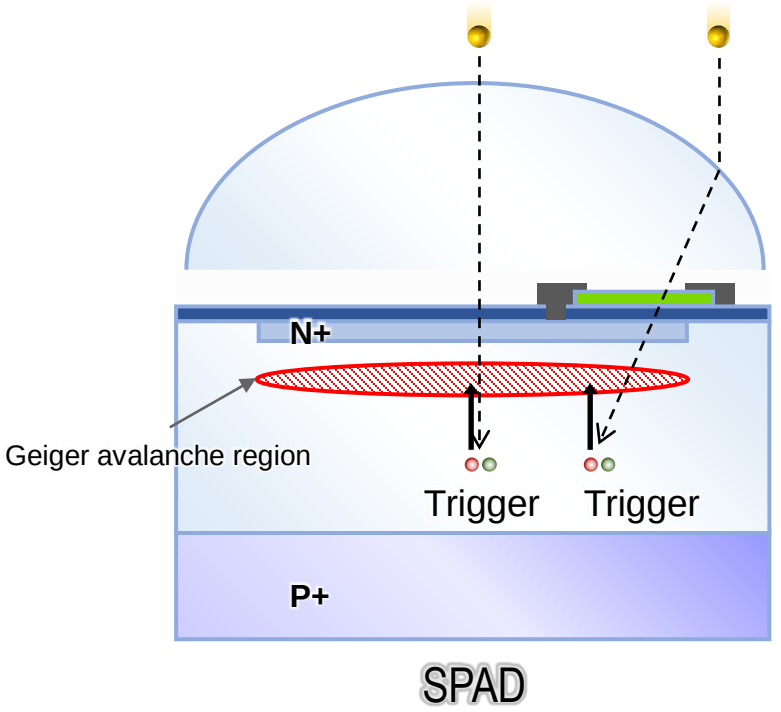
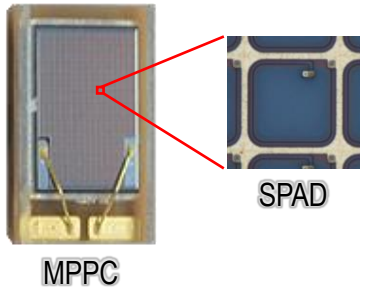
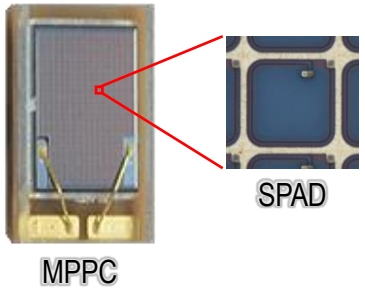


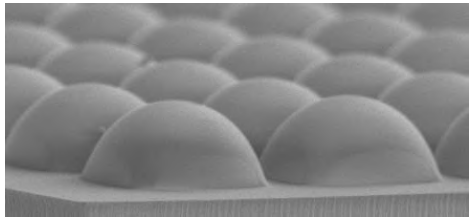


Conventional



New





PDE (Photon Detection Efficiency)

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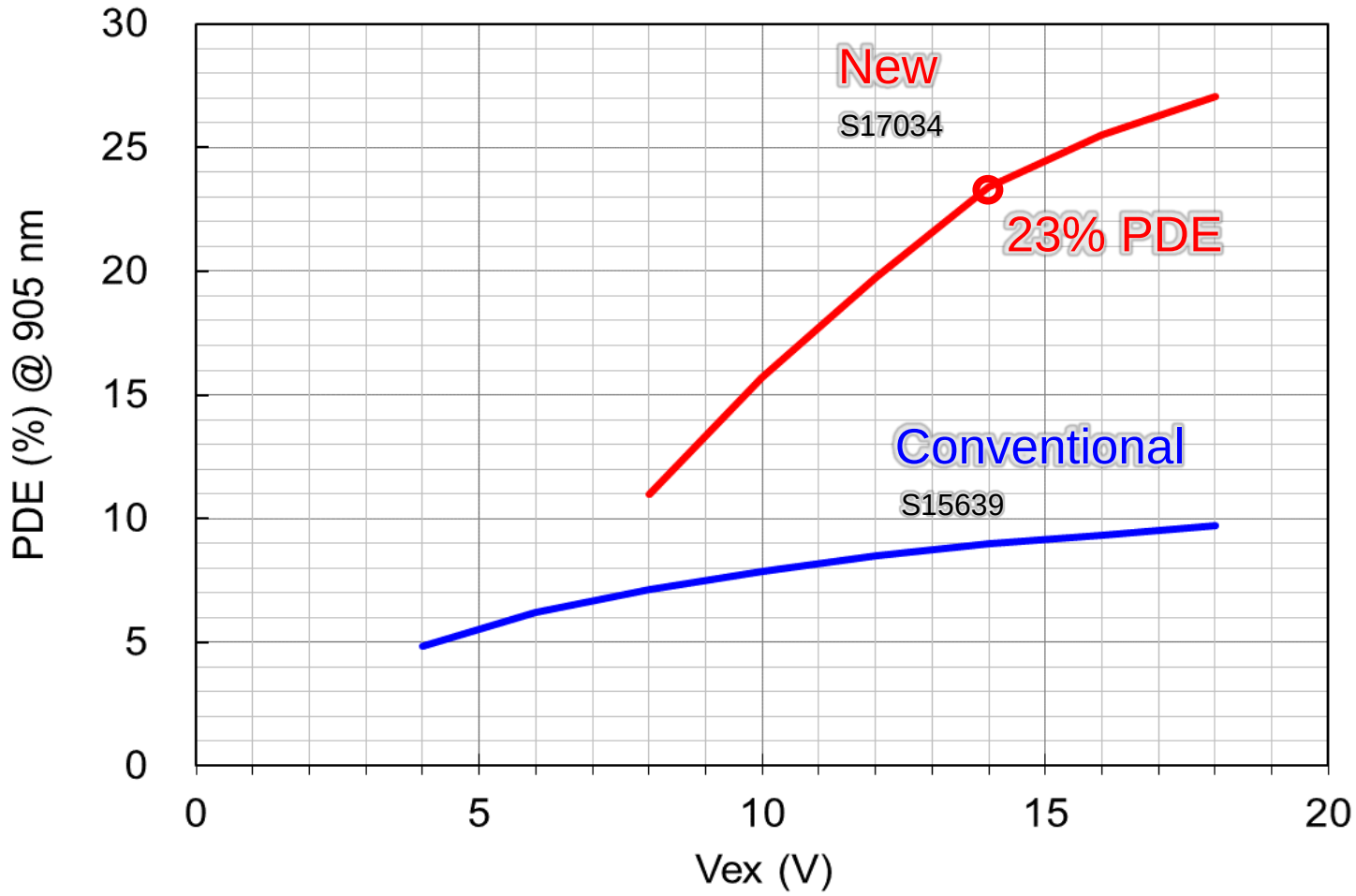
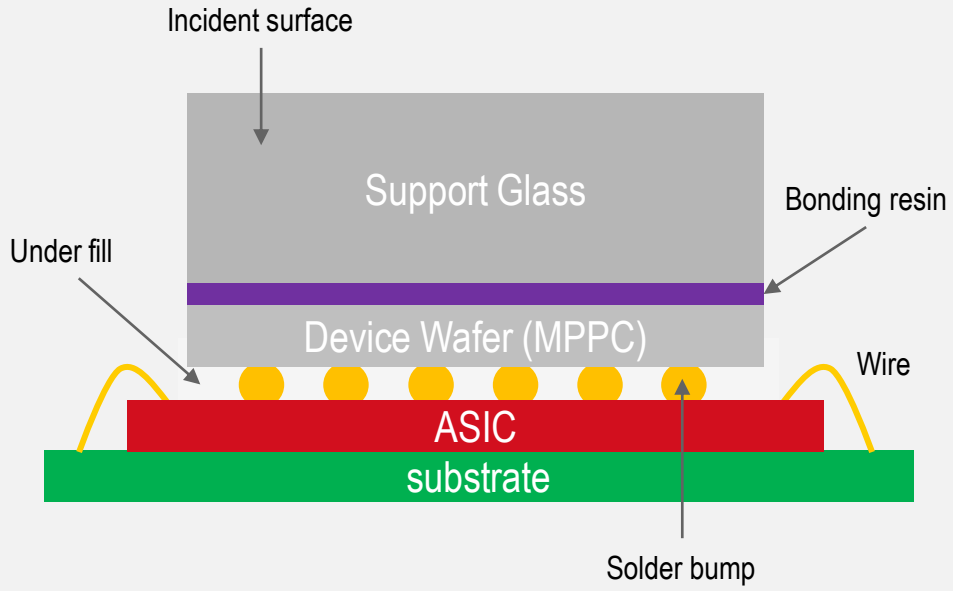


Vex : Excess bias voltage, Vop : Operation voltage
Vbr : Breakdown voltage, Vop = Vbr + Vex

Wire bonding

Back illuminated 2D SPAD/MPPC Array with ASIC (before Cu-Cu bonding)



Bad point

- Solder bump cannot be narrow pitch (less than 100µm)
- This structure cannot guarantee in-vehicle reliability
- This structure cannot form Microlens (because of the glass)
- Transmittance(@905nm) decreases due to bonding resin

From wire bonding to Cu-Cu Bonding

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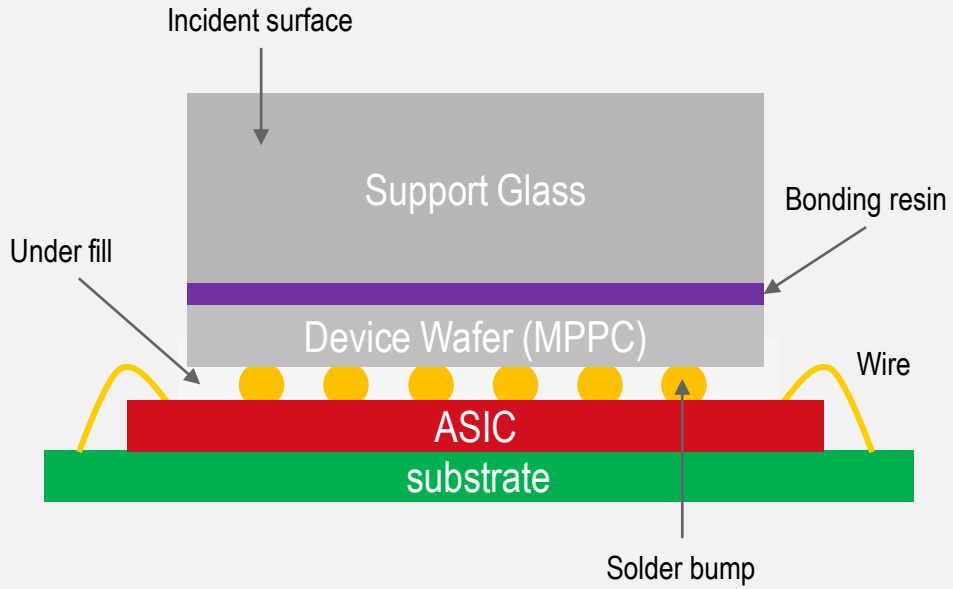
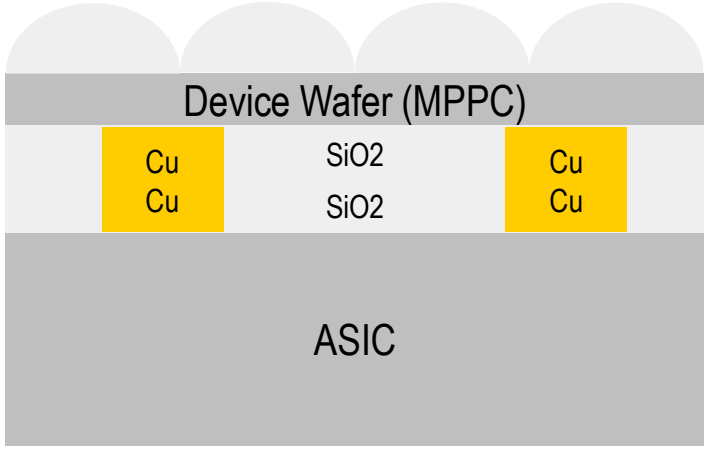
Back illuminated 2D SPAD/MPPC Array with ASIC (before Cu-Cu bonding)



NEW Back illuminated 2D SPAD/MPPC Array with ASIC (Cu-Cu bonding)

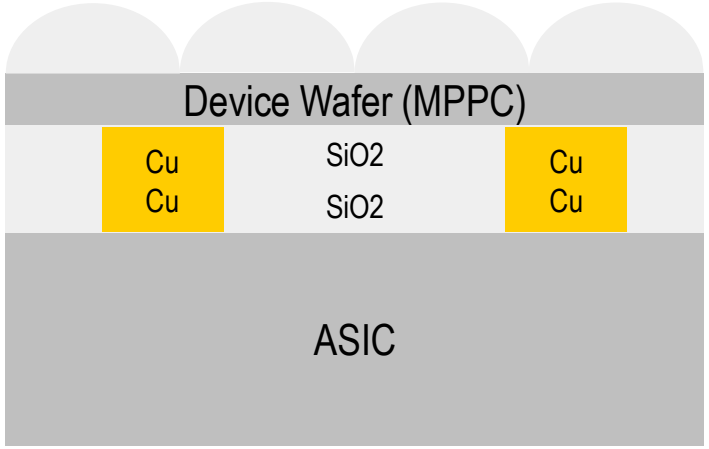


Cu-Cu Bonding

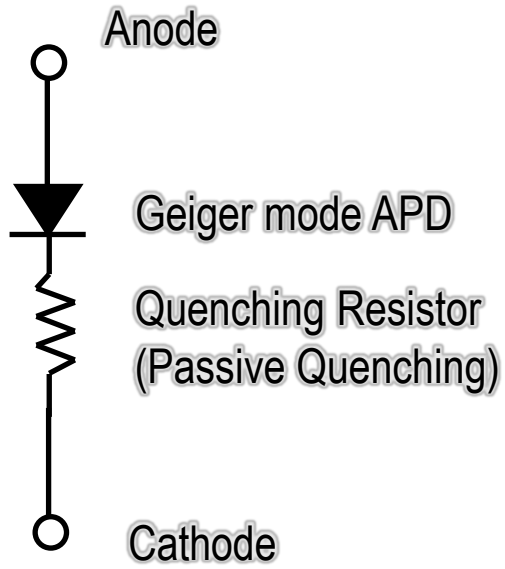
NEW Back illuminated 2D SPAD/MPPC Array with ASIC (Cu-Cu bonding)

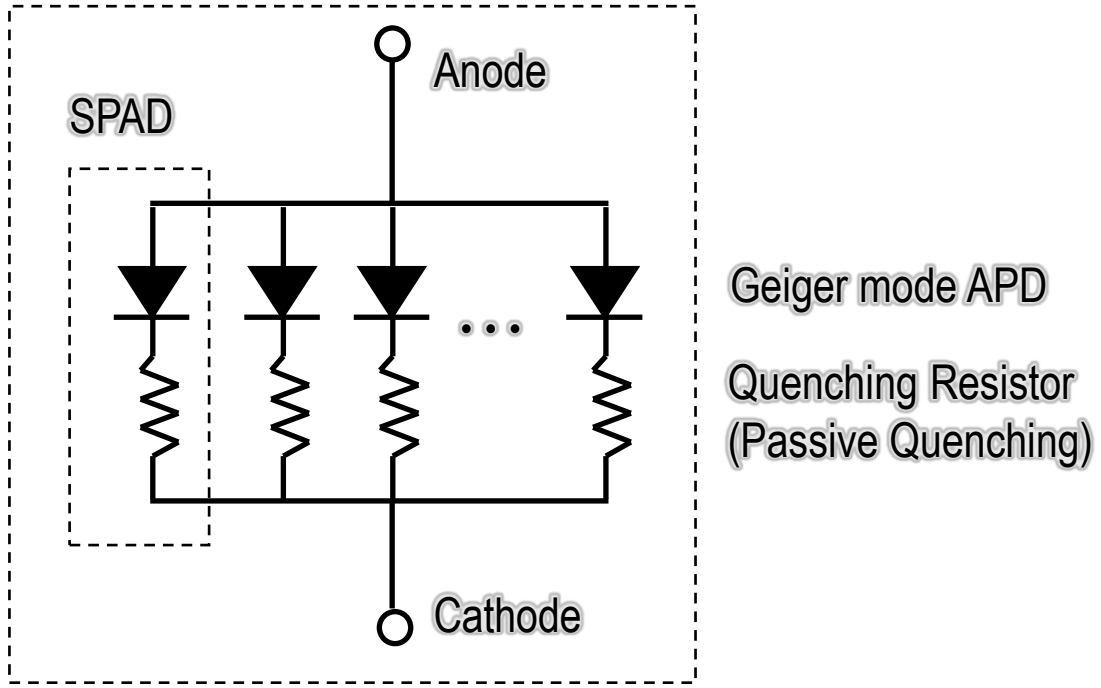
Good point

- Cu-Cu Bonding can be narrow pitch (minimum 10μm)
- Cu-Cu Bonding can guarantee in-vehicle reliability
- Cu-Cu Bonding can form Microlens



Difference between SPAD and MPPC





SPAD

Includes 1 geiger mode APD and 1 quenching resistor in one output

MPPC (SiPM) = Multi SPADs in channel

Multiple SPADs are connected in parallel in one output

Difference between SPAD and MPPC

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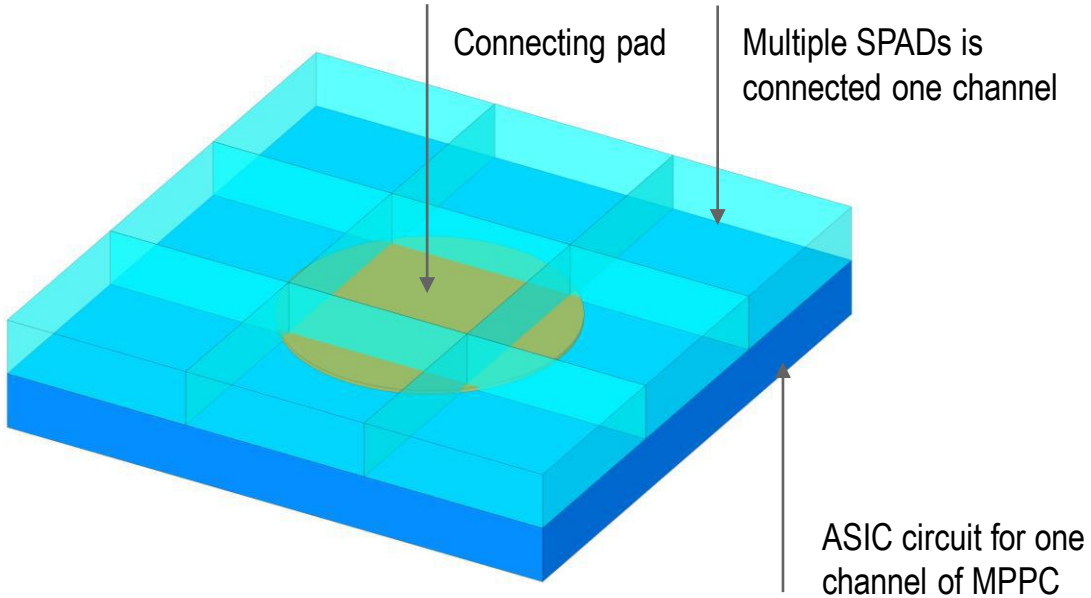
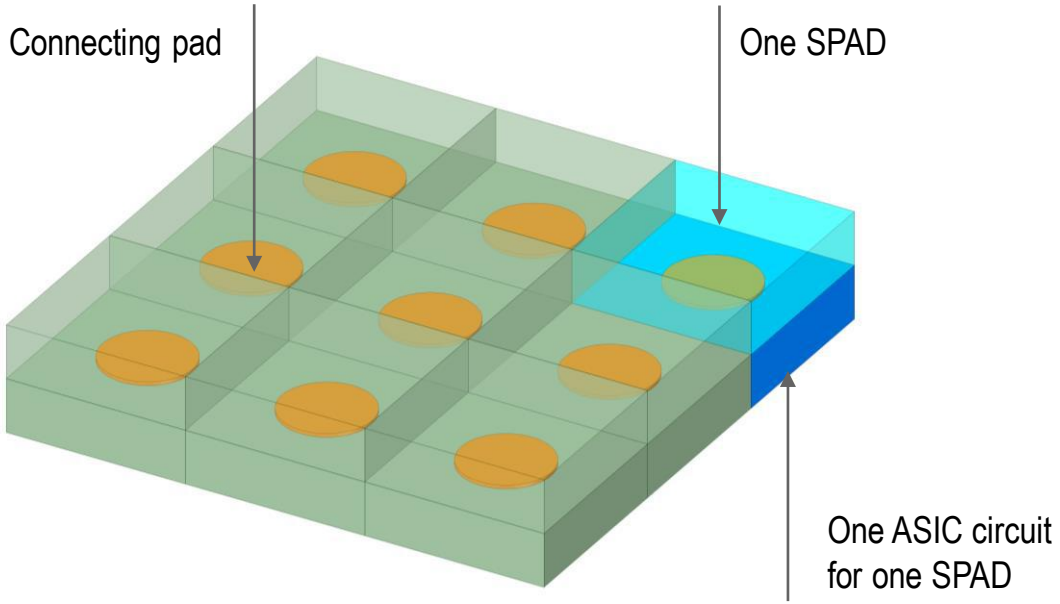
The ASIC circuit of MPPC with ASIC can achieve the higher performance and it is more flexible to the custom design.

Layout of MPPC with ASIC



One Channel of MPPC with ASIC as LiDAR detector
The signal and noise are distinguished by comparator threshold.

Layout of Multi-SPADs with ASIC

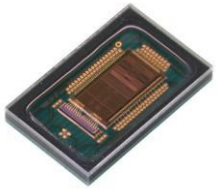


One Channel of SPAD with ASIC as LiDAR detector
The channel has Multi-SPADs for time correction to distinguish noise.

Road map summary

1D MPPC with ASIC

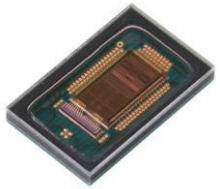
S15022-0215GL-01



- 1x16ch
- 15x15um SPAD size
- 13x12 spads per ch
- PDE :15%
- Not AEC qualified

1D MPPC with ASIC

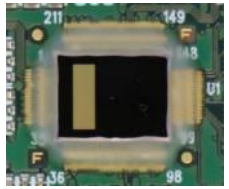
S15022-0215GL-**02**



- 1x16ch
- 15x15um SPAD size
- 26x12 spads per ch
- PDE :23%
- AEC Grade 2

2D MPC with ASIC

S15013-025NP-01

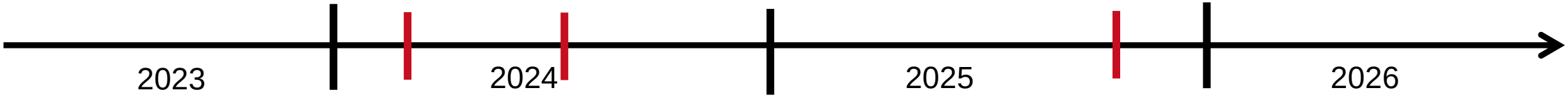


- 120x40ch
- 25x25um SPAD size
- 2x2 spads per ch
- PDE :20%
- Not AEC qualified

2D MPPC with ASIC

S15013-025NP-01

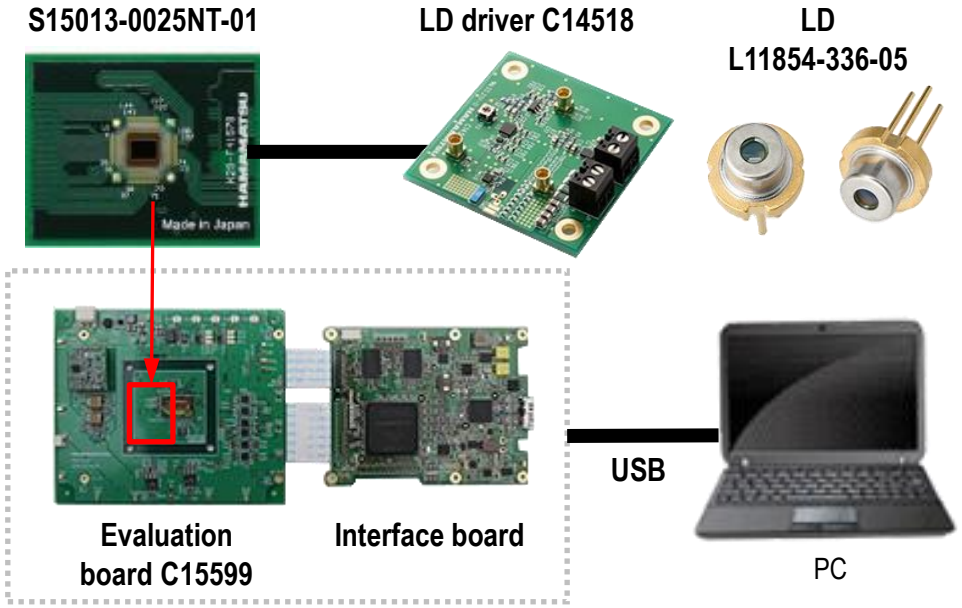
- 320x240ch
- 15x15um SPAD size
- 3x3 spads per ch
- PDE :>25%
- AEC Grade 2



Evaluation kit

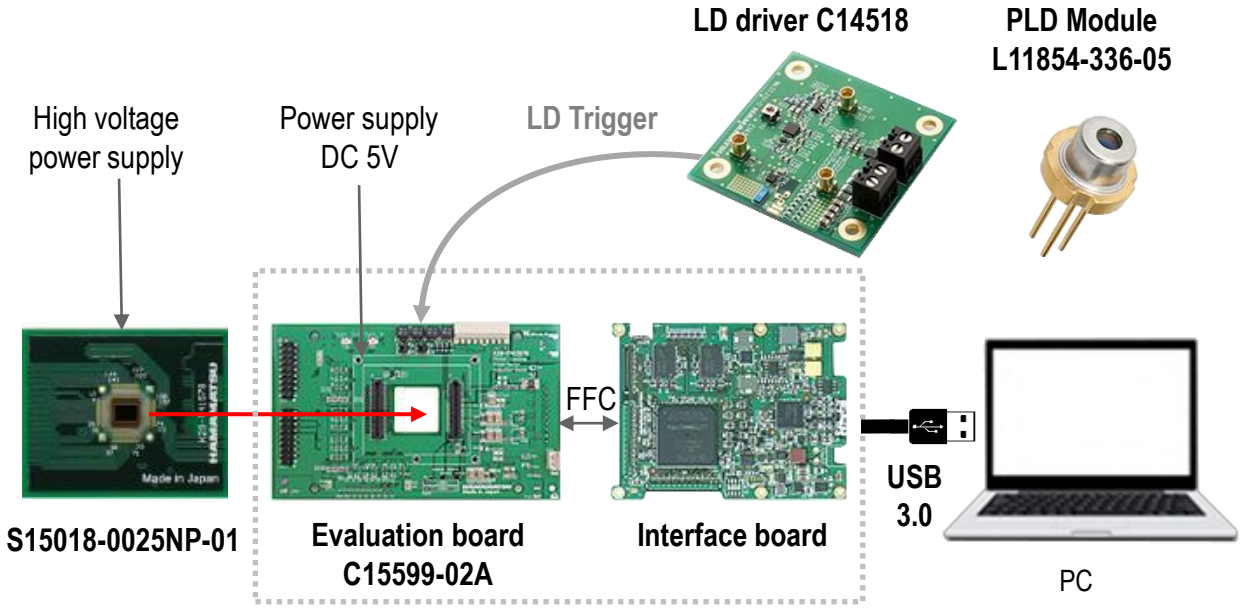
S15013-0025NT-01 (120x40ch 2D MPPC + ASIC) C15599 (Evaluation board)

- Including hybrid 2D-MPPC and USB 3.2 I/F
- Data acquisition by PC
- Built-in clock output pin (Connectable to LD driver C14518)
- Lens unit mounting hole
- Power: USB bus power only, external –HV for MPPC (optional)
- Evaluation software



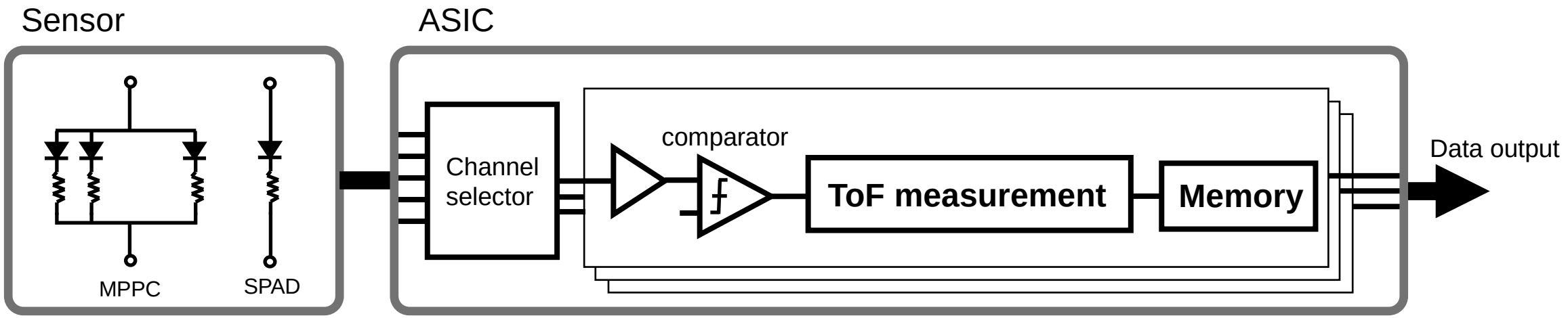
S15018-0025NP-01 (120x40ch 2D SPAD + ASIC) C15599-02A (Evaluation board)

- USB 3.2 I/F
- Data acquisition by PC
- Built-in clock output pin (Connectable to LD driver C14518)
- Lens unit mounting hole
- Power: USB bus power only, external –HV for MPPC (optional)
- Evaluation software



Customization

Basic configuration block diagram of MPPC/SPAD+ASIC



Customization items(example)

- Channel number
- SPAD number per channel
- SPAD size/pitch

- Time of flight by TDC(time to digital converter)
- Energy measurement by TOT(time over threshold)(MPPC only)
- Passive quench / Active quench(SPAD only)
- Pixel TDC / Column select TDC
- Channel select(Zone, Column)
- Multi Echo Detection
- Noise removal by comparator threshold(MPPC only)

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Thank you!

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BOOTH #G5

DVN