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System design considerations for a short-range segmented flash LiDAR

DVN LiDAR Conference 2023 in Wiesbaden

29-30 NOV. 2023 FRANKFURT

DVN Lidar

6TH DVN AUTOMOTIVE LIDAR CONFERENCE & EXPO

"2024 - The Year Lidar Breaks out!"

DORINT HOTEL PALLAS WIESBADEN, FRANKFURT AREA

Clemens Hofmann, Senior Principal Engineer LiDAR, ams-OSRAM International GmbH
2023-11-30

Short Range LiDAR use cases in Automotive Applications

Market trend seen for short range LiDAR sensors using flash VCSEL technology

Short range LiDAR use cases

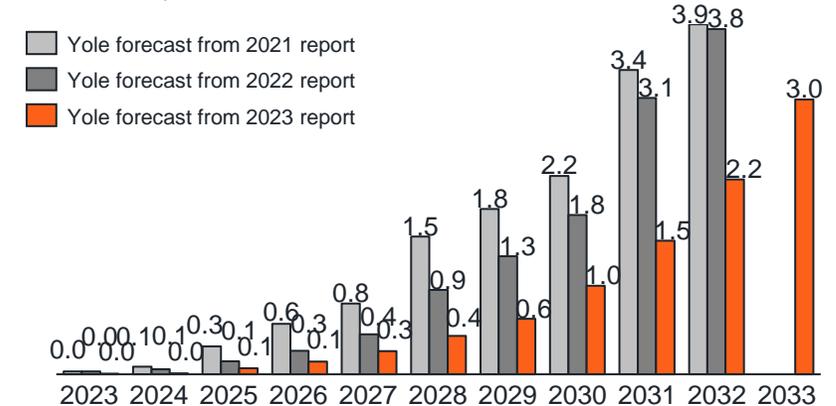**Urban pilot (UP)**

Parking

L4/L5 Robo Taxi (RT)

Market forecast short range LiDAR – Yole report

- ADAS
  - slow penetration as OEMs focus on TJP and HWP
  - applied in urban L2 use cases (mainly in China)
  - parking is appearing

- Robo trucks and Robo taxis
  - require SR for L4 functionality
 - slow growth compared to ADAS

AM LiDAR, # of SR sensors in millions

- Yole forecast from 2021 report
- Yole forecast from 2022 report
- Yole forecast from 2023 report

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Short Range LiDAR use cases in Automotive Applications

Market trend seen for short range LiDAR sensors using flash VCSEL technology

LiDAR Sensor with segmented flash technology

Segmented Flash

Field-of-View

RX optics

SPAD array
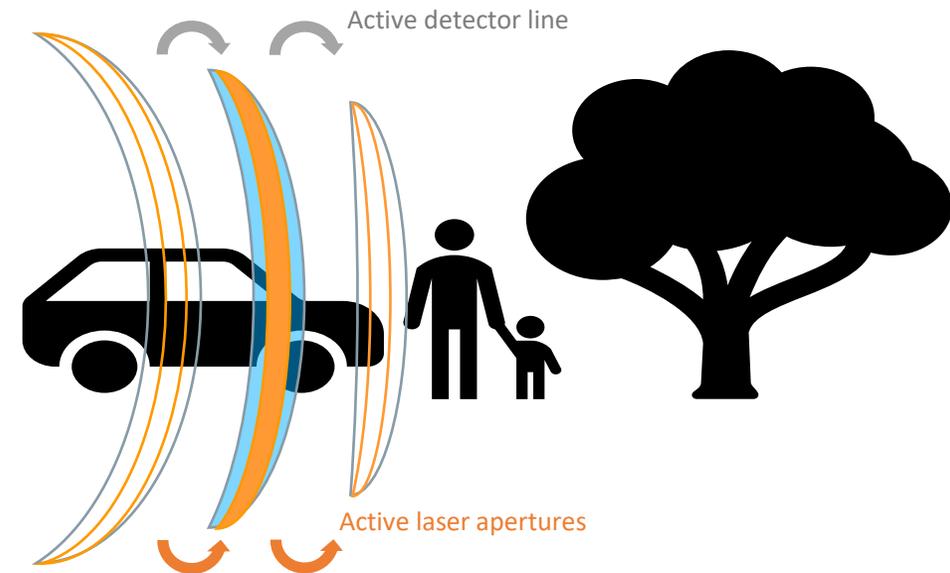rolling shutter

VCSEL array - Addressable

TX optics
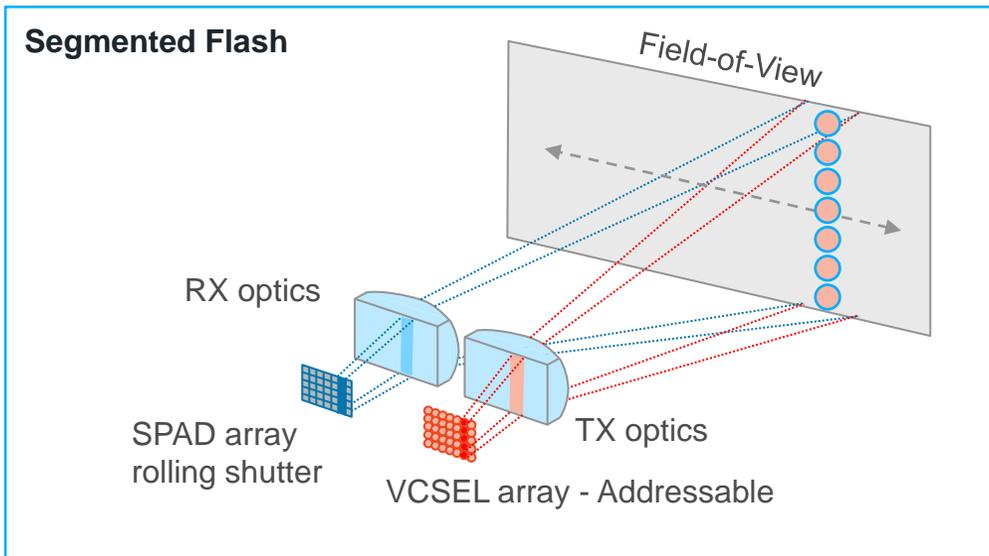
Segmented Flash

- light up only one segment (e.g., a line) of the VCSEL
- read out matching SPAD segment
- light up next segment of VCSEL
- read out next segment of SPAD

VCSEL and SPAD segments need to match

Optical distortions in the far field

Active detector line

Active laser apertures

Optical distortions

- image of VCSEL segment can be distorted, especially toward outer edge of FoV

Distortions of optics for emitter and detector need to be matched

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Segmented Flash LiDAR concepts

Identical pixel pitch for TX and RX ease optical design but are challenge for VCSEL design
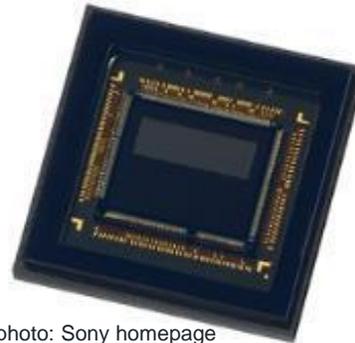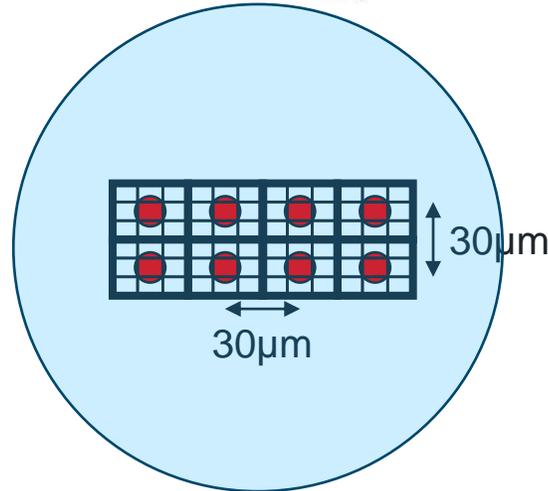
VCSEL	SPAD	Key take aways
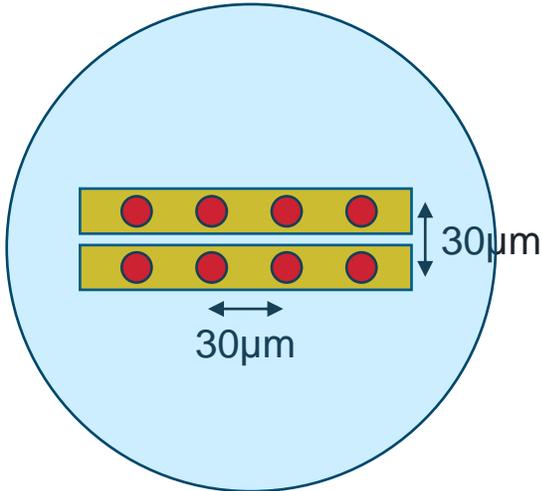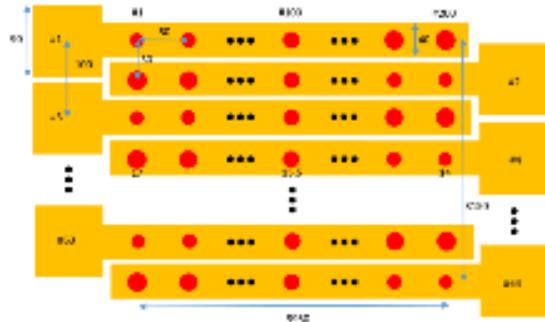
photo: Sony homepage
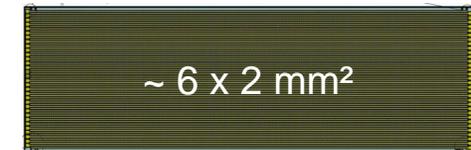
30μm

30μm

30μm

30μm

Optics
- Same pitch for VCSEL and SPAD
- TX and RX can use same optics
  - ➢ identical distortions

VCSEL design (e.g., for IMX459)
- 56 rows x 192 apertures (30μm pitch)
- large VCSEL, low fill factor
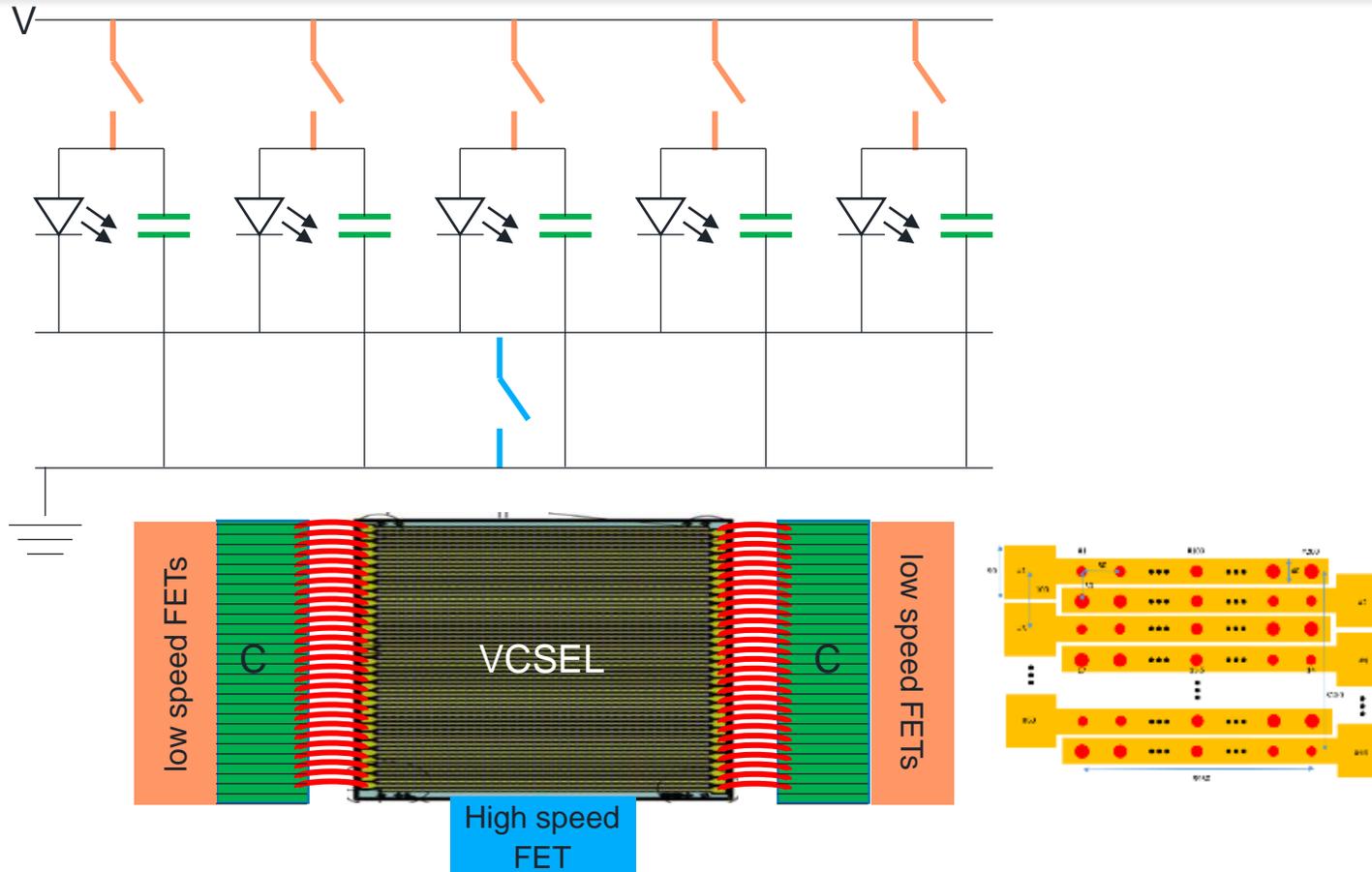- challenging for VCSEL design rules

Driver
- What about multi-channel driver

~ 6 x 2 mm²

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Segmented Flash LiDAR concepts

Identical pixel pitch for TX and RX ease optical design but are challenge for VCSEL design and driver design

Capacitor Voltage Control – 1D VCSEL

Key take aways

VCSEL specifications
- Target is >100W per line
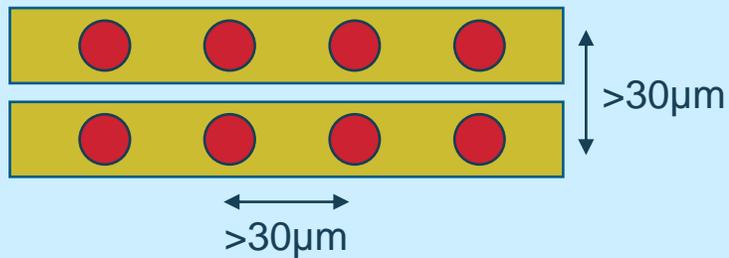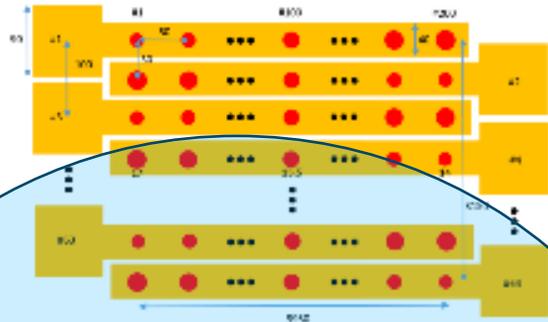- 20-30A needed per line
- 500-1000nJ pulse energy

Driver
- 30μm channel pitch will be challenging for multi-channel driver

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Segmented Flash LiDAR concepts

Different pixel pitch for TX and RX ease VCSEL design and driver design but make optics more complicated
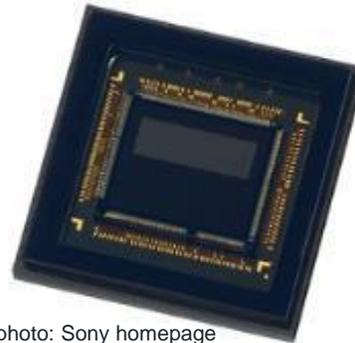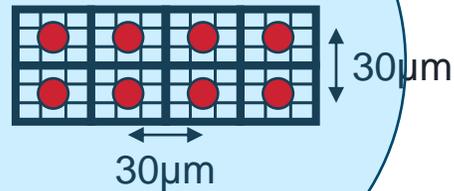
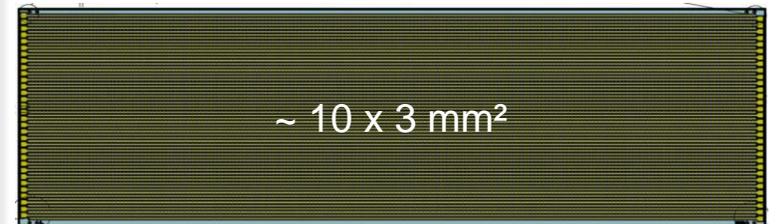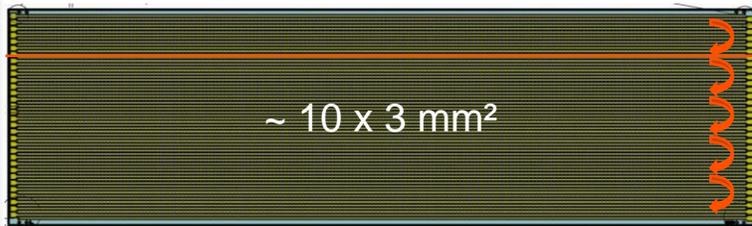| VCSEL	SPAD	Key take aways
	photo: Sony homepage	**Optics** • Different pitch for VCSEL and SPAD • TX and RX use different optics ➢ challenge to match distortions **VCSEL design 100W (e.g., for IMX459)** • 56 rows x 192 apertures (50µm pitch) • Well within VCSEL design rules • Very large VCSEL, low fill factor **Driver** • feasible for multi-channel driver ~ 10 x 3 mm²

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Segmented Flash LiDAR concepts

1:1 pixel relationship eases optics design at cost of large VCSEL. Homogeneous line allows small VCSEL, but optics design is challenging
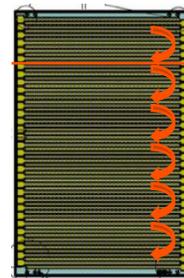
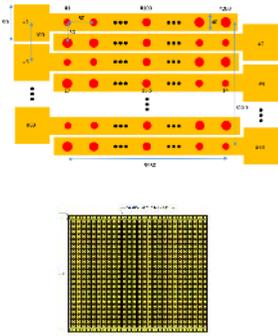| 1:1 pixel relationship	Homogeneous line illumination	Key take aways
VCSEL design for 100W • 56 rows x 192 small apertures • Well within VCSEL design rules • Very large VCSEL, low fill factor ~ 10 x 3 mm²	**VCSEL design for 100W** • 56 rows x 40 large apertures • Well within VCSEL design rules • Large VCSEL, good fill factor ~ 2.4 x 4 mm²	**1:1 pixel relationship** • 1:1 aspect ratio requires large VCSEL • Simple optics can be used, although it is more challenging for different pitch sizes of VCSEL and SPAD **Homogeneous line illumination** • Illuminations of SPAD row with homogeneous line leads to smaller VCSEL • Optics will be more complicated

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Automotive VCSEL Product Roadmap at ams-OSRAM

Addressable VCSEL feature enables segmented flash

AM VCSEL Product Portfolio

1D-addressable VCSEL – Segmented Flash
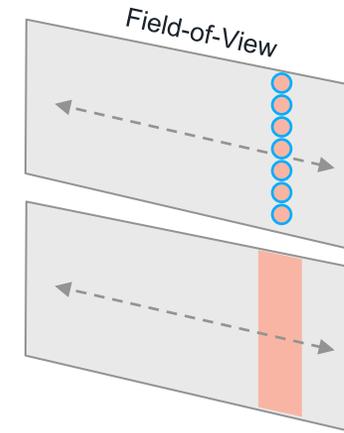

1:1 pixel relationship

| Oslo 905 & 940nm 80 x 100W | 5 |

Homogeneous line

| Riga 905nm 56 x 250W | 8 |
| Riga 940nm 56 x 250W | 8 |

Field-of-View

### 1D-addressable VCSEL – OSLO Evaluation kit

- Motherboard + Tx Board with VCSEL + VCSEL driver
- Available with 905nm or 940nm Tx VCSEL Board
- Software and firmware elements included for operation

Tx Board
- Oslo VCSEL → 72 x 30W peak optical power
- 2 Driver ICs
- Mechanical interface for optics

Motherboard
- Signal and power I/F to Tx Module
- FPGA and Raspberry Boards
- Power management

Motherboard   TX Module

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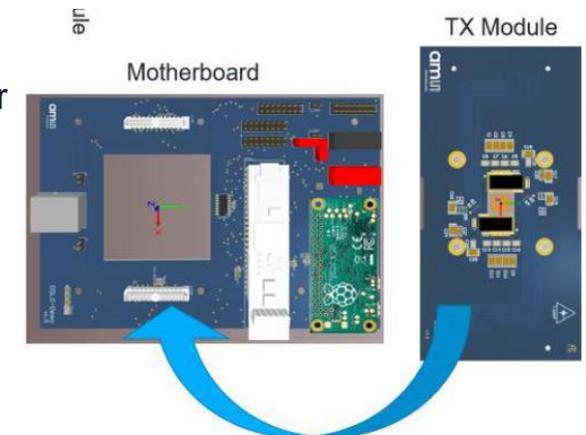
Summary

Close alignment needed between Optics, SPAD, VCSEL, and Driver companies to enable optimal sensor system

Key take aways

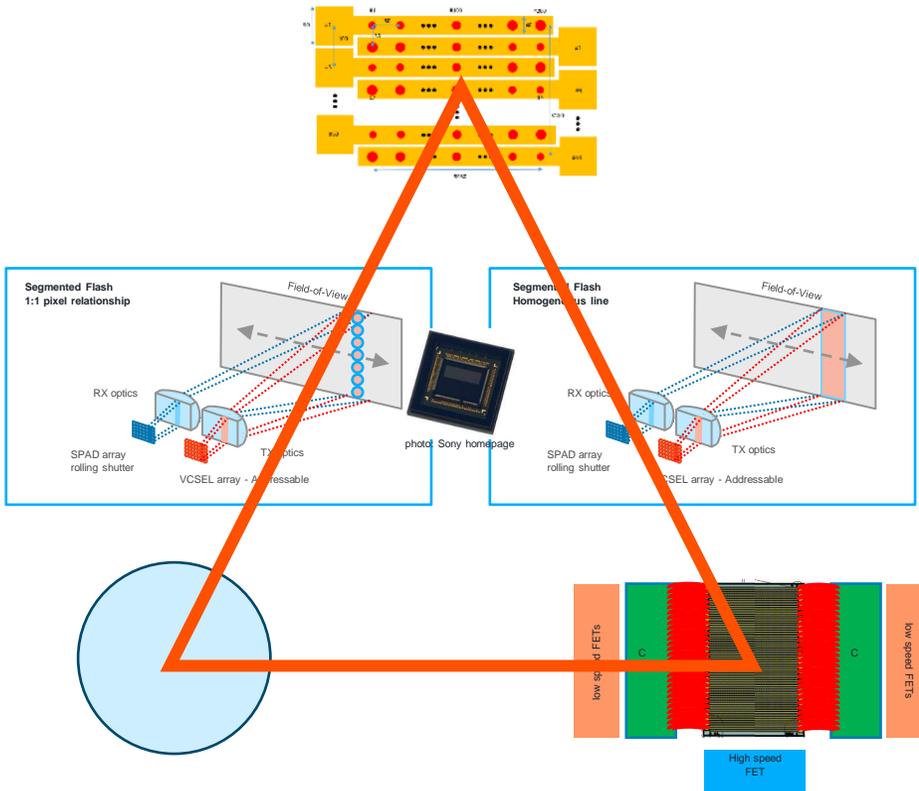
Pixel Pitch of TX and RX
- **Identical pitch:** easy for optics, challenge for VCSEL and Driver
- **Different pitch:** easy for VCSEL and driver, more complex optics

Optics Concept
- **1:1 pixel relationship:** simple optics, large VCSEL
- **Homogeneous line:** small VCSEL, challenging optics

Road to Success
- Close alignment and exchange between optics, SPAD, VCSEL, and driver suppliers to enable optimal sensor system

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Sensing is life

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