Detectors

Dr. Jennifer Ruskowski, 13th of September 2022
@ DVN Lidar Workshop 2022

LiDAR Detectors

source: Youtube

or „the race to Gold?“

Overview of leading questions

1. What properties must a perfect detector have?
2. What is the role of the photo-detecting elements?
3. What are future perspectives?

© Fraunhofer

Leading question

1. What properties must a perfect detector have?

Fraunhofer IMS

Detector structure

source: www

Raw data
Point cloud
Objects

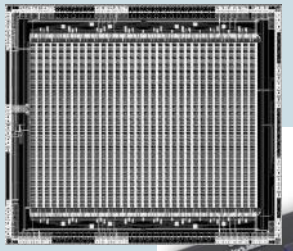
Electronics

source: vhdlwhiz.com

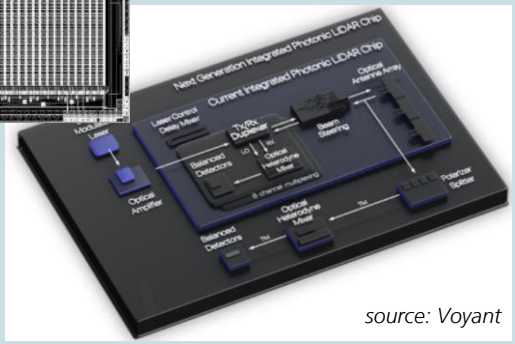
source: LeddarTech

Photonic Chip

Photodiode array

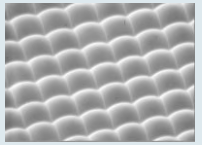


Photonic Integrated Circuits (PiC)



source: Voyant

Microlens arrays (MLA)



source: Viavi Solutions

Receiving optics

source: www

Light

 © Fraunhofer

Fraunhofer IMS

Detector structure

source: www

Raw data
Point cloud
Objects

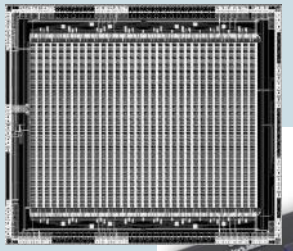
Electronics

source: vhdlwhiz.com

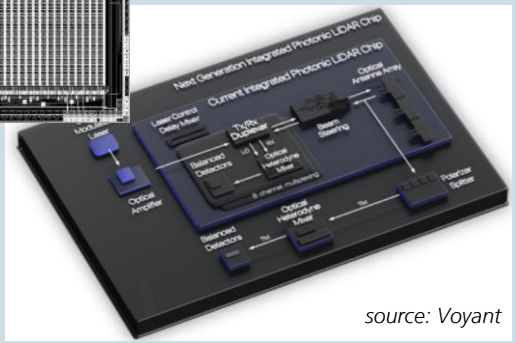
source: LeddarTech

Photonic Chip

Photodiode array

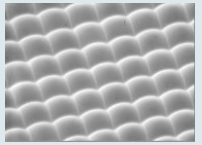


Photonic Integrated Circuits (PiC)



source: Voyant

Microlens arrays (MLA)



source: Viavi Solutions

Receiving optics

source: www

Light

- Acquisition and processing
- Conversion of light to electronic signal
- Contains photodiodes
- Increasing fill-factor
- Receiving lens for Flash LiDAR

© Fraunhofer - 13th of September 2022 - DVN Lidar Workshop 2022

Detector structure

Automotive grade & safety
High-volume production
Dimensions & Cost

Long ranges

Raw data
Point cloud
Objects

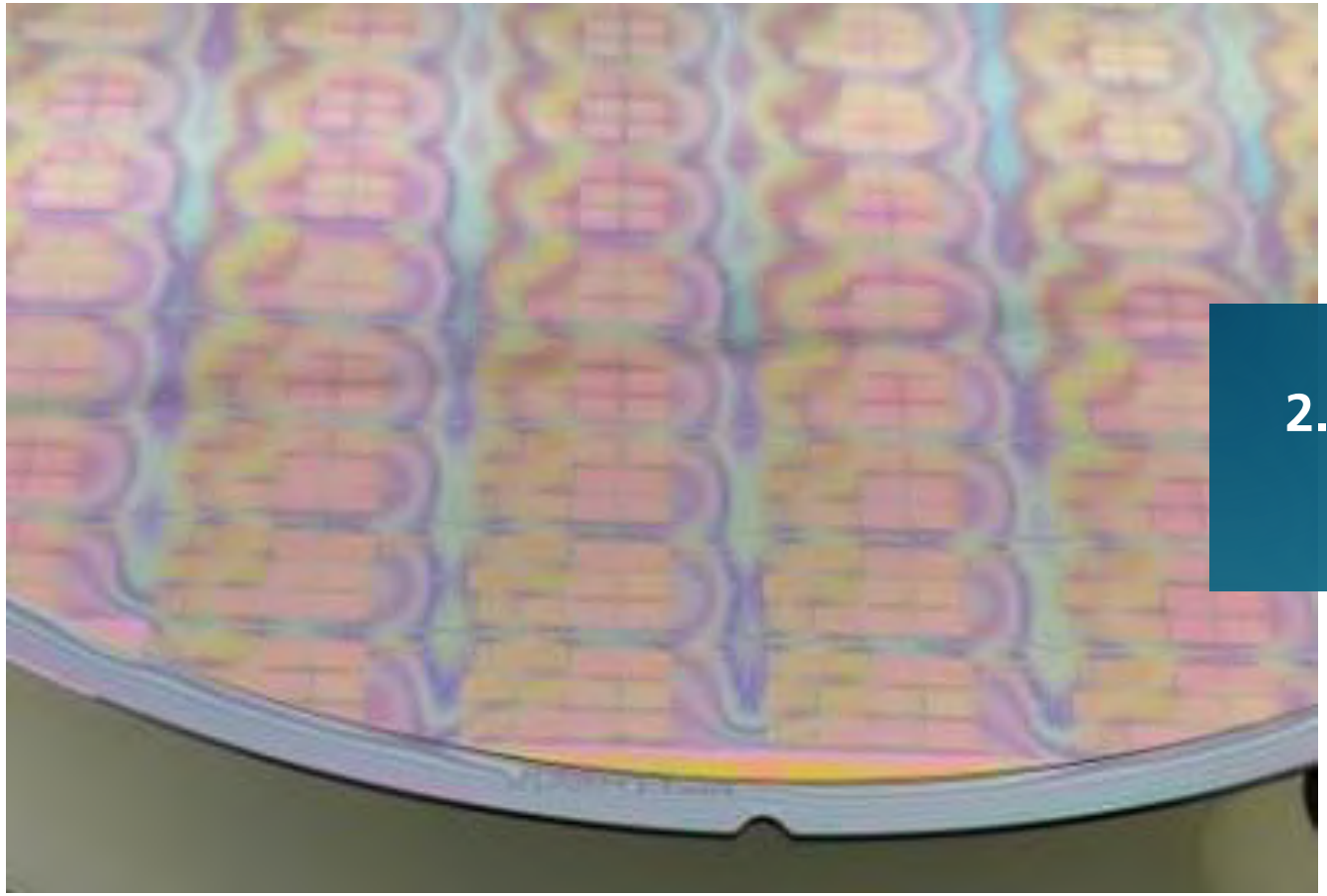
Electronics	Photonic Chip	Microlens arrays (MLA)	Receiving optics
Speed	*Conversion efficiency*		
Low-power	*High-dynamic*		
No cooling	(High resolution)		

Light

- Ac… …al
- Increasing fill-factor
- Receiving lens for Flash LiDAR

© Fraunhofer - 13th of September 2022 - DVN Lidar Workshop 2022

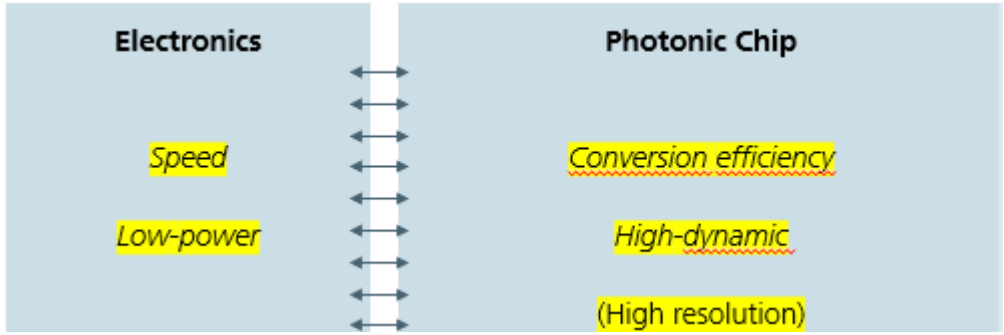
Leading question



2. What is the role of the photo detecting elements?

Photodiodes

Long ranges



Automotive grade & safety
High-volume production
Dimensions & Cost

	PIN-PD	APD	SiPM	SPAD
Gain	1	10^3	10^6	10^6
Single photon detection	No	No	Yes	Yes
Operational Bias	Low	Medium	Medium	Medium
Temperature Sensitivity	Low	High	Low	Low
Array possible	Limited	Limited	Limited	Yes
Readout / Electronics	Complex	Complex	Medium	Simple
Rise time	Medium	Slow	Fast	Fast

Fraunhofer IMS

Photodiodes

	PIN-PD	APD	SiPM	SPAD
Gain	1	10^3	10^6	10^6
Single photon detection	No	No	Yes	Yes
Operational Bias	Low	Medium	Medium	Medium
Temperature Sensitivity	Low	High	Low	Low
Array possible	Limited	Limited	Limited	Yes
Readout / Electronics	Complex	Complex	Medium	Simple
Rise time	Medium	Slow	Fast	Fast

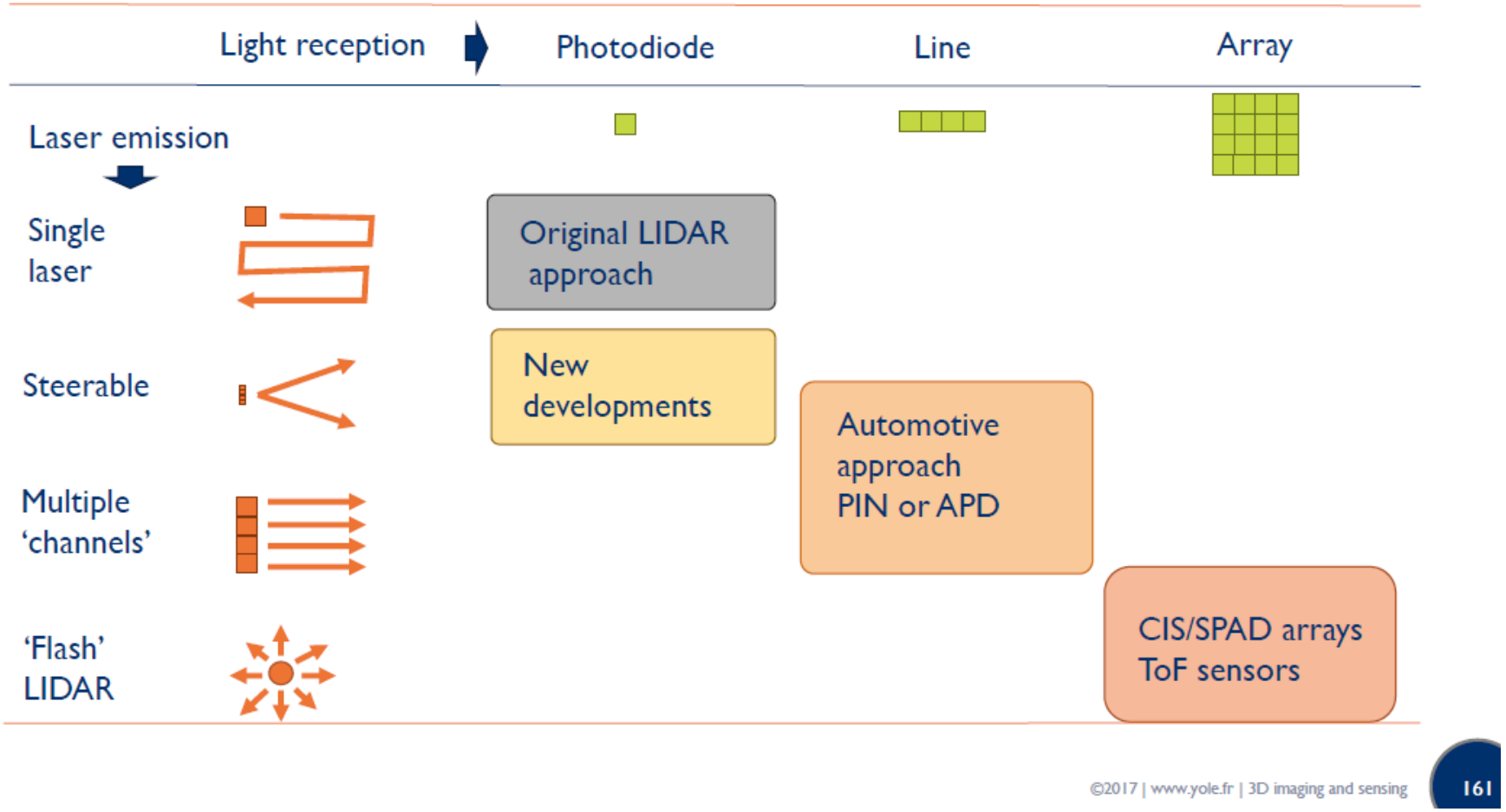
Do we need an all-rounder, who is good at everything?

…like a decathlete?

- Jürgen Hingsen,
  Olympia silver medalist 1984 in Los Angeles

Fraunhofer IMS

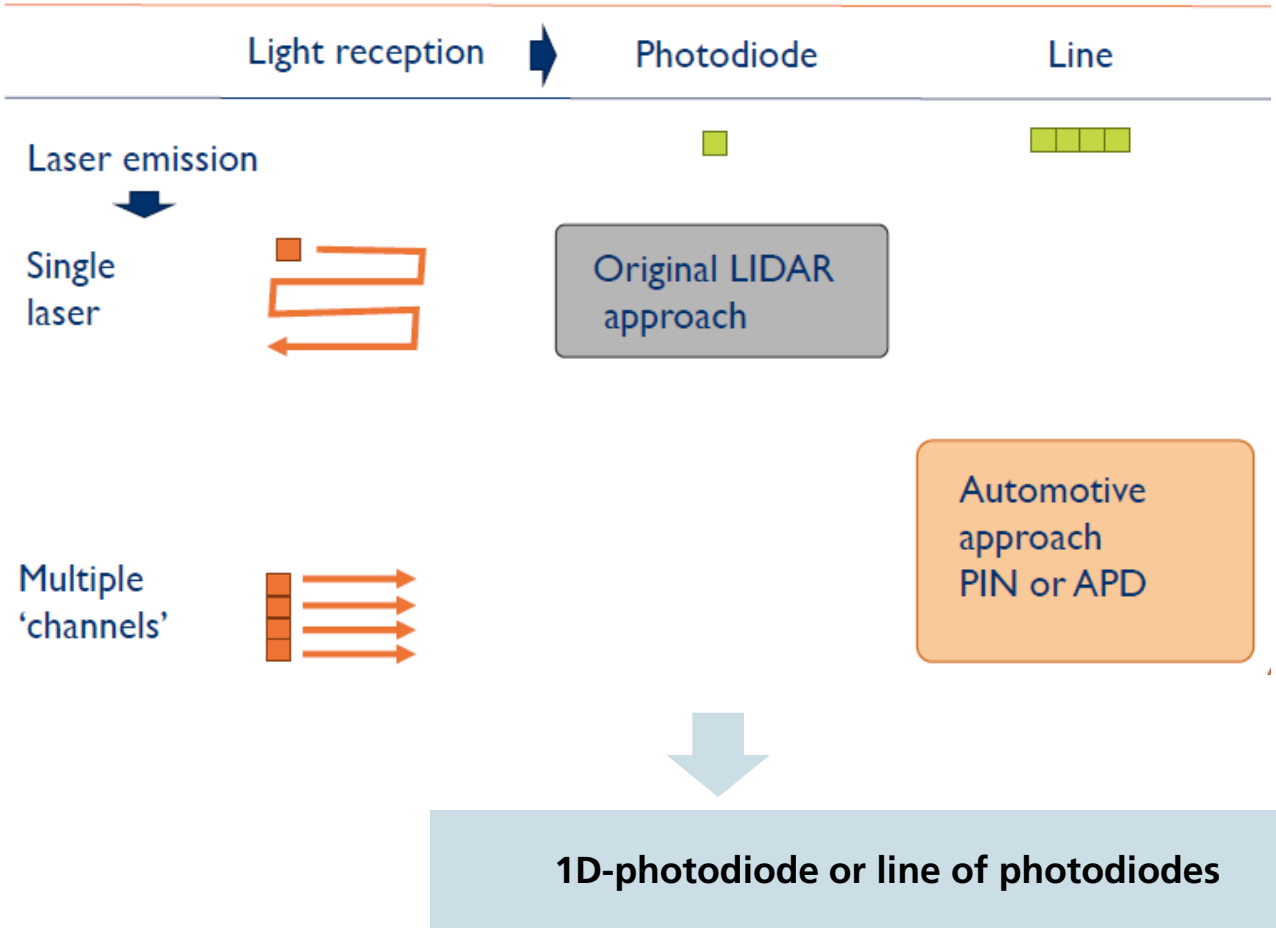
LiDAR methods



source: Yolé 2017

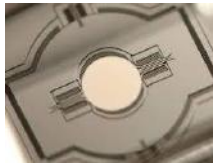
Fraunhofer IMS

LiDAR methods



source: Velodyne

source: Valeo



source: Fraunhofer ISIT

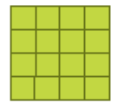
Fraunhofer IMS

LiDAR methods

Light reception

Laser emission

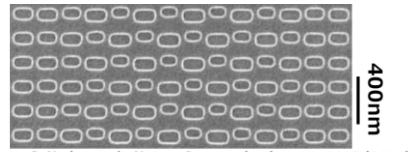
Array



Steerable

Photonic Crystal Surface-Emitting Lasers

source:
Kyoto
University



R. Sakata, S. Noda, et.al., *Nature Communications* 11, 3487 (2020)

Optical Phased Array

Controllable VCSEL arrays

'Flash'
LIDAR

Pure Flash: distribution of laser in x & y

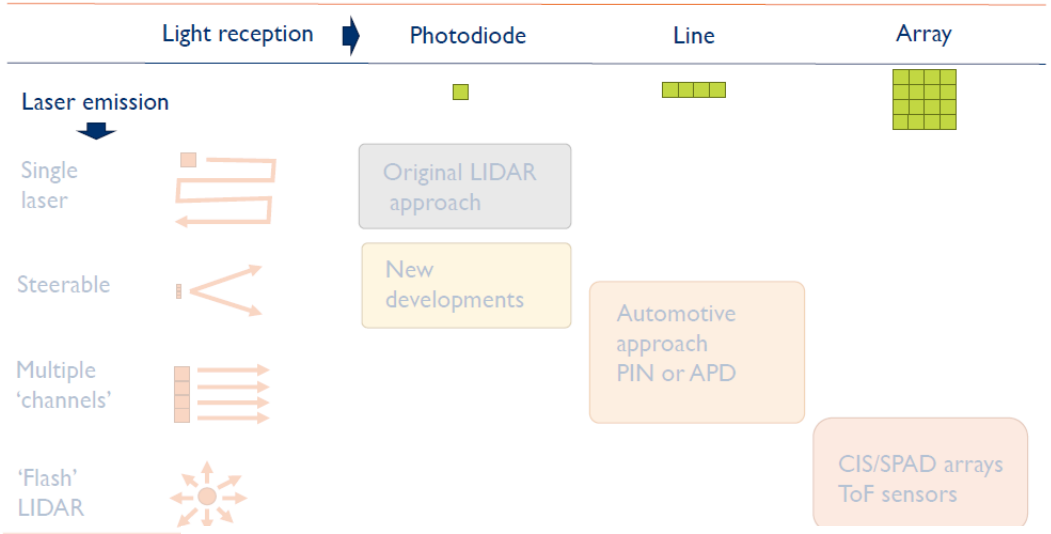
CIS/SPAD arrays
ToF sensors

Photodiode array

©2017 | www.yole.fr | 3D imaging and sensing 161

Fraunhofer IMS

Photodiodes



	PIN-PD	APD	SiPM	SPAD
Gain	1	10^3	10^6	10^6
Single photon detection	No	No	Yes	Yes
Operational Bias	Low	Medium	Medium	Medium
Temperature Sensitivity	Low	High	Low	Low
Array possible	Limited	Limited	Limited	Yes
Readout / Electronics	Complex	Complex	Medium	Simple
Rise time	Medium	Slow	Fast	Fast

The light reception decides…
the type of arrangement of the photoactive elements.

The arrangement decides…
on the type of photodiode.

The type of the photodiode usually also decides…
on the splitting or merging with the electronics.

© Fraunhofer - 13th of September 2022 - DVN Lidar Workshop 2022

Leading question

3. What are future perspectives?

Future perspectives

SPADs

- Higher integration levels
- Higher SPAD pixel resolutions
- Foundry services of SPADs

- InGaAs SPADs

⇒ Pushing Flash LiDAR

Data processing

- Between „on-chip“ and FPGA all variants in use

- Higher on-chip integration (processing ASICs) on longer term

- Combination with AI processing and neuromorphic computing

PiCs

- More photonic chips, as compact FMCW solutions, expected

- Materials:
  moving to scalable base materials as silicon waveguides

And the race winner is….

…. ?

source: Youtube

Invitation to LiDAR Olympics 2022

Date: 8th of November 2022

At Automotive Campus Helmond, NL

Home Program Get Involved Partners About Press TV News Contact

Lidar Olympics

Initiated and organised by

Fraunhofer IMS

Jakajima matchmaker for innovators

Fraunhofer IMS