FUTURE OF FLASH LIDAR COMPONENTS AND EMBEDDED KI FOR LIDAR

Dr. Christian Walk, Dr. Jennifer Ruskowski
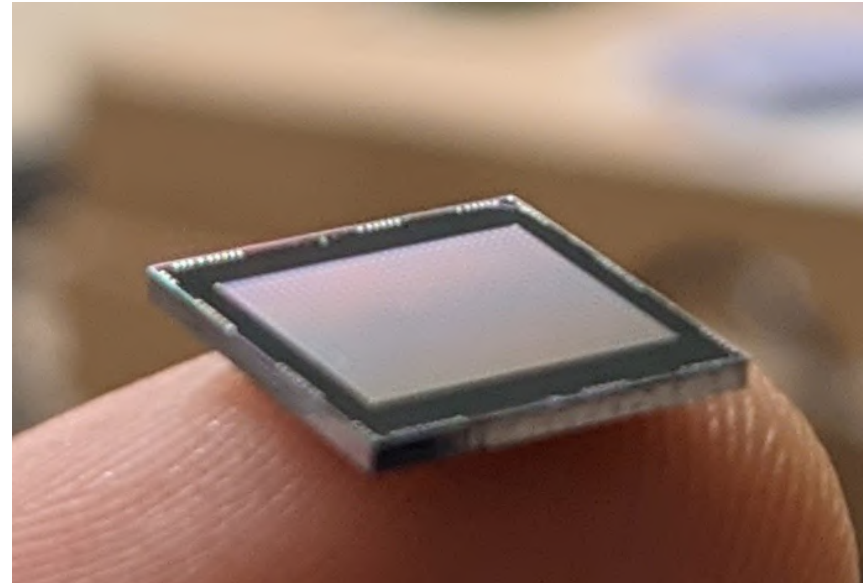
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CONTENT

- What kind of LiDAR do we address in this talk ?

- Flash LiDAR stands on the pull position !

- Why processing LiDAR data embedded with AI ?

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What kind of LiDAR do we address in this talk?

- Direct Time-of-Flight (d-ToF)

  - Focussed on Flash LiDAR

    → Spatial resolution based on 2D detector arrays

    → SPADs (Single-Photon Avalanche Diodes)

    → Fabricated in CMOS

Why Flash LiDAR ?

1. Most compact,
2. cheapest,
3. with lowest power consumption,
4. and most stable (no moving (MEMS) parts)

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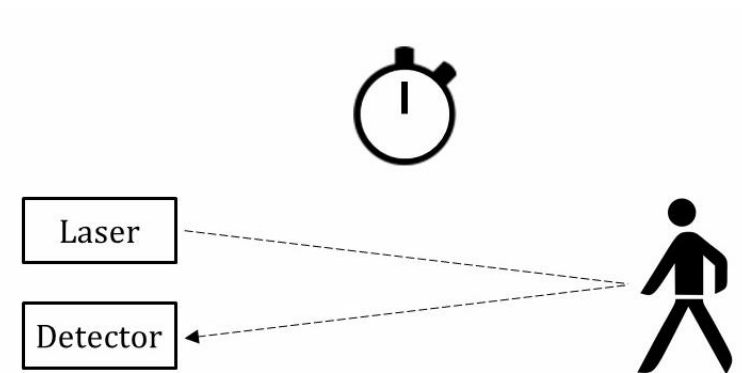
Flash LiDAR stands on the pull position

Component "Laser"

©Lumentum, website

©AMS, website

| Laser | = {VCSEL, EEL, Photonic-crystal,..} |

- Higher Power
- Shorter Pulses

Trade off's

- Beam divergence
- Repetition rate

- Temperature stability of the emission

- ...

©OSRAM, website

©Laser Components, website

- Combination of those attributes improved in the last years

- Improvements in assembly and interconnection technology, heat dissipation, segmentation, improved laser drivers, new technology concepts

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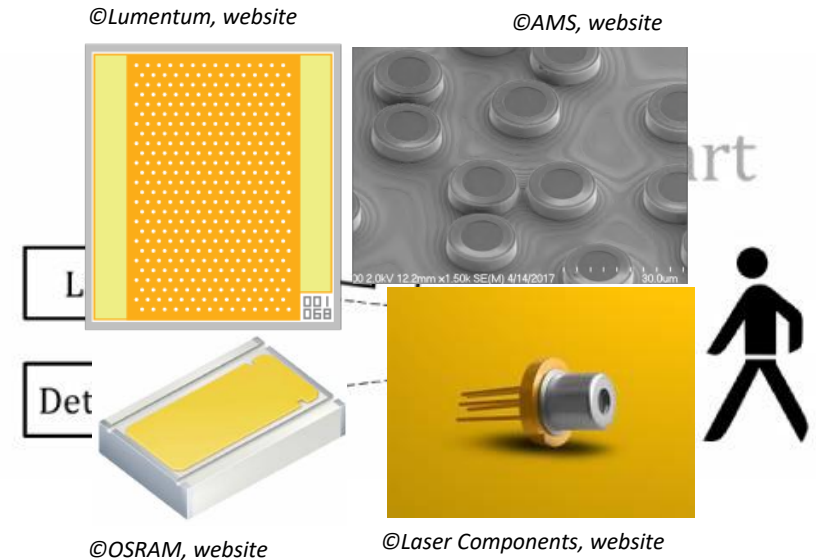
Flash LiDAR stands on the pull position

- Improvements of maximum measuring distances depending on laser source power (80 W, 500 W) for Flash LiDAR with a field of view of 30° x 10° and 25fps.
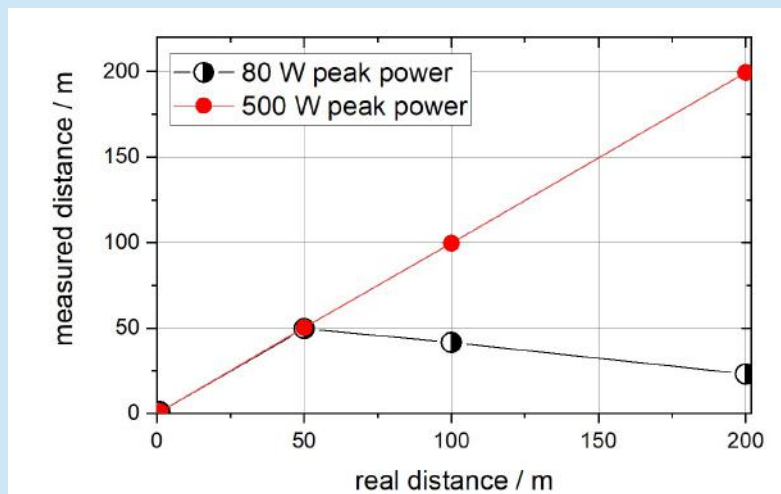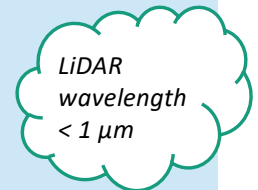

simulation

Flash LiDAR for long range with "cost-effective" components is realizable !

LiDAR wavelength < 1 µm

Question:

Where do I get the components to achieve this goal within the next years?
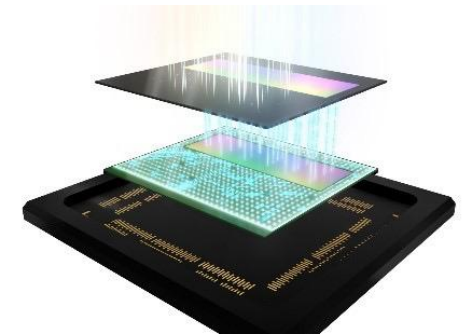
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Component "Detector"

Detector	= {2D-SPAD arrays}

■ High pixel number

Trade off's

■ High pixel area

■ High NIR efficiency

■ Sunlight suppression

■ Fast read-out

■ Some 2D SPAD arrays were presented 2021: as from Sony or Canon

■ Still a lack of 1) free-available devices and 2) accessible SPAD-processes for customized detector arrays
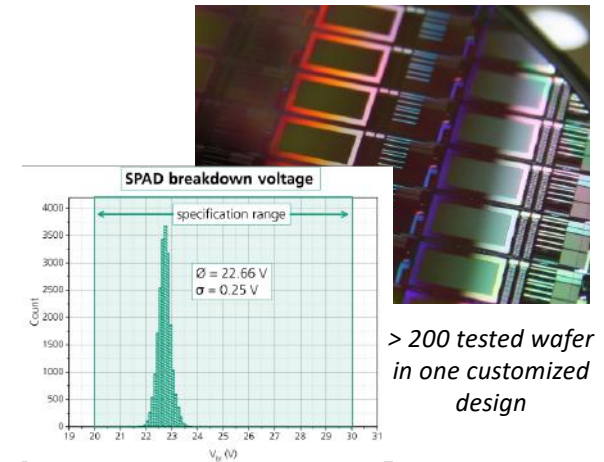
©Sony, website IMX459

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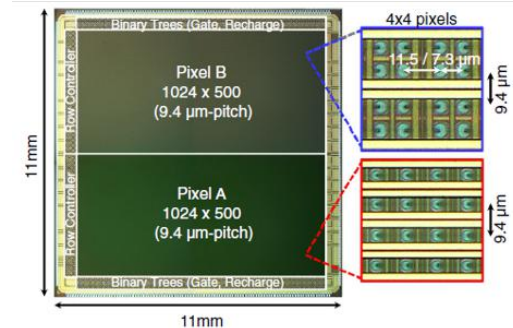
Pile, D. Megapixel single-photon camera. *Nat. Photonics* **14,** 597 (2020). https://doi.org/10.1038/s41566-020-0697-7

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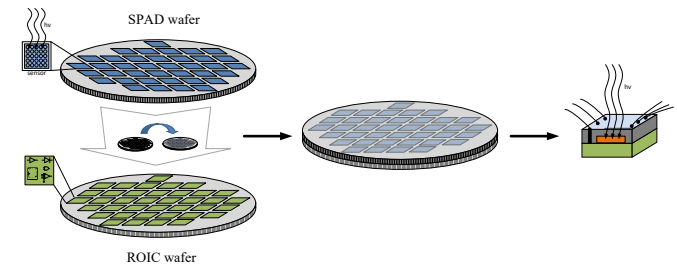
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Fraunhofer IMS stands on the pull position

Only known accessible 2D-SPAD array process on 8 inch wafer

- Inhouse CMOS SPAD process
  - Proved quality in customized designs with high throughput
  - NIR improvements under development
- ROIC design
  - TDCs, quenching and sunlight suppression algorithms
- Fabrication in standard CMOS process
  - 180 nm foundry process in fabrication
- Inhouse Wafer-to-Wafer bonding and final processing
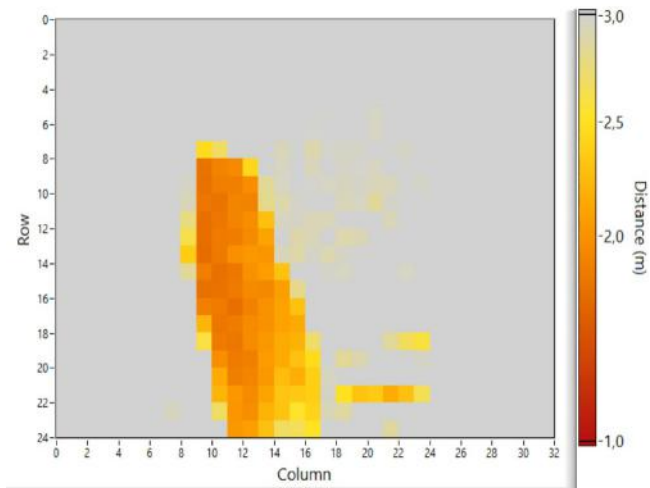- Commissioning third party to attach Micro-lens arrays (MLA)

SPAD breakdown voltage

Ø = 22.66 V
σ = 0.25 V

> 200 tested wafer in one customized design

SPAD wafer

ROIC wafer

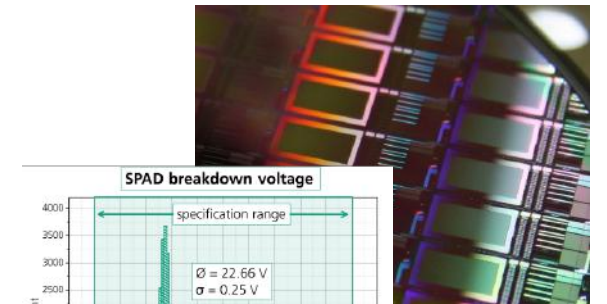**DVN** LiDAR Conference 15-16 November 2021, Frankfurt
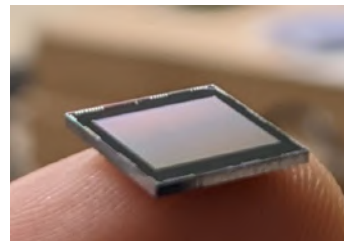
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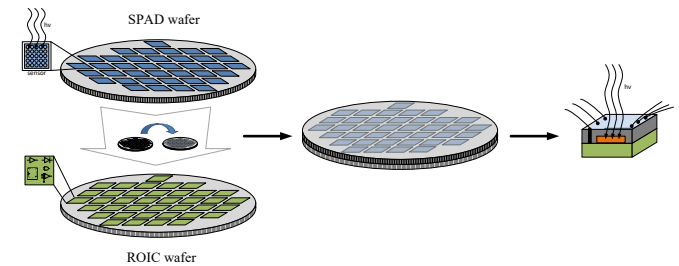# Fraunhofer IMS stands on the pull position

Only known accessible 2D-SPAD array process on 8 inch wafer

Successfully demonstrated with CSPAD αlpha

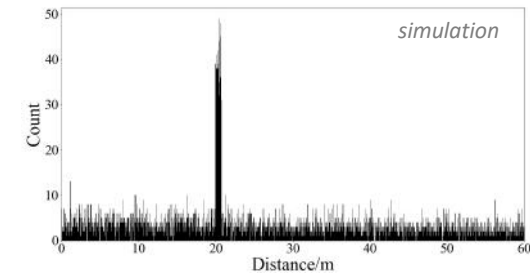*> 200 tested wafer in one customized design*
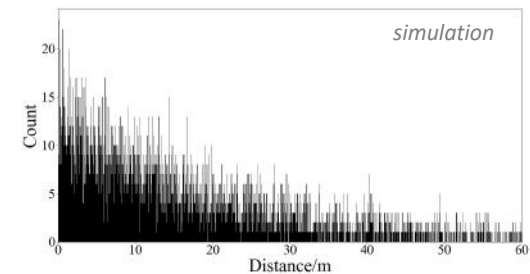
Why to process LiDAR embedded with AI?

Brief insight into the world of LiDAR raw data

- **Histograms**: collects raw-data of LiDAR acquisitions

- Contains information about single photon behavior in every pixel

- Influenced by system performance, applied algorithms and environmental condition (object, weather condition, ..)

- Every histogram speaks with a characteristic DNA !

- Disadvantage of DNA: too much data → slow processing
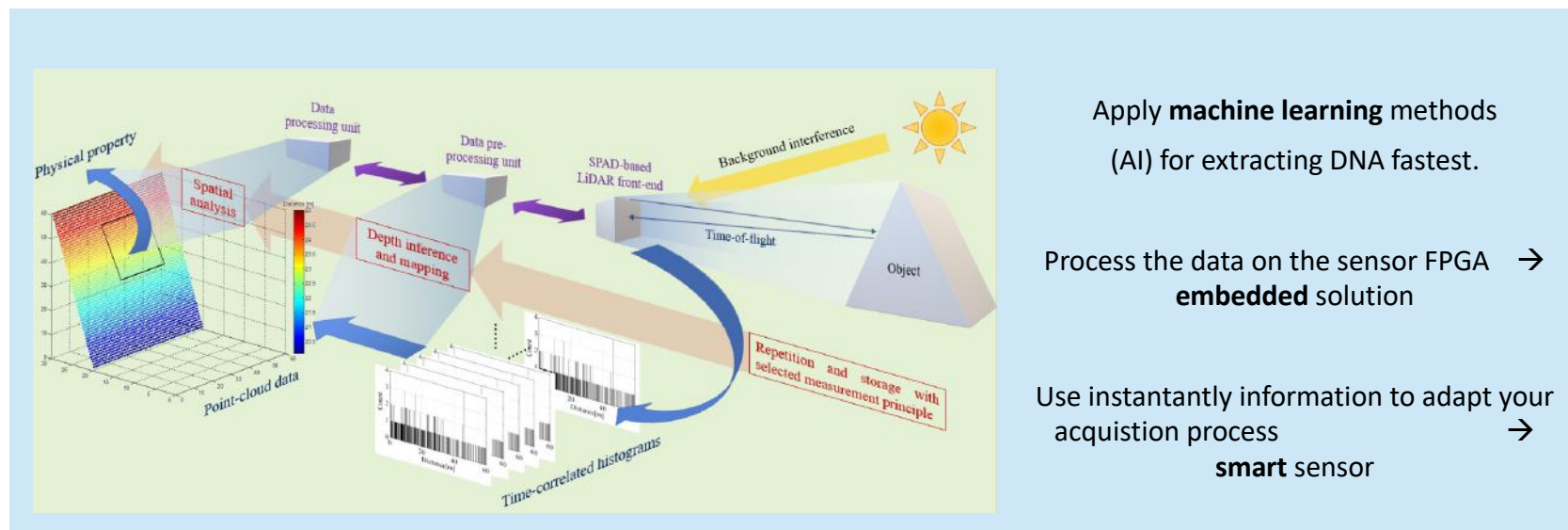

simulation

= object @ 20 m, low sunlight

simulation

= object @ 40 m, strong sunlight

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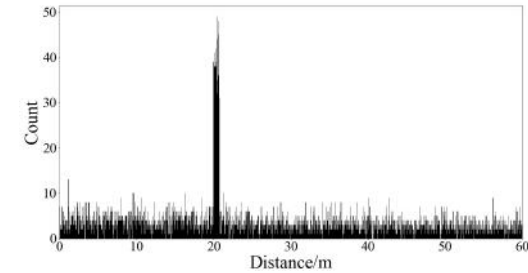IMS

Why to process LiDAR embedded with AI?

Brief insight into the world of LiDAR raw data

- Disadvantage of histogram DNA: too much data → slow processing

Apply **machine learning** methods (AI) for extracting DNA fastest.

Process the data on the sensor FPGA → **embedded** solution

Use instantly information to adapt your acquistion process → **smart** sensor

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Take Aways

- Flash LiDAR powers up by improved components

- Limited access to 2D SPAD CMOS processes

  CSPAD technology at Fraunhofer IMS ready for customized solutions

- Embedded AI on LiDAR raw-data is needed to prove data quality

Find more information about 3D-Sensing at https://www.ims.fraunhofer.de/en/

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Thank you for your attention!

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