SCANTINEL PHOTONICS

Scan | Detect | Navigate

Frank Gindele
Head of Optics & Mechanics
Ulm, Germany
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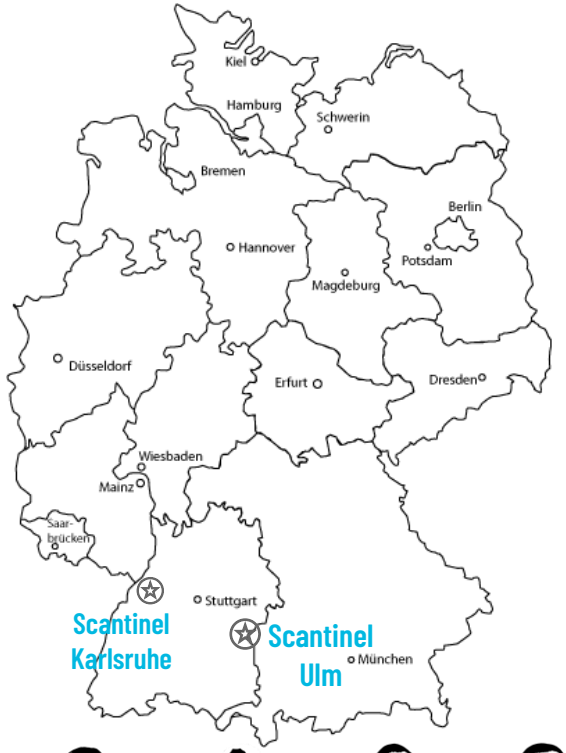
Photonic Integrated Circuit based FMCW LiDAR for Automotive and Industrial Applications

EPIC meeting on CMOS Compatible Integrated Photonics 7-8 Sept 2022, Leuven, Belgium

SCANTINEL PHOTONICS



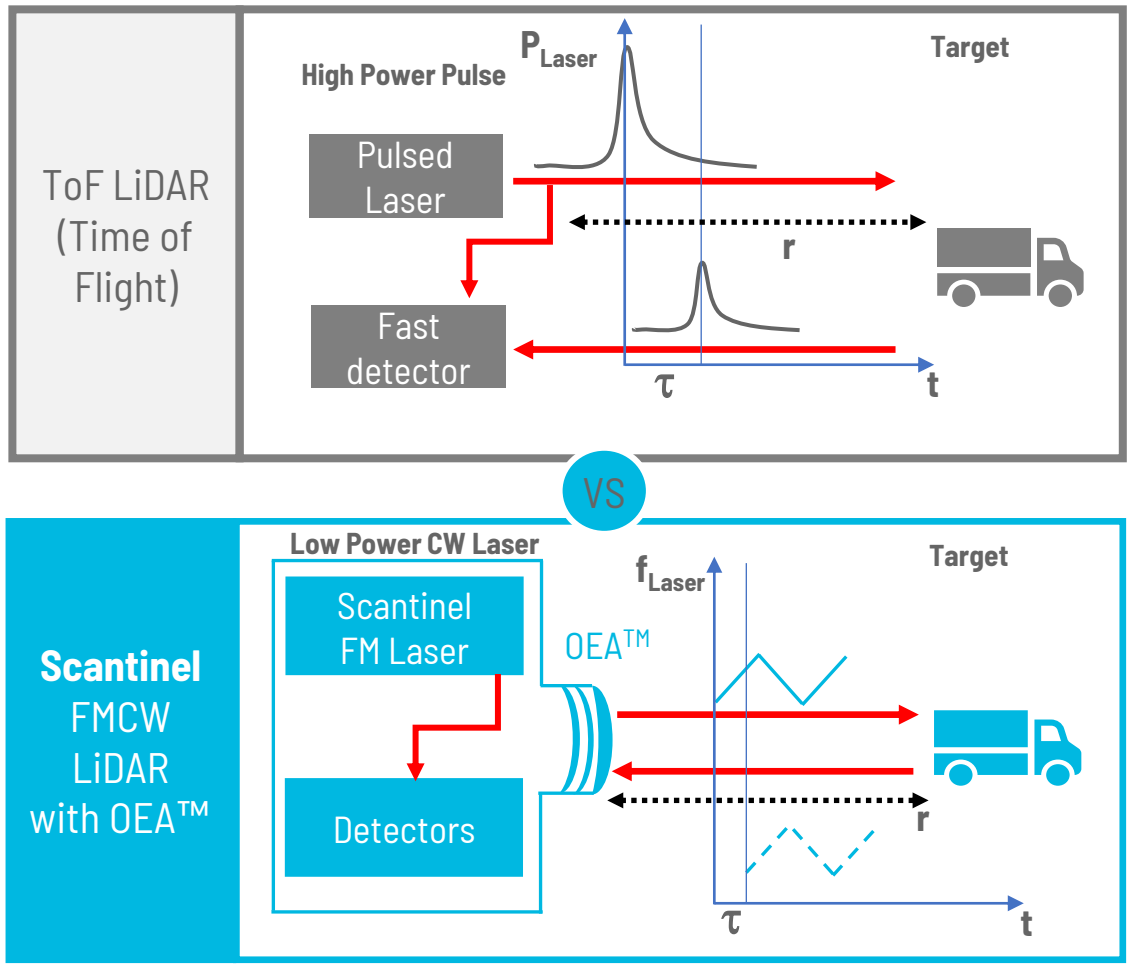
- Spin-off start-up from ZEISS
- Located in Ulm & Karlsruhe, Baden-Württemberg, Germany
- Solid-state FMCW sensing technology for mobility and industrial applications
- International team of 40 experts from >10 different countries (80%+ engineers, 40%+ PhDs)

Our mission is to create optimum value for our customers and partners by providing outstanding LIDAR solutions

ZEISS SCANIA

Scantinel is backed by ZEISS Ventures and Scania Growth Capital

Coherent FMCW Drives Next Generation LiDAR Technology



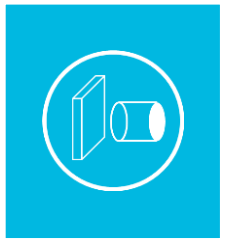
Performance	ToF	FMCW
Wavelength	905nm	1550nm
Long Range	< 200m	> 300m
Spatial Resolution	n x cm	< 1cm
Max. P_{Laser} - Eye Safety	P_{Laser}	10 x P_{Laser}
Sensitivity	~ R_{Target}	~ SQRT (R_{Target})
SNR	~ P_r^2	~ P_r x $P_{LO}/(a+P_{LO})$
Velocity	No	Yes
Photonic Integration	No	Yes
Detection	Intenstity	Amplitude / Beat Freq.
Complexity	Low	High
Scanning	Mech.	Mech. / Solid State
Cost	Low	High Potential

P_r : One Way Signal Power
P_{LO}: Local Oscillator Power
R_{Target}: Reflectivity Target

OEA™: Optical Enhanced Array

Scantinel's Approach is a 1550nm Solid-State FMCW LiDAR Leveraging Maximum Integration on Silicon Photonics

Enablement of **Silicon Photonics**

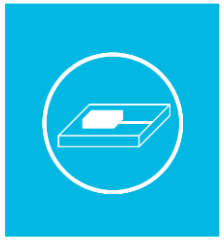


Solid-State Scanning

- PIC-based scanner for 1 & 2D scanning
- Adapted Optics for highly efficient optical signal processing (Optical Enhanced Array - OEA™)

Maximum Integration

- Integration of Thermo-optical switching
- Mode field matching for free space optics
- Integration of Laser and Detector
- Semiconductor Optical Amplifier (SOA)

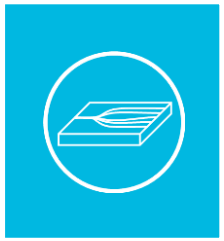


Multi-Channel Parallelization

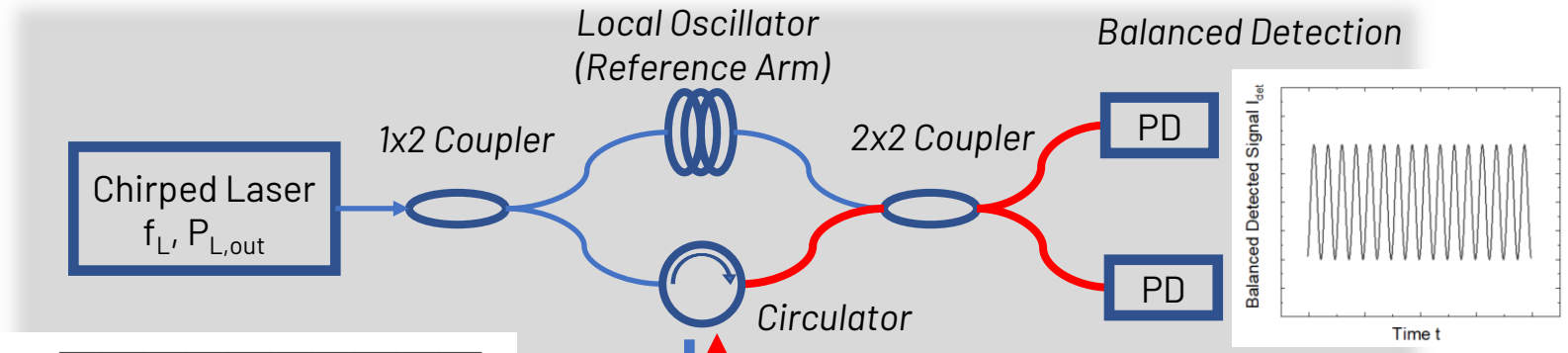
- 5D point clouds (xyz, direct velocity, reflectivity)
- High frame rate by 16x parallel channels

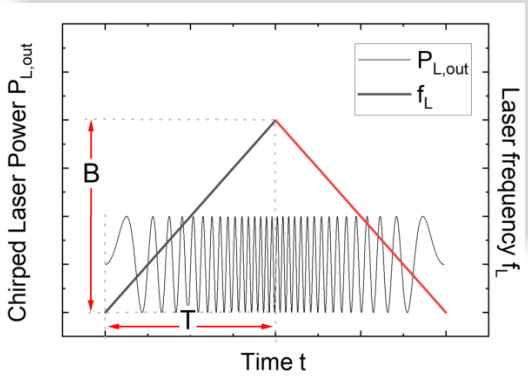
Scalability

- CMOS compatible for volume manufacturing
- Adaptive to various applications



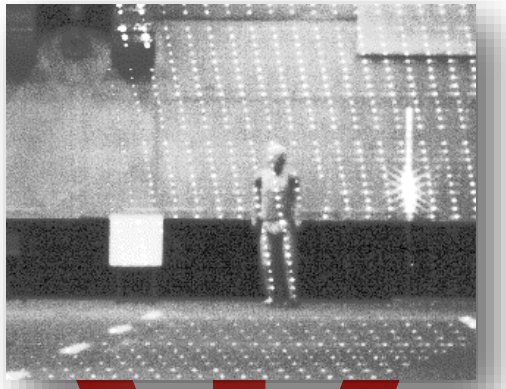
FMCW LiDAR System: What About the Basics?





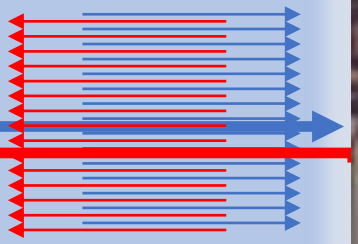
Signal generation & detection

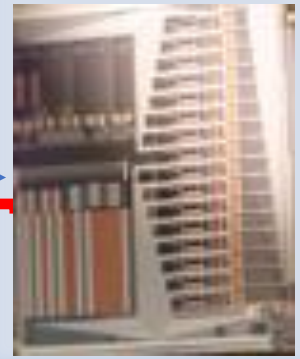
Point Cloud 256x120



PIC

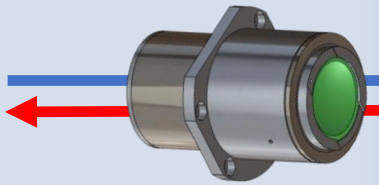
Outgoing path TX channels

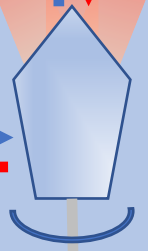




Incoming path RX channels

Collimator





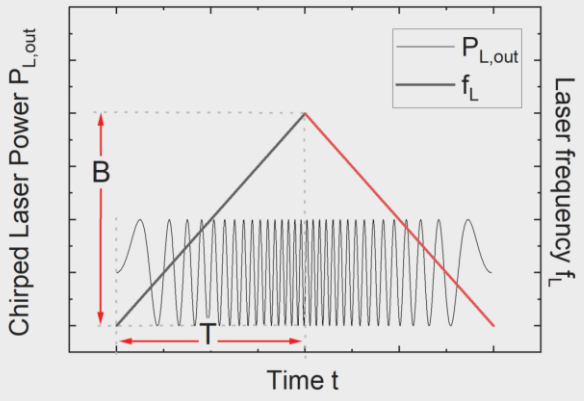
Mechanical Scanner

Optical Enhanced Array **OEA™**

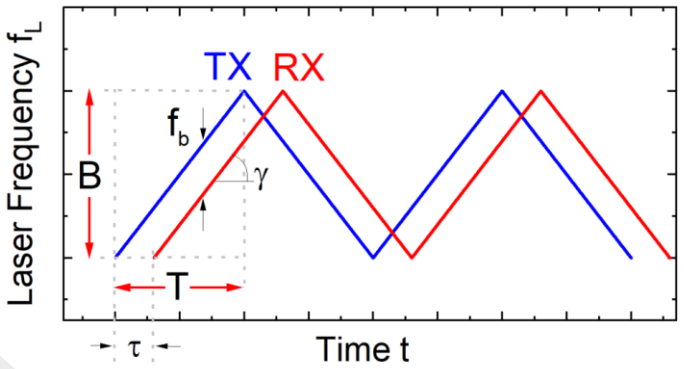
Optical signal processing

FMCW LiDAR Systems Enables Distance and Velocity Measurement

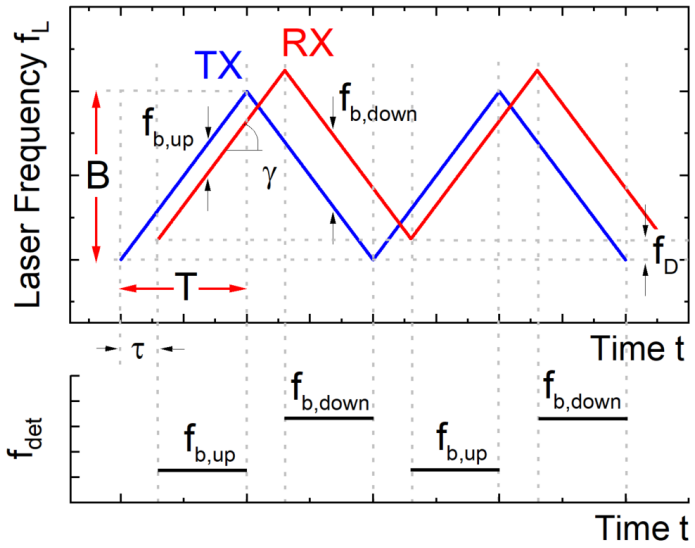
Outgoing laser signal



Distance measurement



Distance & Velocity measurement



Beat frequency: $f_b = \gamma \times \tau$

Chirp rate: $\gamma = \frac{B}{T}$

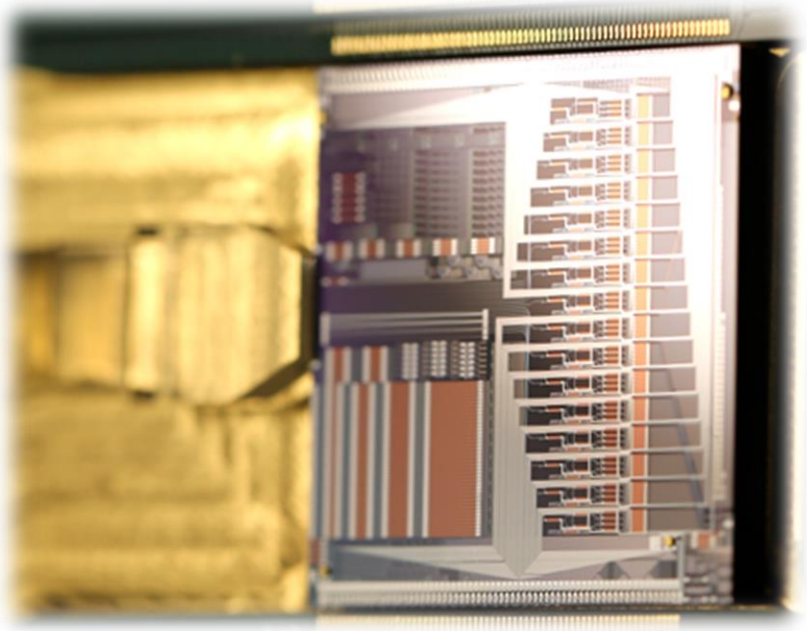
Target distance: $r = \frac{c}{2\gamma} \times f_b$

Doppler Shift: $f_D = \frac{f_{b,down} - f_{b,up}}{2}$

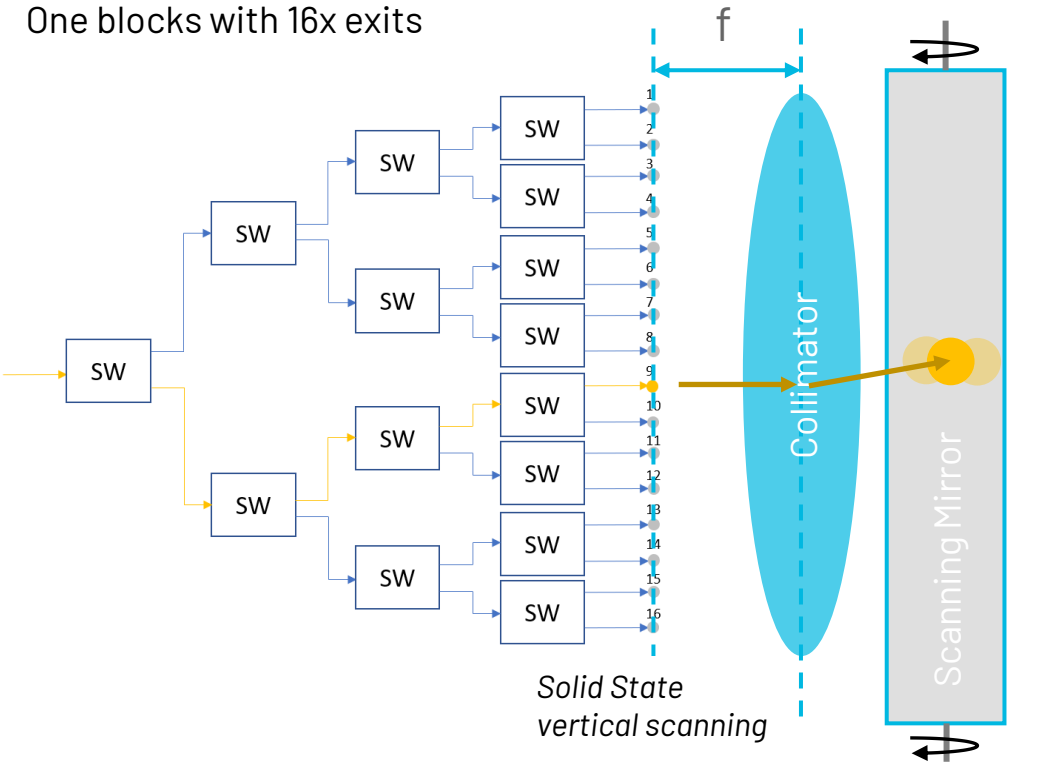
Target distance: $r = \frac{c}{4\gamma} \times (f_{b,up} + f_{b,down})$

Target Velocity: $v = \frac{\lambda}{4} \times (f_{b,down} - f_{b,up})$

Solid State Scanning with Optical Enhanced Array (OEA™)



Schematic drawing:
One blocks with 16x exits



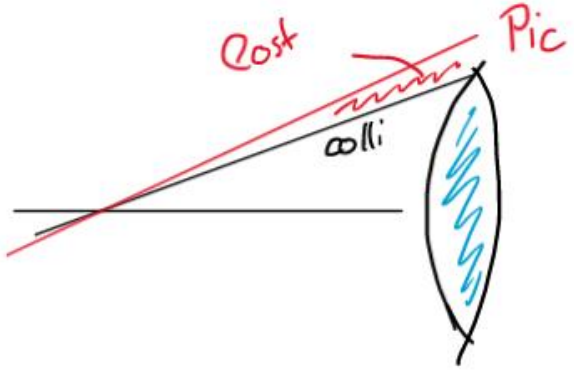
OEA™ Scanning Principle

- Scan Controller controls the switches to select one exit for each block
- One exit corresponds to one exit angle from the collimator
- 16 channels are switched

The Overall System Performance Depends on the Coupling Efficiency Between PIC and Free-Space Optics

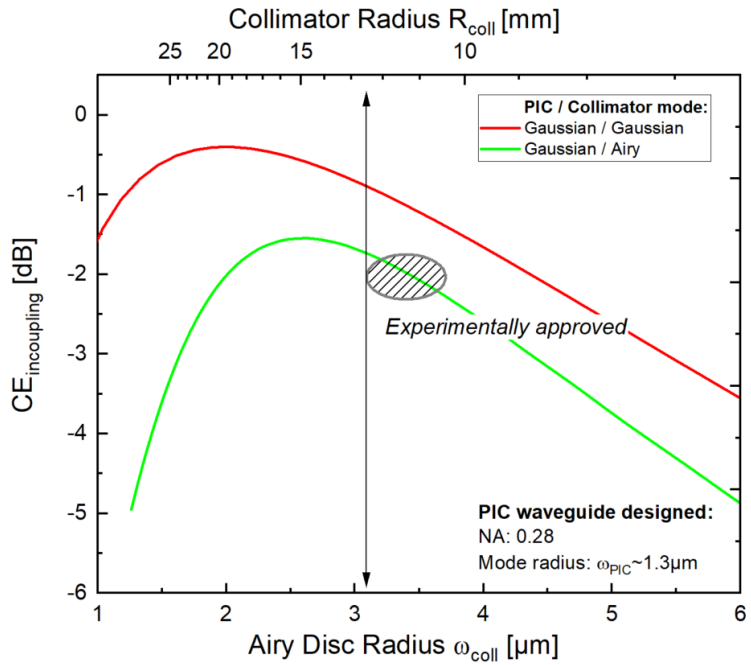
1) Outgoing beam from PIC

$NA_{waveguide} < NA_{collimator}$



2) Incoming beam from collimator

$$CE_{incoupling} = \frac{|\int E_1^* E_2 dA|^2}{\int |E_1|^2 dA \int |E_2|^2 dA}$$



- Mode field size of waveguide and collimator have to be aligned

3) Free space propagation from target to collimator

$$\eta = \frac{P_{RX}}{P_{TX}} \sim \frac{D^2}{r^2}$$

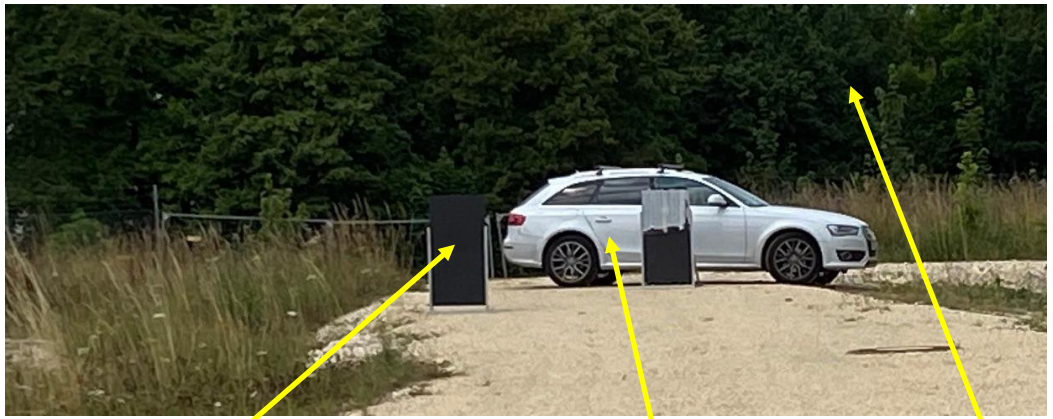
Specifications are On-Going Improved and Aligned to Customer requirements

Specifications	Value
Max range	400 m
Range at 10%	>120m
Range resolution	10 cm
Max velocity	100 m/s
FoV horizontal	12°
Resolution horizontal	0.1°
FoV vertical	20°
Resolution vertical	0.07°
Frame Rate	5 Hz

PoC System mounted for test measurements

Distance Measurement has been Confirmed up to 130m

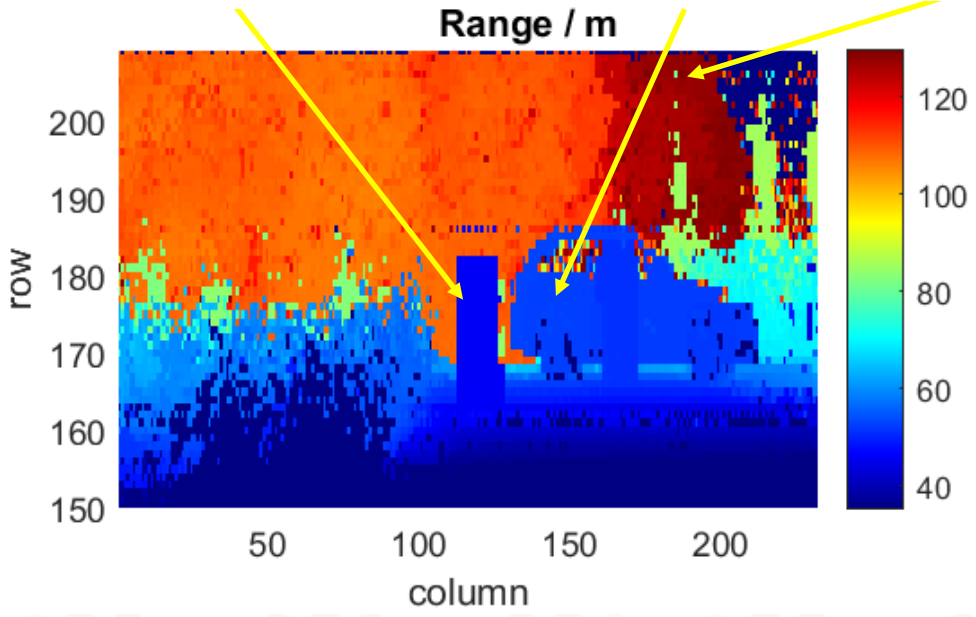
Approximate scan region of LIDAR

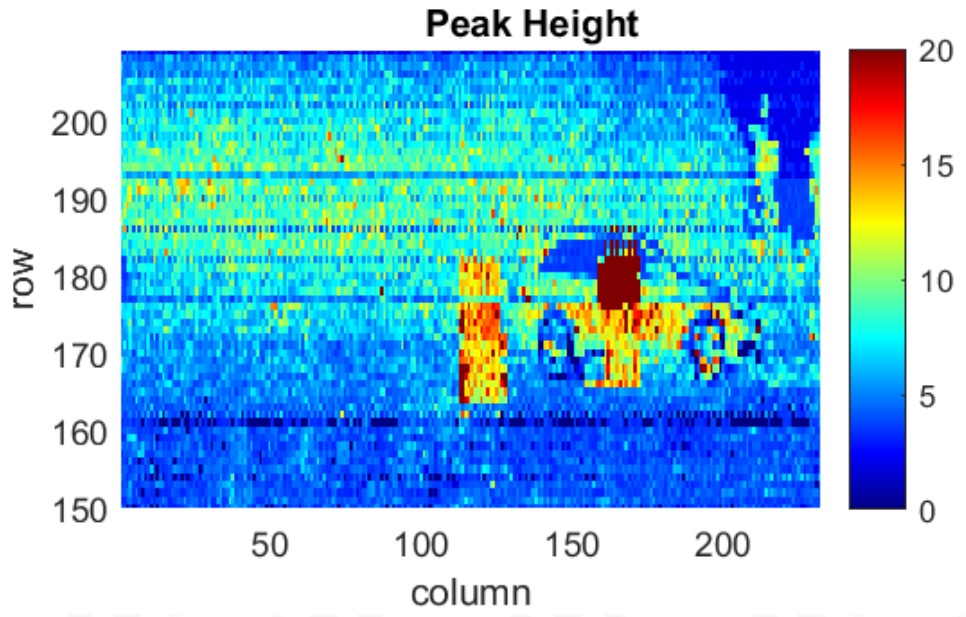


Target R30%

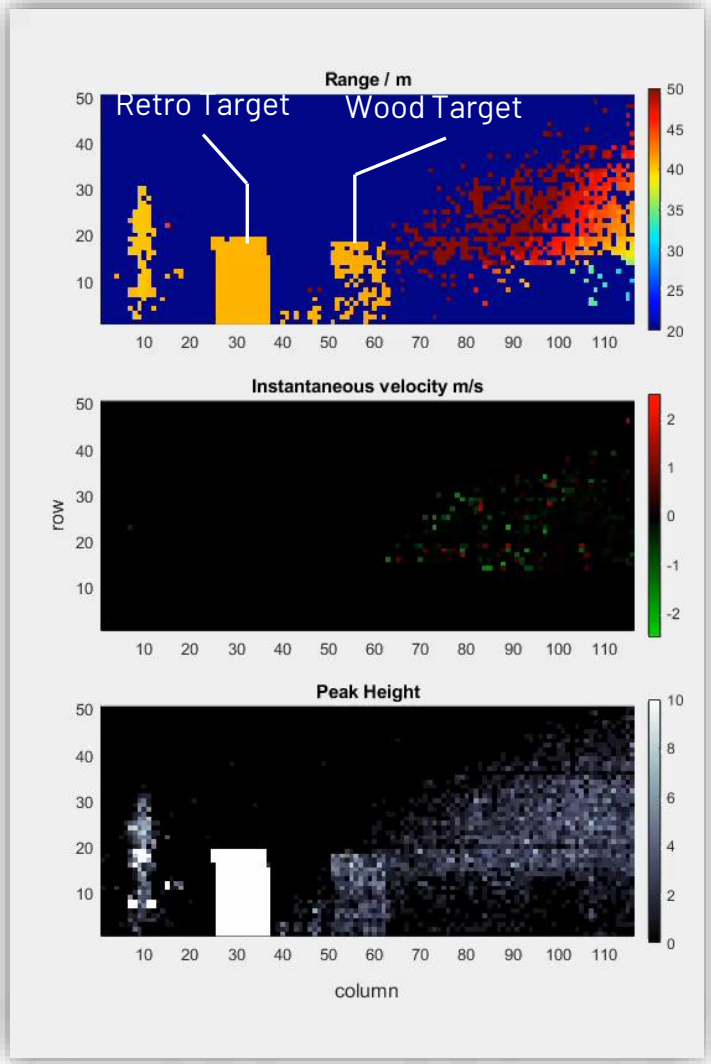
Car 52m

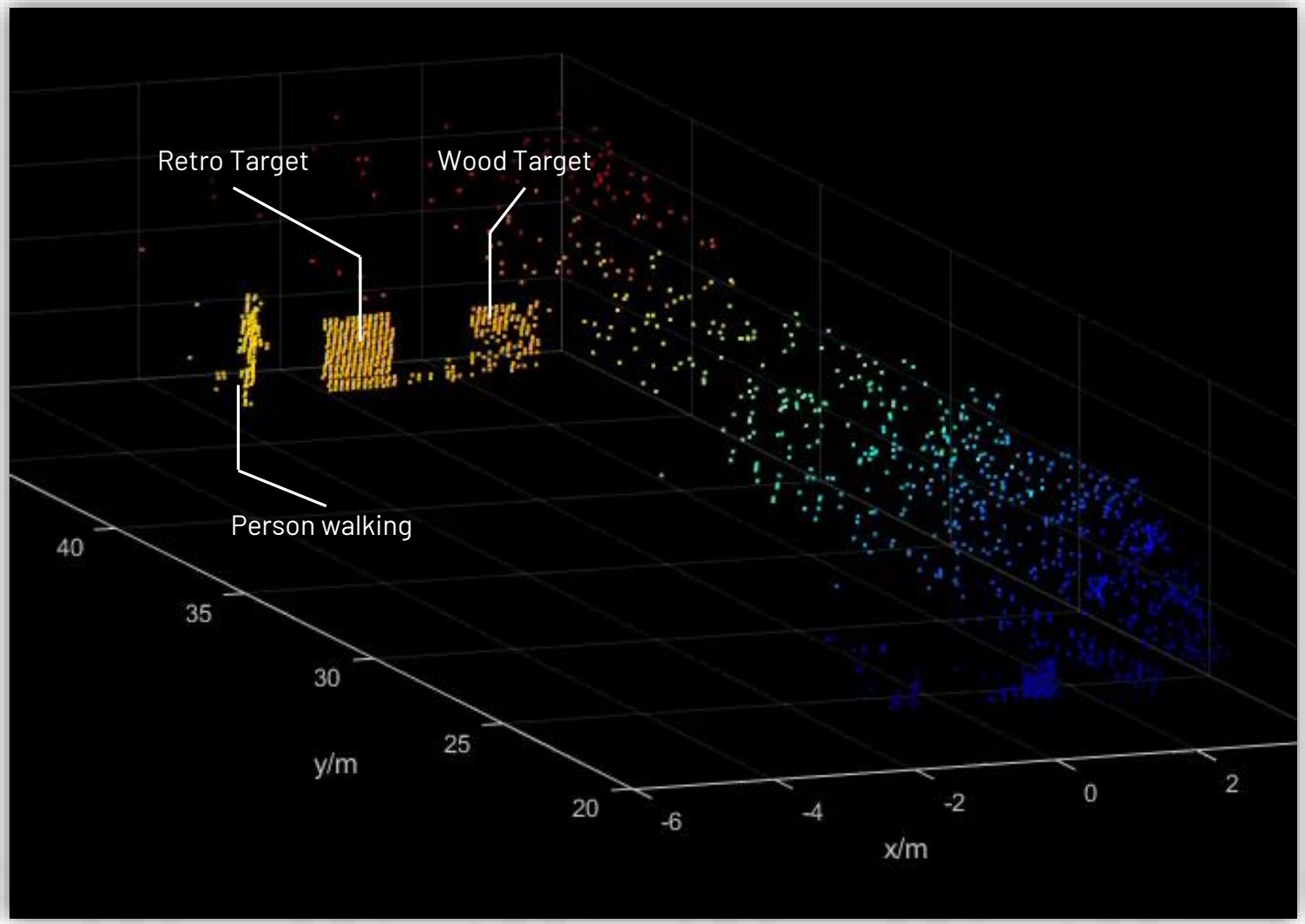
Tree 126-128m





FMCW Immunity to Highly Reflective Objects Enables Robust Sensing Capability for Distance and Velocity





Point Cloud with high and low reflecting target and walking person

Our FMCW LiDAR on Chip Module Addresses Multiple Attractive Segments

Market Segments

Automotive (ADAS/AD)

Passenger

Commercial

Mobility Service

Robo-Taxi

Logistics

Delivery

Industrial

Rail

Mining

Robot/Automation

Harbor

Smart City

Autonomous Cranes

Autonomous loading and unloading of container ships to enhance harbors' operations

de.freepik.com/containerfrachtschiff-frachtschifffahrt-entladen-_7672184.htm

Roadmap to Highly Integrated and Robust LiDAR System for Volume Production

Full Solid State 2D scanning solution

No mechanical movable components required

Higher level of integration on PIC structure

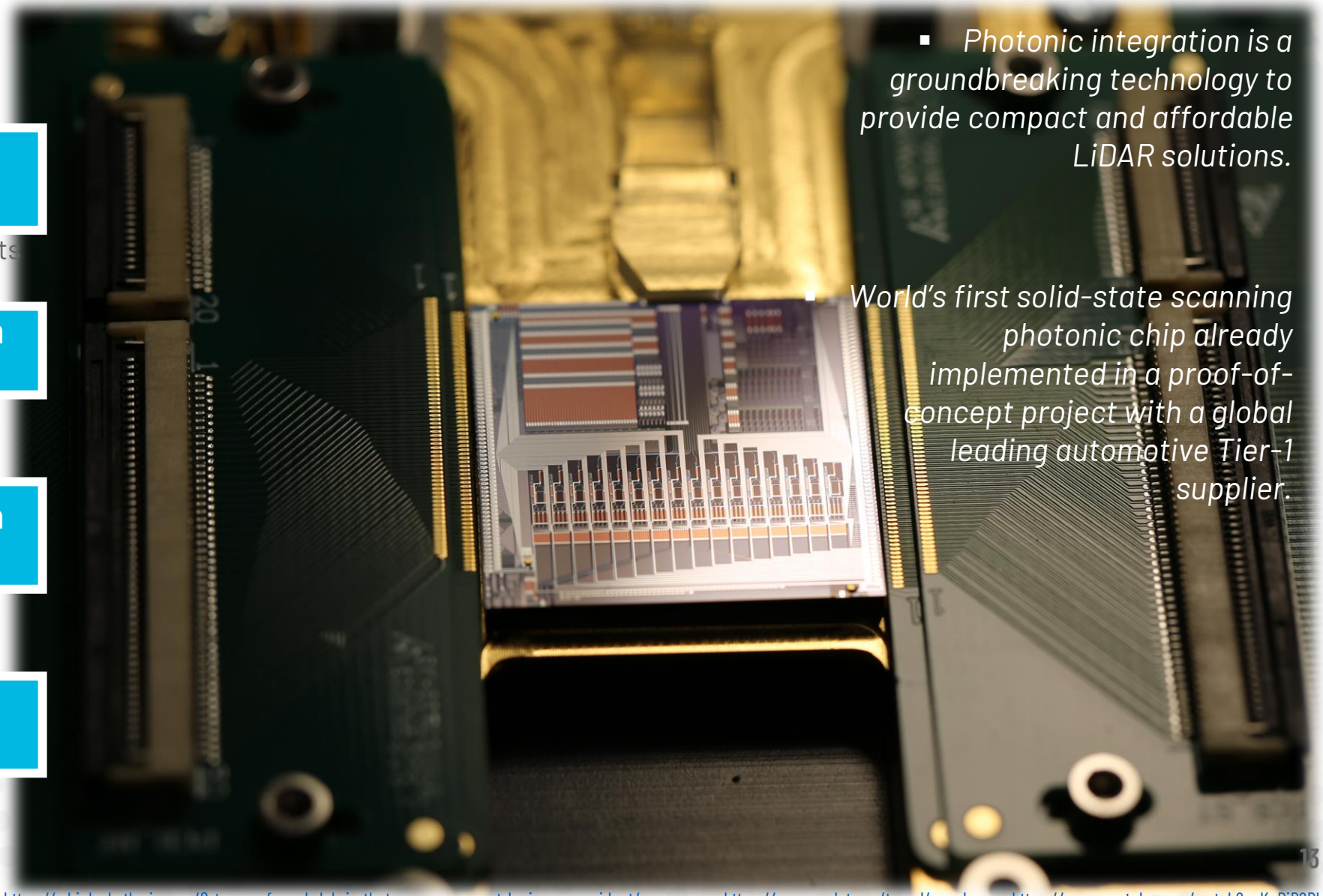
Integration of detector on PIC

Higher level of integration of laser amplifier

SOA and Driver electronics

Increased signal intensity and SNR

Reduced optical losses on PIC and coupling losses

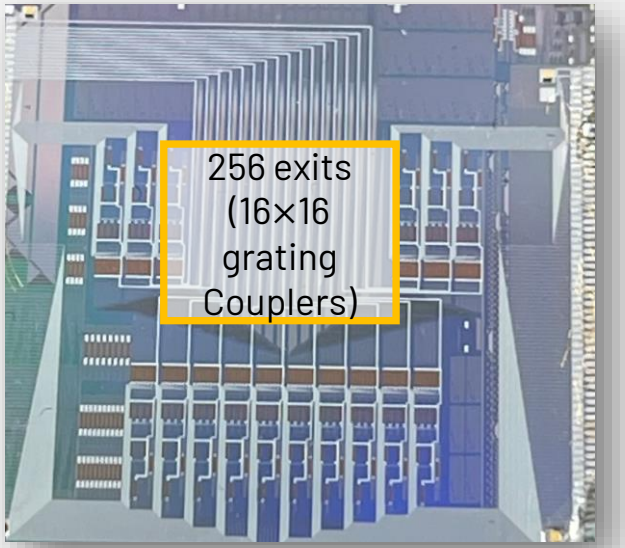


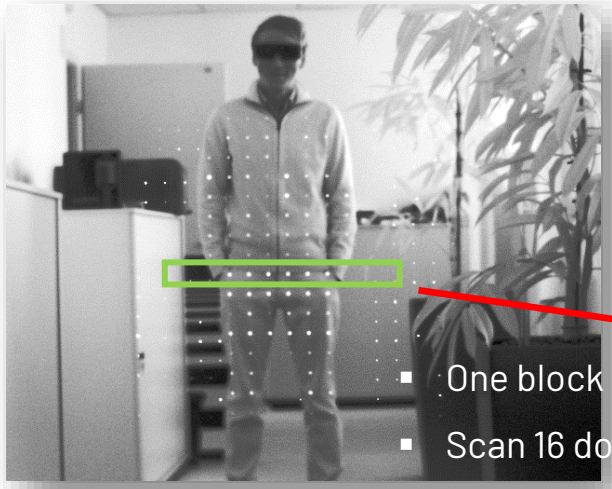
- *Photonic integration is a groundbreaking technology to provide compact and affordable LiDAR solutions.*
- *World's first solid-state scanning photonic chip already implemented in a proof-of-concept project with a global leading automotive Tier-1 supplier.*

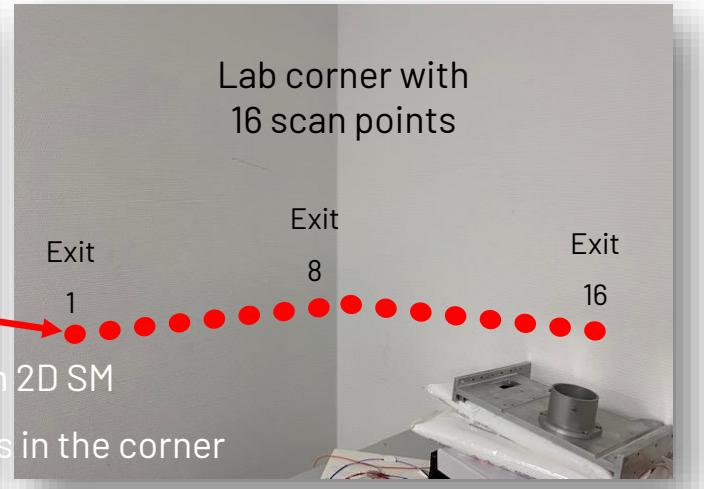
https://whiplashstlouis.com/8-types-of-road-debris-that-can-cause-a-st-louis-car-accident/ https://www.codot.gov/travel/sunglare https://www.youtube.com/watch?v=KnPiP9PkLAs

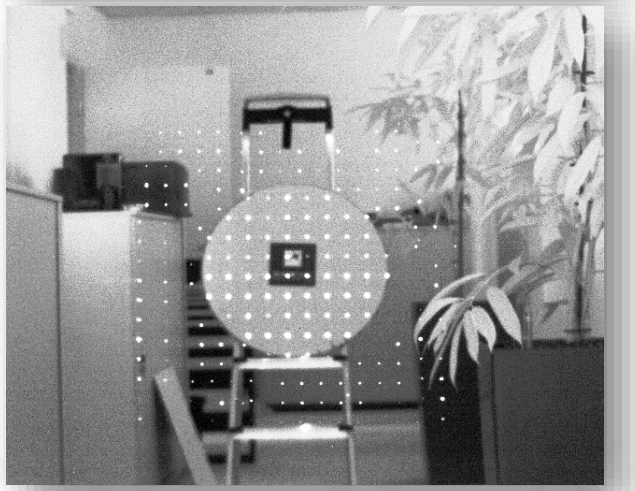
Successful demonstration of full solid-state 2D scanning

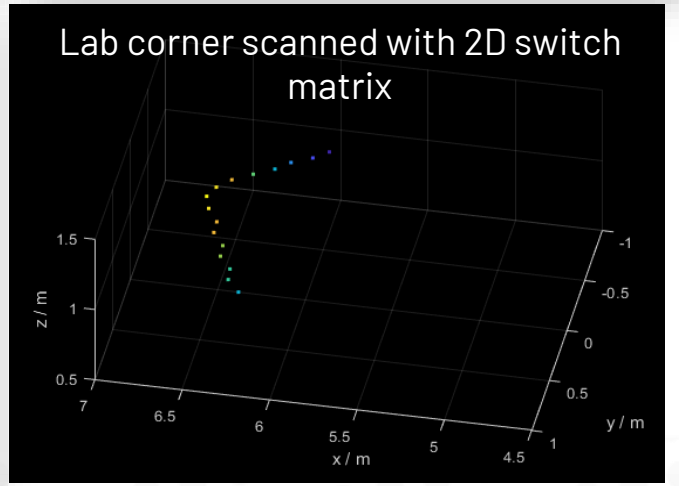
Scantinel
16x16 lines full solid-state 2D PIC











[Scantinel Photonics demonstrates world first full solid state parallelized FMCW 5D+ LiDAR system]

Summary and Outlook

SCANTINEL PHOTONICS
Scan | Detect | Navigate

Now

PoC Sample

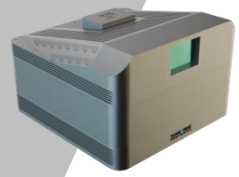
1D Solid State scanning 256 exits

Distance and Velocity measurement

Point cloud with high angle resolution

Full 2D solid state scanning shown

2022



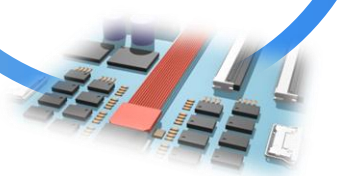
A Sample

High level of system integration

More robust system setup

Improved optical performance, sensitivity, SNR

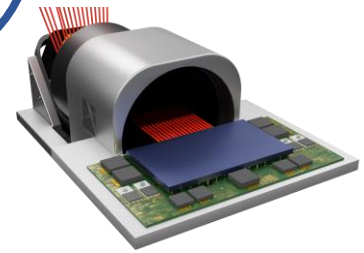
2023



Highly Integrated OCM™ Module

OEA™ with readout and driver electronics

2025



Solid-State FMCW LiDAR OCM™ Module for Industrialization