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III/V-on-Si based Single-Chip Beam Scanner LiDAR

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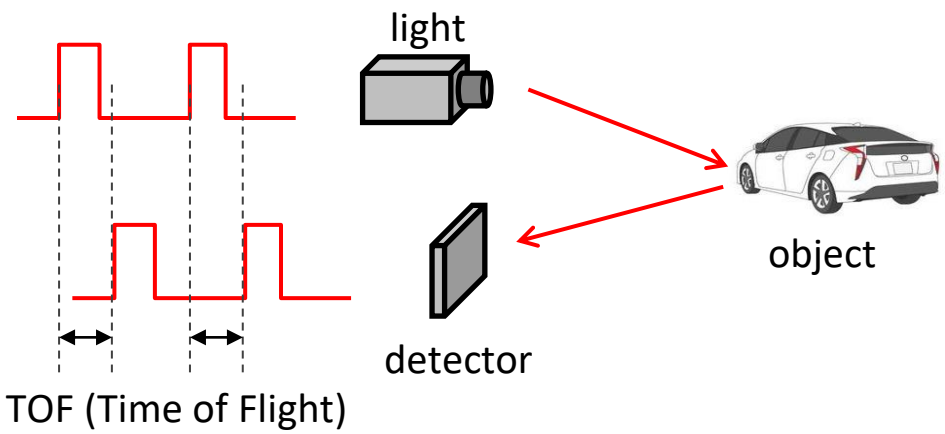
Outline

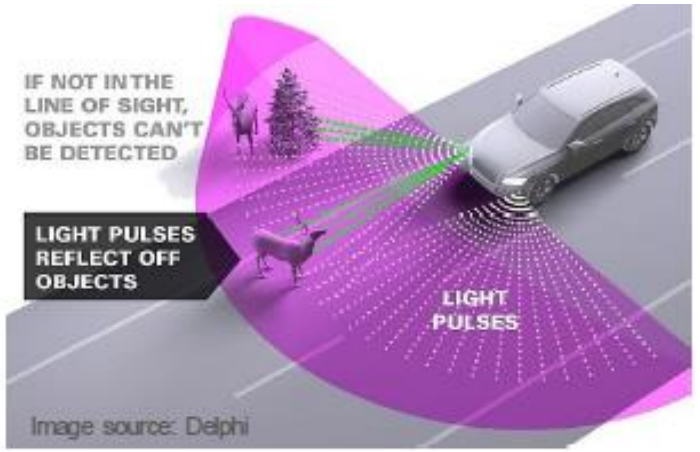
- Introduction
- LiDAR Technologies
  - Wavelength, Illumination, Scanning and Detection
  - Our approach : Light Source Integrated Photonic IC
- Results
  - Chip, Beam Scanning, Module, Ranging, Demonstration and Field Test
- Summary

Introduction : LiDAR

- LiDAR: Light Detection and Ranging
- Distance measurement by Time of Flight (TOF)
- Applications: Autonomous Driving, Robot, Mobile, Security, etc.

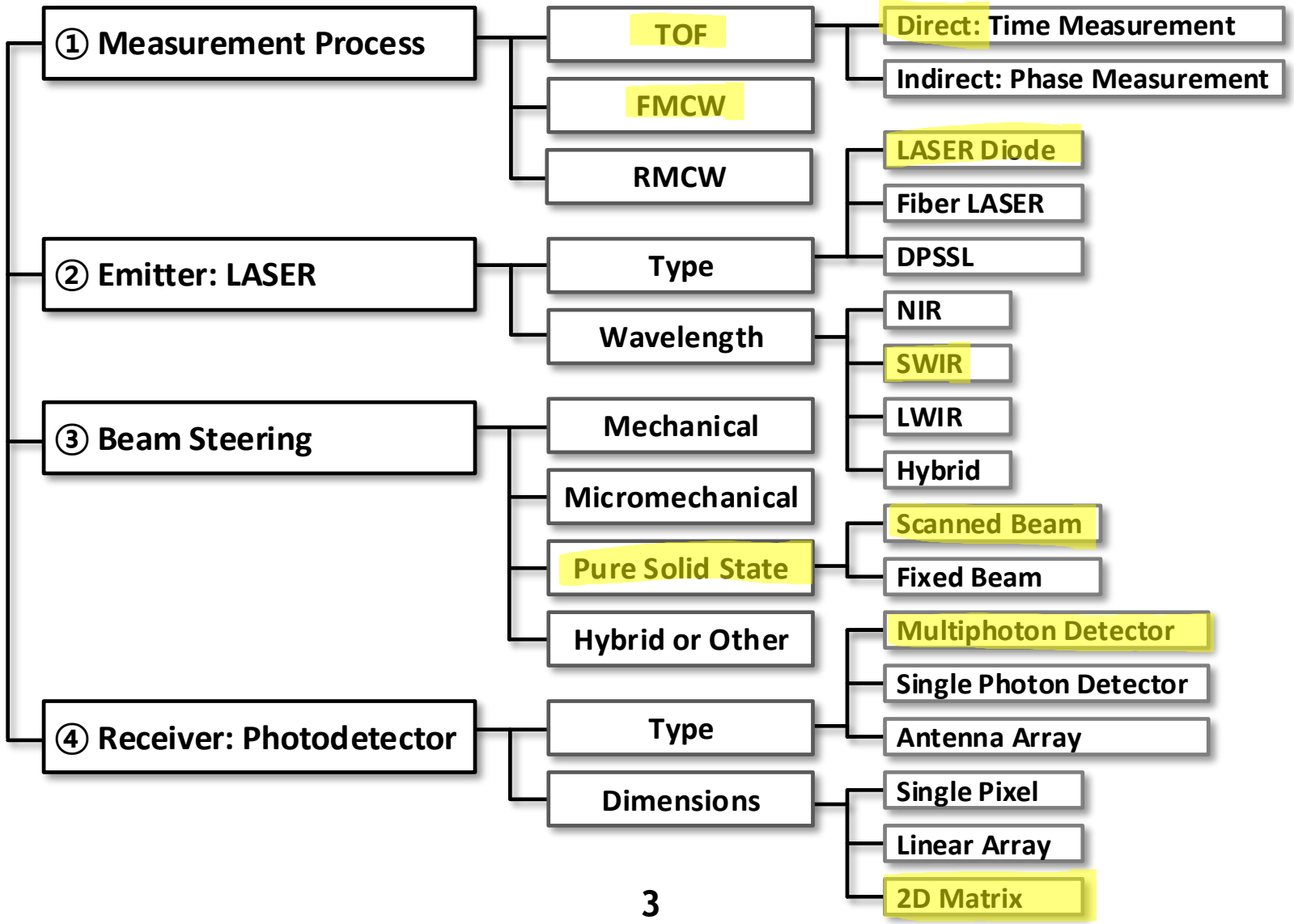
Time-of-flight (pulsed LiDAR)





(Object Detection)

Our Approach

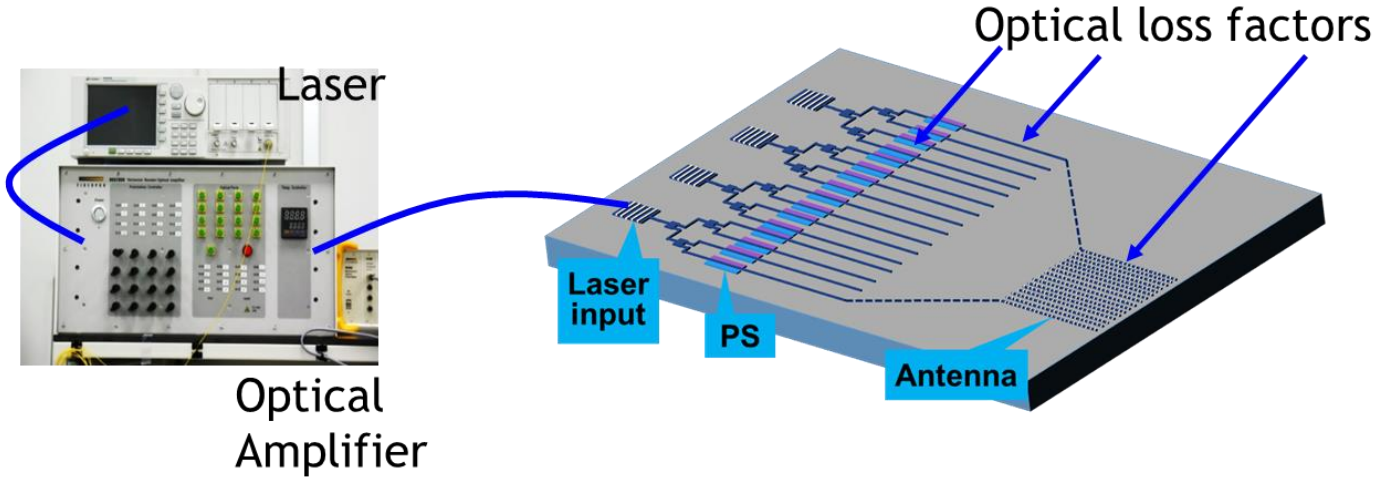


Light Source integrated Photonic IC

- Problems of existing OPA LiDAR

  ① External wavelength-tunable laser source required

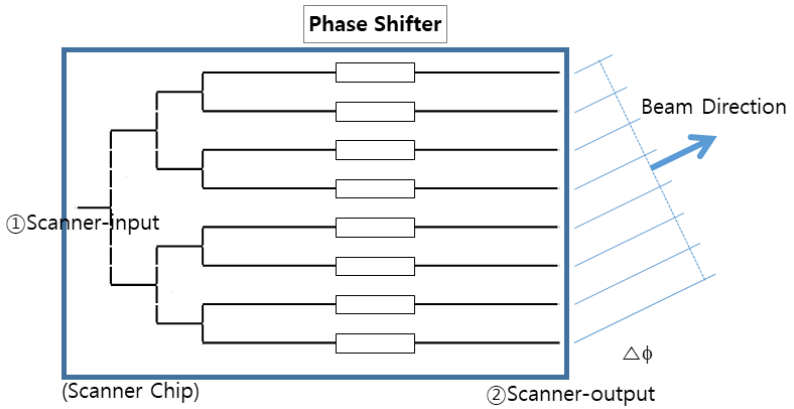
  ➔ Solution : Light source integrated Photonic IC

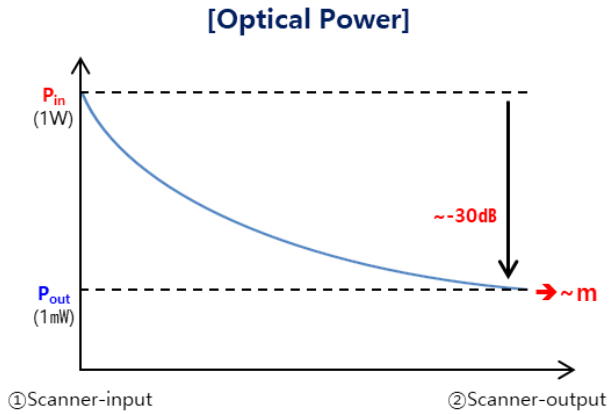


Light Source integrated Photonic IC

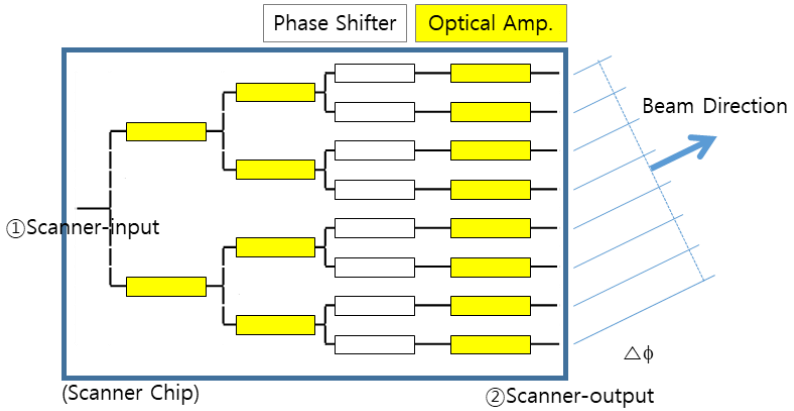
② High loss (10~30dB) through phase shifter, waveguide, grating antenna, …

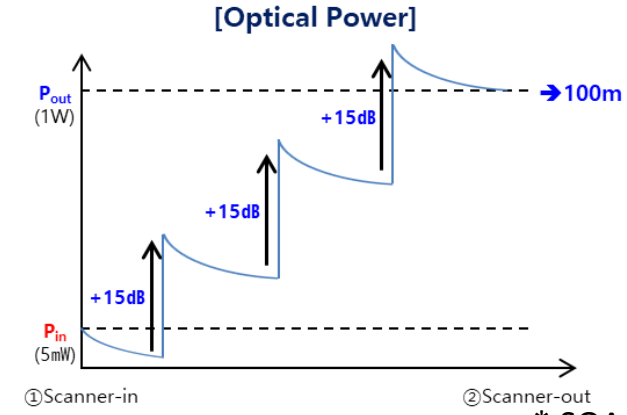
➔ Solution : Distributed Optical Amplification





(w/o SOA)



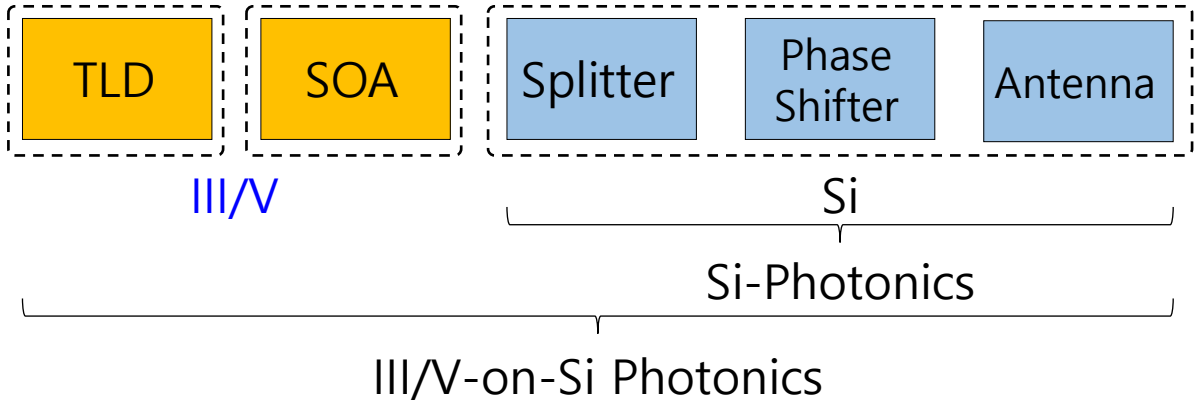


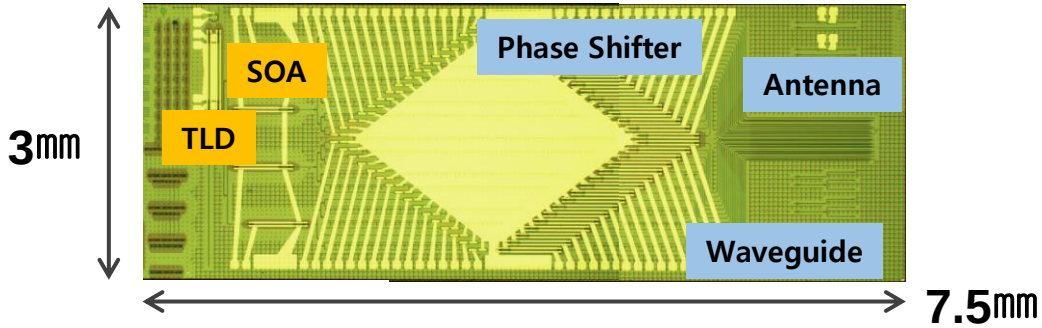
(w/ SOA)

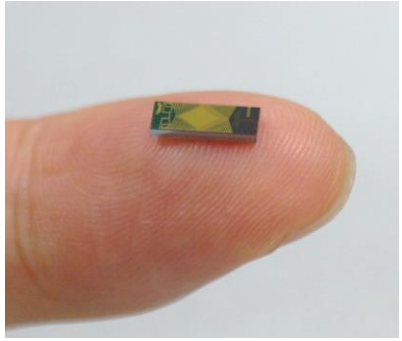
* SOA : Semiconductor Optical Amplifier

Our Results : Chip

- All photonic functions integrated on 7.5 x 3㎜² single chip
  - III/V-on-Si Photonic process used for TLD, SOA and Si-Photonic IC

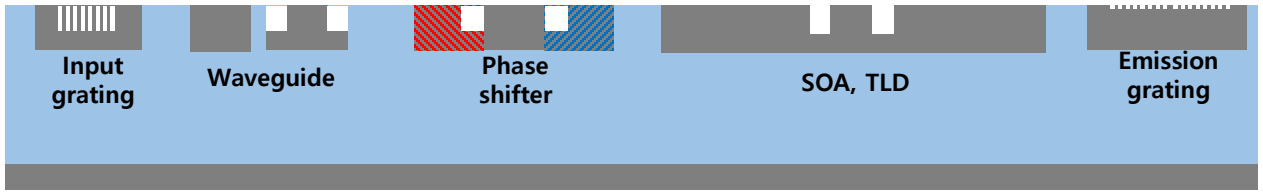


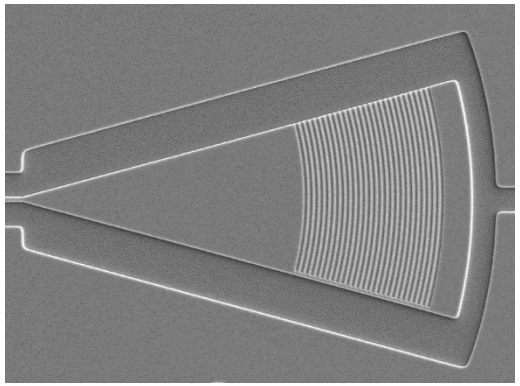




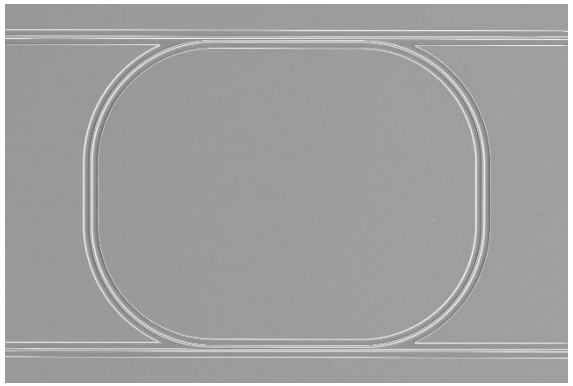
Our Results : Fabrication process

- Ggrating, waveguide, phase shifter, and emission grating defined
- Triple-depth etch (full, ~half, shallow)

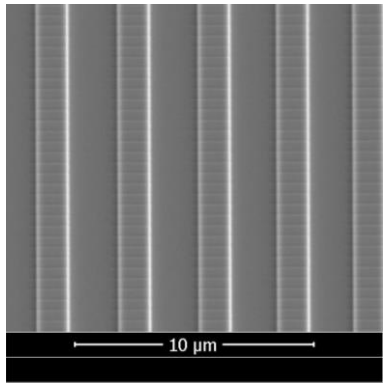




Input grating



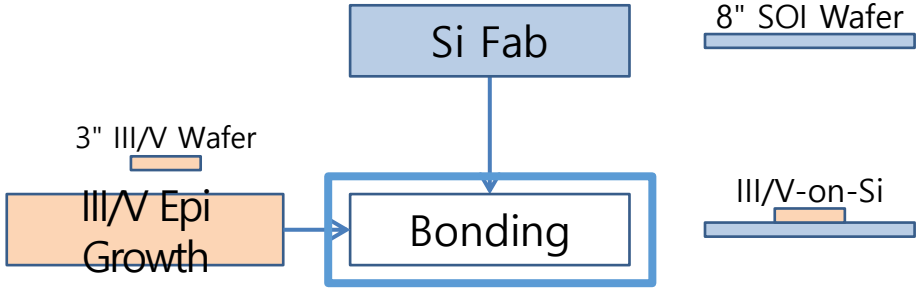
Waveguide (Ring)

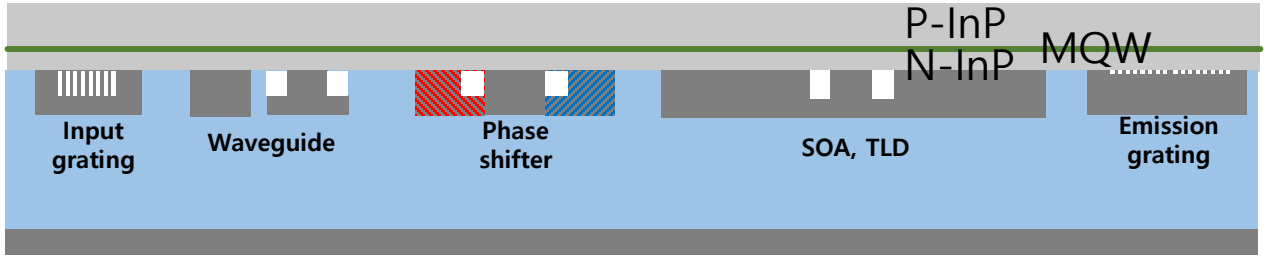


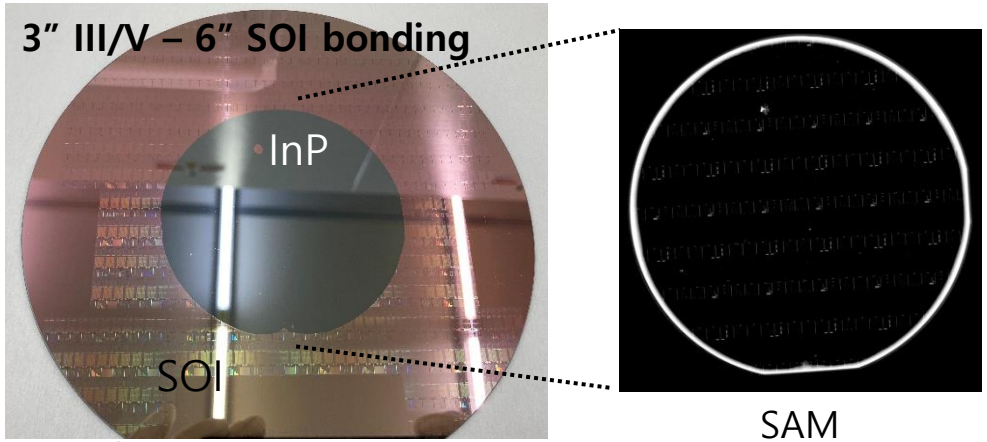
Emission grating

Our Results : Fabrication process

- Direct bonding between III/V Epi wafer and patterned Si wafer
- Cleaning → O_2 plasma activation → bonding
- Selective wet etching for InP sub. removal



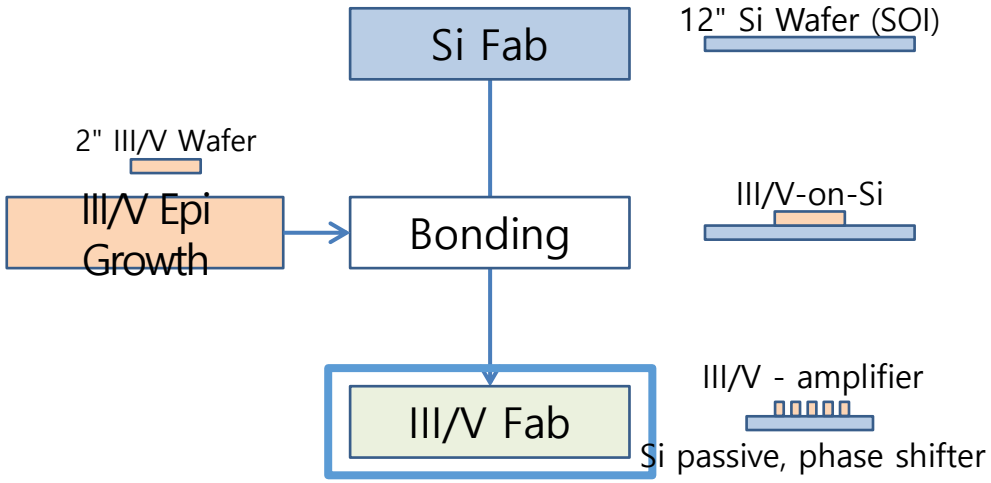




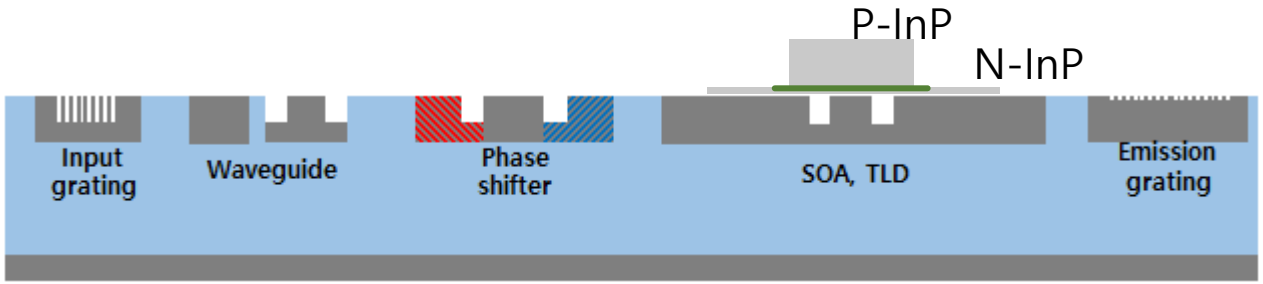
Light camera

SAM
(Scanning Acoustic

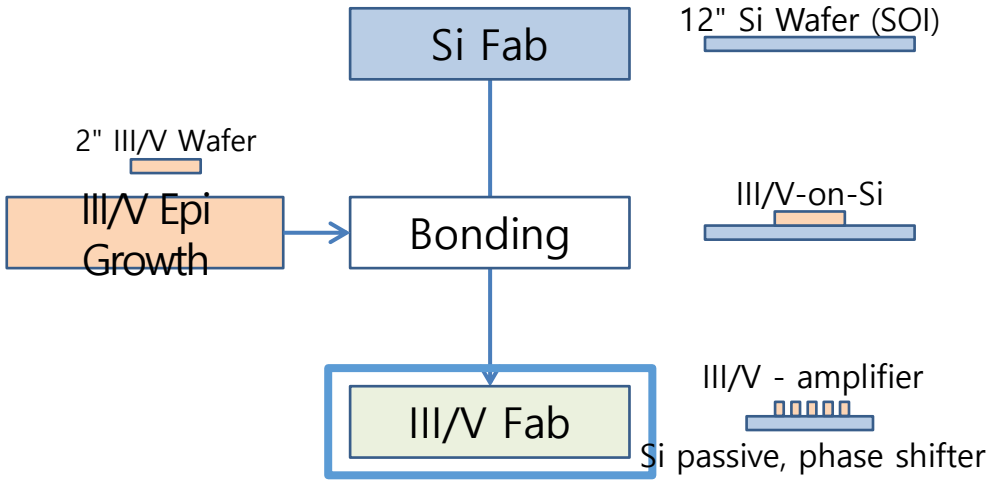
Our Results : Fabrication process



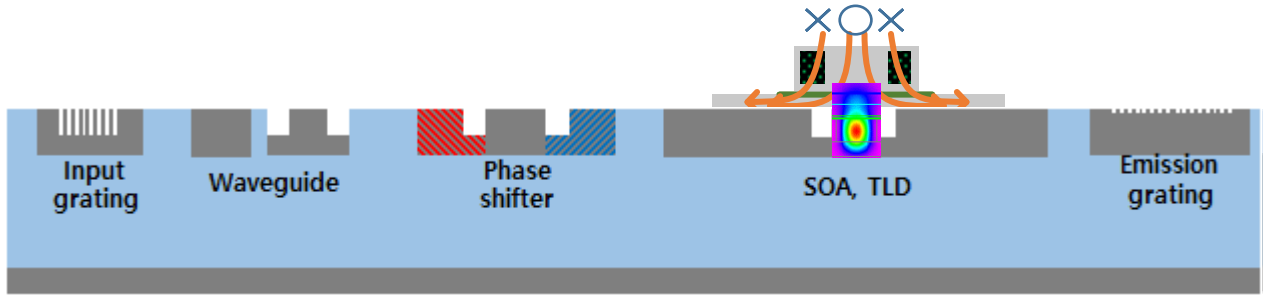
- Mesa structure defined



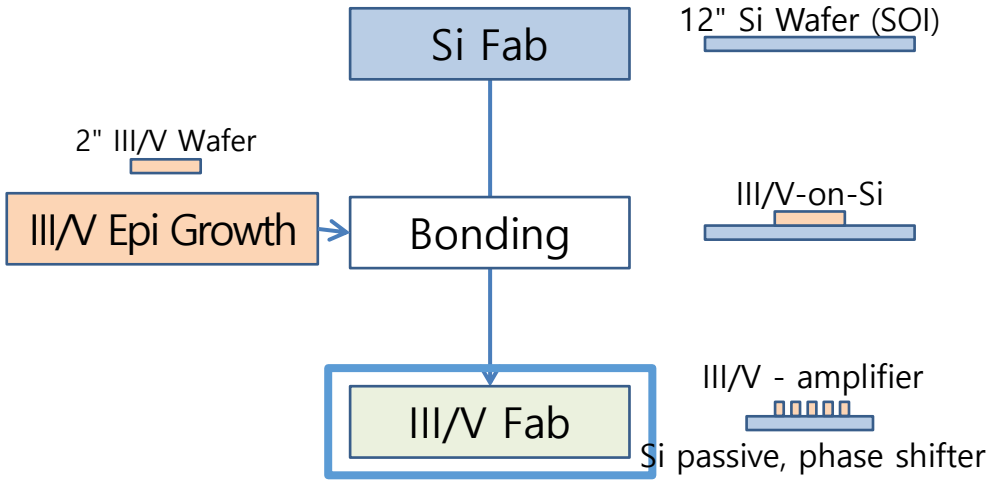
Our Results : Fabrication process



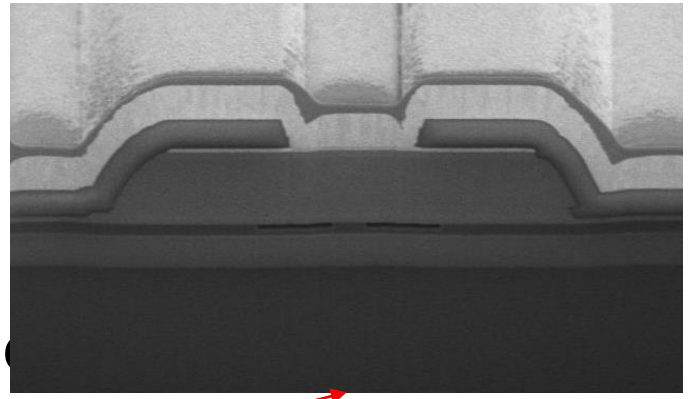
- Proton implant to control current path

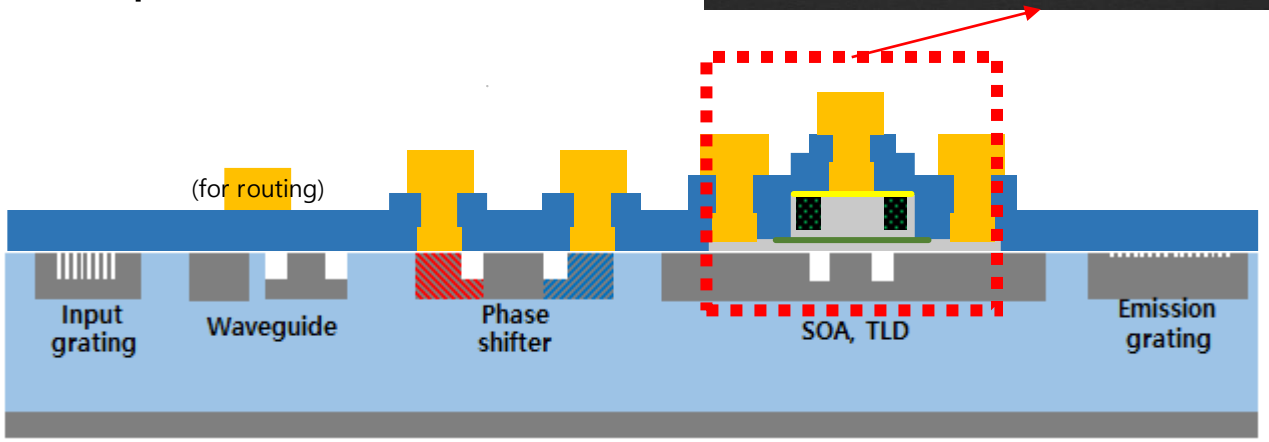


Our Results : Fabrication process



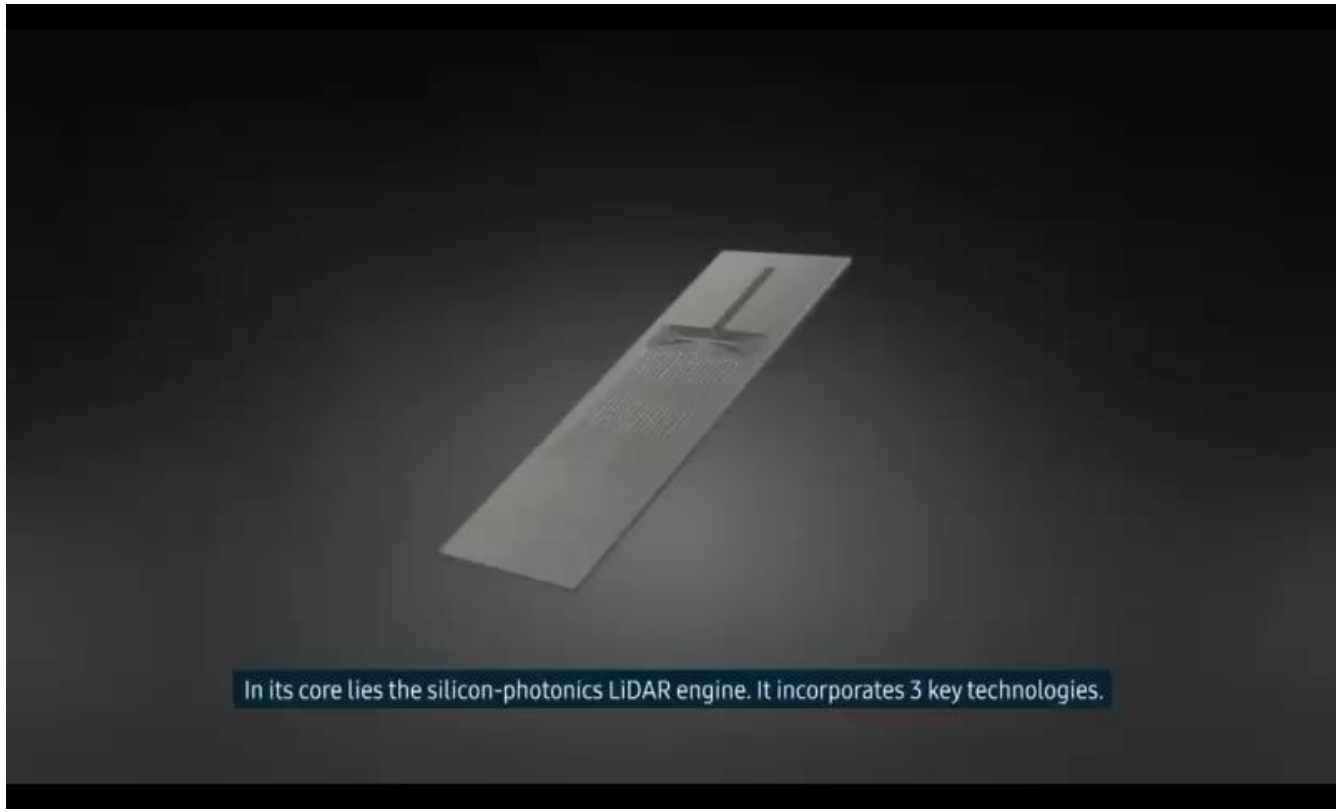
- Top metal (Au) define





Our Results : Beam Scanning

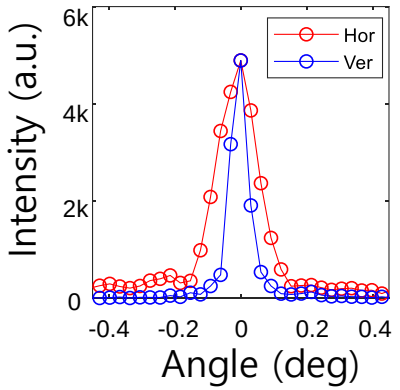
- 2D beam steering without moving parts
  - Phase control(Horizontal scan), Wavelength control(Vertical scan)



Our Results : Beam Scanning

2D beam steering performance

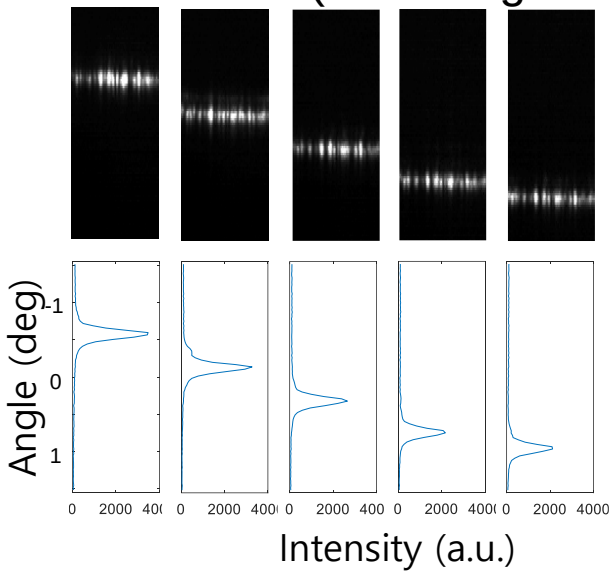
- Genetic algorithm used for 32 channels
- Beam size : 0.15°(H) X 0.09°(V)
- FOV : 20°(H) X 3.5°(V)



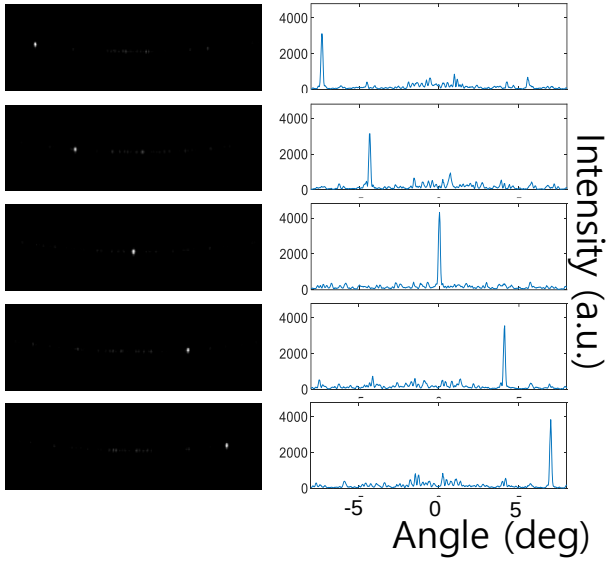
IEDM2020

2D beam scanning method (captured by IR Camera)

Vertical scan (wavelength tuning)

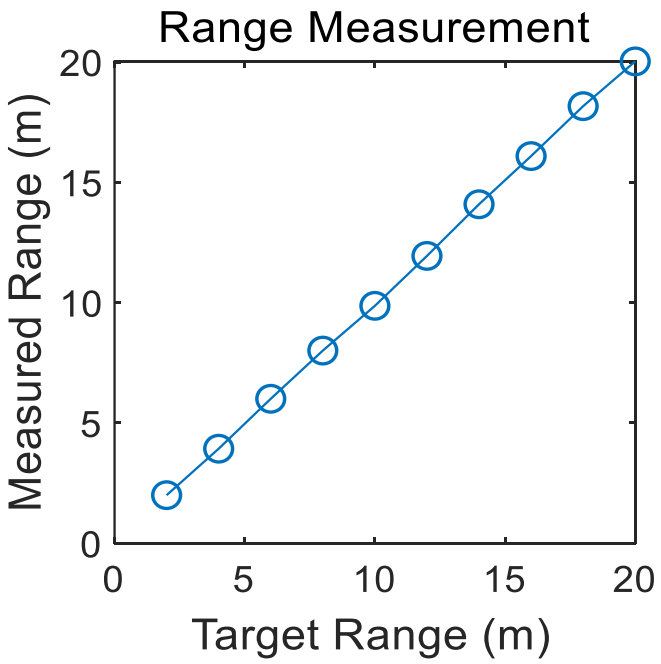


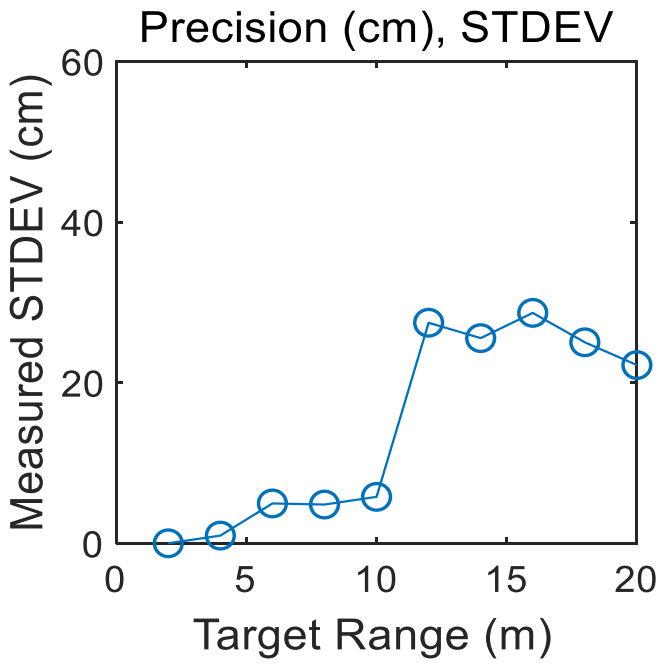
Horizontal scan (phase tuning)

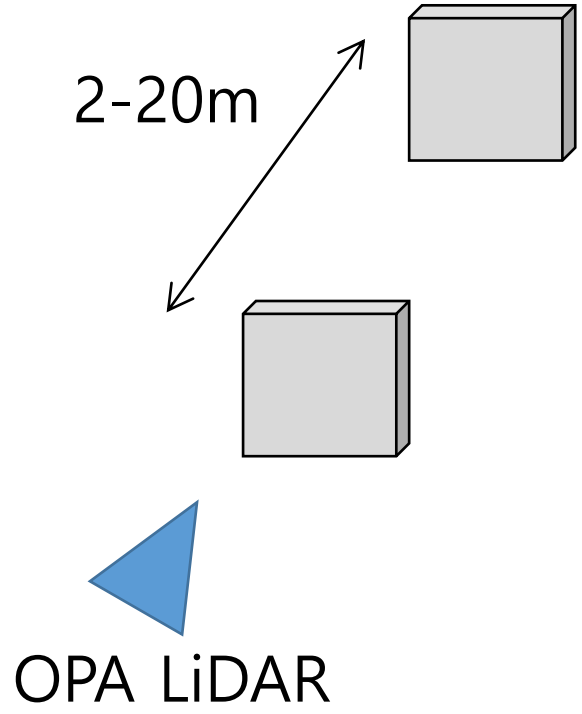


Our Results : Ranging

- Depth measurement up to 20m under 100,000lx
  - Accuracy 5.8㎝
  - Precision 22㎝ (1%) at 20m distance





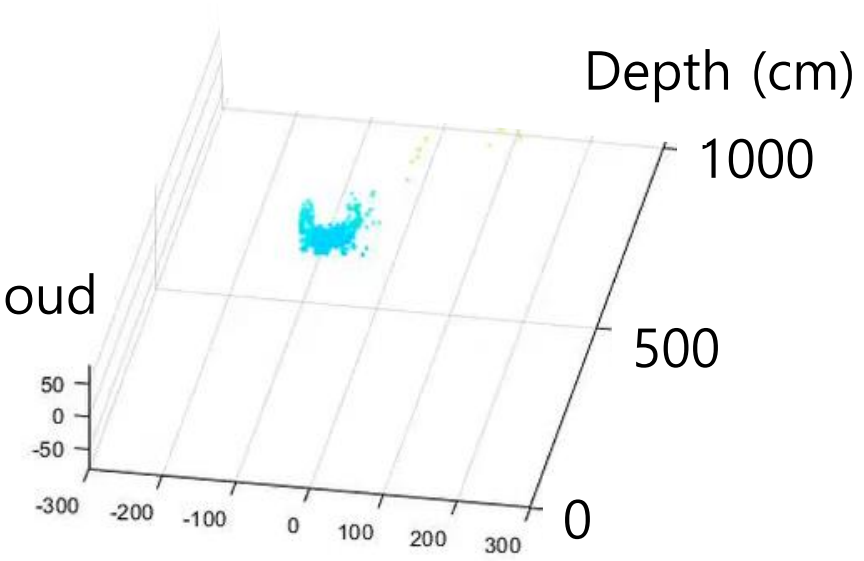


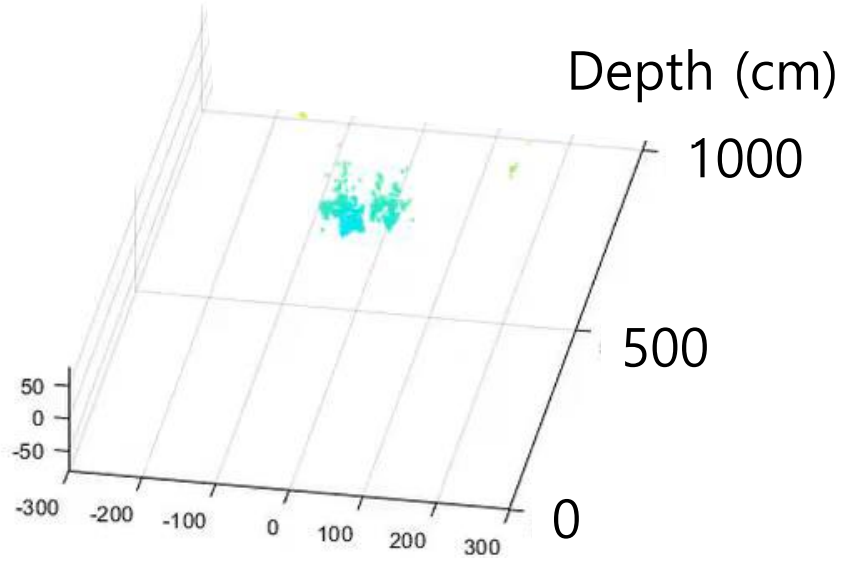
Our Results : Demonstration

- Real time imaging with sunlight interference of 100,000lx
- Ranging up to 10m @ 20fps

Camera

3D Point Cloud





Ongoing Field Test

- Test for LiDAR helping blind spots in ADAS level
- Measurement with Camera-based ADAS + Samsung LiDAR

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Summary

- We considered optimal LIDAR technologies in the wavelength, lighting, scanning and detection.
- We demonstrated 20m ranging and 10m real-time LiDAR operation with single-chip OPA.
- We are verifing our LiDAR can cover various issues in ADAS.