HAMAMATSU

PHOTON IS OUR BUSINESS

LIDAR Technology and Applications

Laurent DEMEZET

Hamamatsu Photonics France

April, 14th 2020

Who is Hamamatsu Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

"A HIDDEN CHAMPION OF THE 21TH CENTURY"

Hermann Simon, author of the *Hidden Champions of the Twenty-First Century*

SINCE **1953**

3 R&D CENTERS

7 MANUFACTURING **FACILITIES**

5,035 EMPLOYEES

$ 1.325 BILLION

1953 ••••••••••••• 2019

3 NOBEL PRIZE CONTRIBUTIONS

15.000 PRODUCTS

9% R&D EXPENSE

1995 ENTRY IN TOKYO **STOCK EXCHANGE**

UNITED NATIONS GLOBAL COMPACT

- HUMAN RIGHTS
- LABOUR STANDARDS
- ENVIRONMENT
- ANTI-CORRUPTION

*Figures taken in 2019

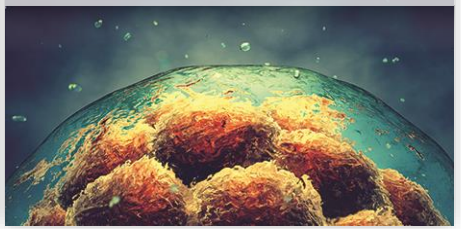
Our diverse markets include..

HAMAMATSU
PHOTON IS OUR BUSINESS

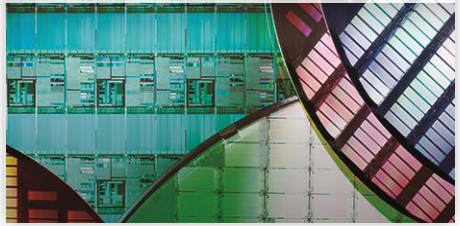
END-USERS SEGMENTS

ACADEMIC RESEARCH - PHYSICS

ACADEMIC RESEARCH - LIFESCIENCE



SEMICONDUCTOR MANUFACTURING

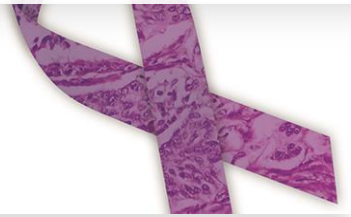


FOOD MANUFACTURING

AUTOMOTIVE MANUFACTURING

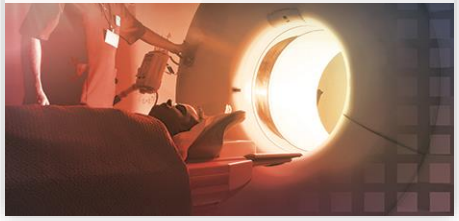
PHARMACEUTICAL MANUFACTURING

HOSPITALS & MEDICAL LABORATORIES



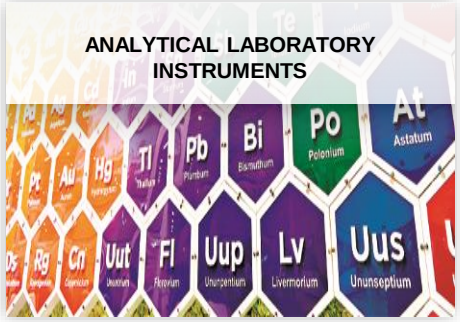
DEVICE SEGMENTS

DIAGNOSIS & MEDICAL DEVICES



ENVIRONMENTAL DEVICES

ANALYTICAL LABORATORY INSTRUMENTS



AUTOMOTIVE

INDUSTRIAL MACHINERY

Extensive portfolio of standard and customized solutions

HAMAMATSU
PHOTON IS OUR BUSINESS

TECH-POWERED SOLUTIONS

LASERS


DIRECT DIODE LASER


FIBER OUTPUT LASER


QUANTUM CASCADE LASER


STEALTH DICING ENGINE


LD HEATER


SPOLD


LASER DIODES


LASER DIODE HEADS


TERAHERTS PHOTOCONDUCTIVE SWITCHES


PHOTONIC CRYTAL SURFACE EMITTING DIODES


HIGH-POWER LASER DIODE BAR MODULES


LASER-DRIVEN LIGHT SOURCES

MODULES


MINI SPECTROMETERS


ELECTROSTATIC REMOVERS


RAMAN SPECTROMETER


PINHOLE INSPECTION UNITS


LCOS-SLM (Optical Phase Modulation)

SYSTEMS


BRAIN & TISSUE OXYGEN MONITORS


APPLIED PRODUCTS OF SEMICONDUCTOR LASERS


VESSELS OBSERVATION CAMERA SYSTEM


DRUG SCREENING SYSTEM


DIGITAL SLIDE SCANNER


THICKNESS MEASUREMENT SYSTEM


FLUORESCENCE LIFESTIME / TRANSIENT ABSORPTION ANALISIS SYSTEM


FAILURE ANALYSIS SYSTEM


IMMUNOCHROMATO READER


LUMINESCENCE EFFICIENCY MEASUREMENT SYSTEM


MOLECULAR ORIENTATION CHARACTERISTICS MEASUREMENT SYSTEM


MULTICHANNEL SPECTRAL SYSTEM


PLASMA PROCESS MONITOR


STREAK CAMERA

OPTICAL SENSORS


PHOTO IC


PHOTOTUBES

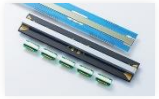

PHOTODIODES


INFRARED DETECTORS


RADIATION SENSORS


UV & FLAME SENSORS


SPECTROMETERS / SPECTRUM SENSORS


X-RAY SENSORS & SCINTILLATORS


APPLICATION-SPECIFIC SENSORS

ELECTRON & ION SENSORS

IMAGE INTENSIFIER (II) UNITS

AVALANCHE PHOTODIODES (APDs)

DISTANCE & POSITION SENSORS

PHOTOMULTIPLIER TUBES (PMT)

MULTI-PIXEL COUNTERS (MPPCs/SiPM)

CAMERAS

CMOS CAMERAS

CCD CAMERAS

EM-CCD CAMERAS

INGAAS CAMERAS

TDI CAMERAS

X-RAY CMOS CAMERAS

X-RAY TDI CAMERAS

BOARD LEVEL TDI CAMERAS

IMAGING SOFTWARE

X-RAY CCD CAMERA

X-RAY LINE SCAN CAMERAS

BOARD LEVEL CMOS CAMERAS

HIGH RESOLUTION X-RAY IMAGING SYSTEM

OPTICAL COMPONENTS

FAC LENSES

OPTICAL BLOCKS

SCAN BLOCKS

FLOW CELLS

FIBER OPTIC PLATES (FOP)

COLLIMATING CAPILLARY LENSES

IMAGE SPLITTING OPTICS

MEMS MIRRORS

IONIZATION-ASSISTING SUBSTRATES DIUTHAME

CAPILLARY PLATES

SERS SUBSTRATES

LIGHT & RADIATION SOURCES

LAMPS

MICROFOCUS X-RAY SOURCES

LAMP MODULES & UNITS

LASER-DRIVEN LIGHT SOURCES

EXTREME ULTRAVIOLET & SOFT X-RAY SOURCES

RF ELECTRIC DISCHARGE TYPE EXCIMER LAMP

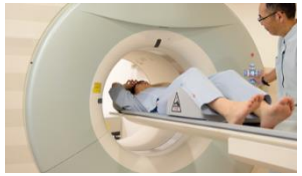
LEDS

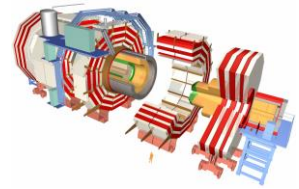
UV-LED LIGHT SOURCES

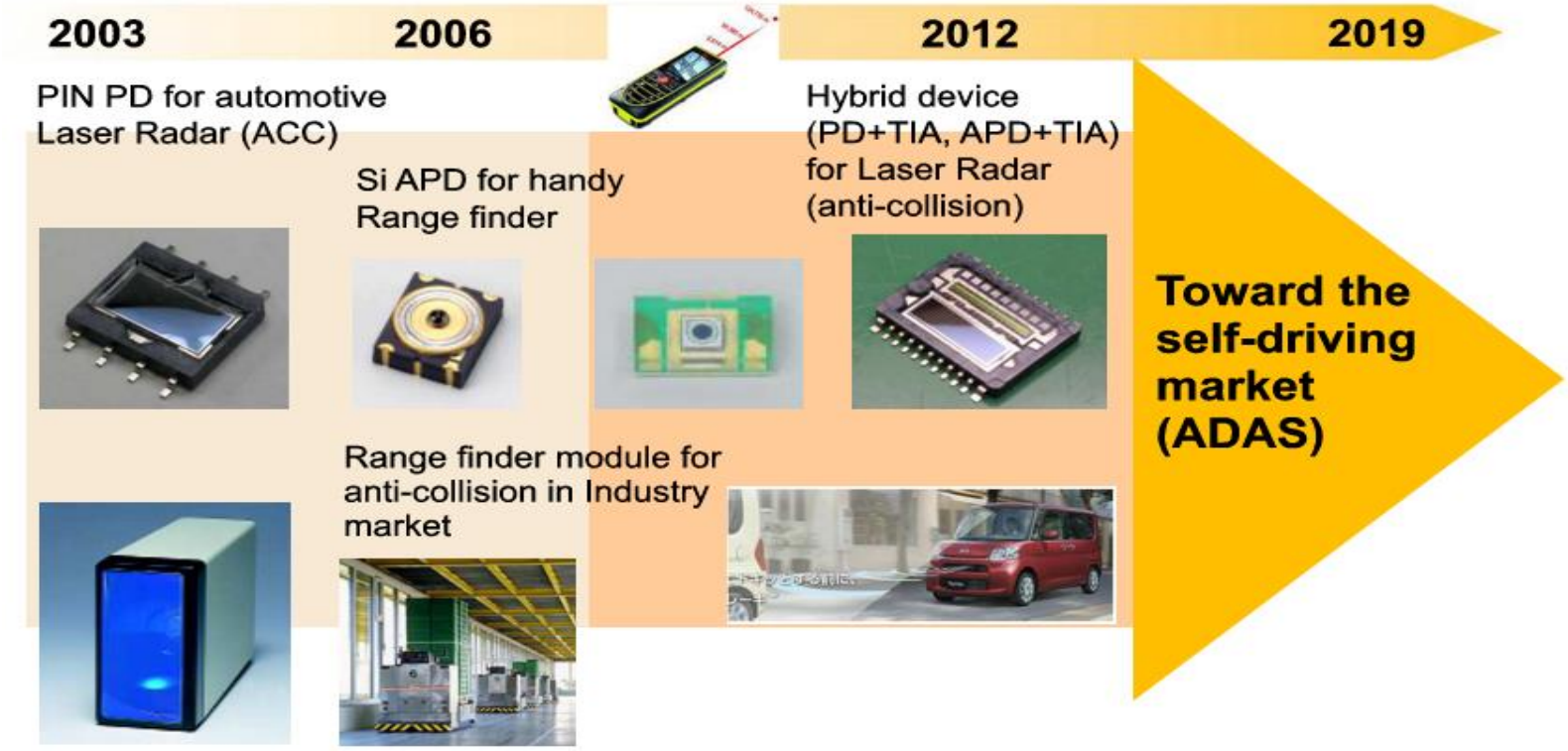
LiDAR Focus

Extensive know-how in the development of core devices

- Hamamatsu Photonics has a long history, extensive experience and know-how in the development and manufacture of ‘core devices’ for LiDAR applications.
- We have a long and established business for LiDAR applications including automotive, industrial and more.



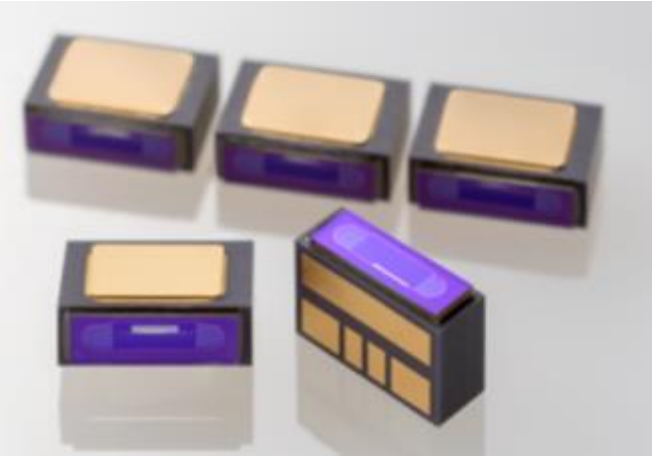




Auto-grade Package for 4ch & 1ch 905nm PLD Array

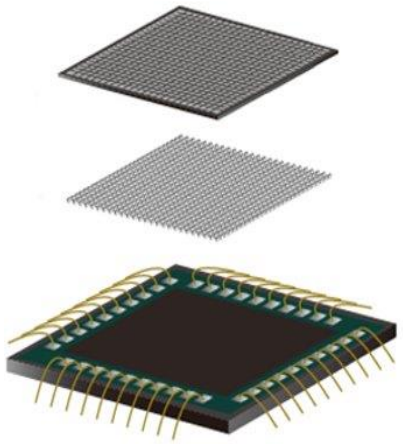
Features

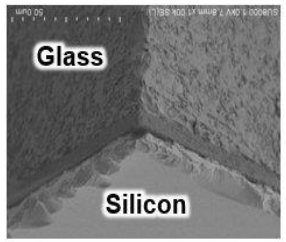
- High temperature operation
- High resistance to environment
- High speed operation



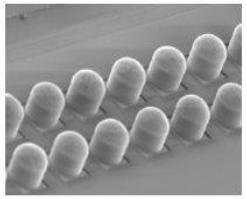
Characteristic	value
Operation temperature	-40 to +105 degC
Storage temperature	-40 to +125 degC

2D – MPPC Arrays





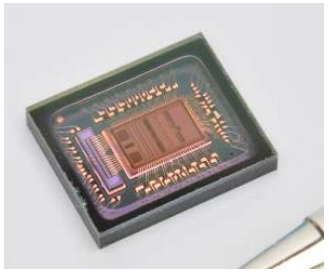
Micro bump



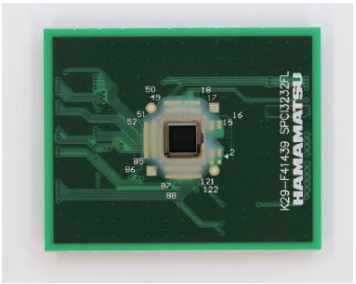
Applied technique for MPPC and ASIC Hybrid 2D Array

- Support glass attachment
- Silicon wafer thinning < 50μm
- Micro bump forming
- Flip chip bonding

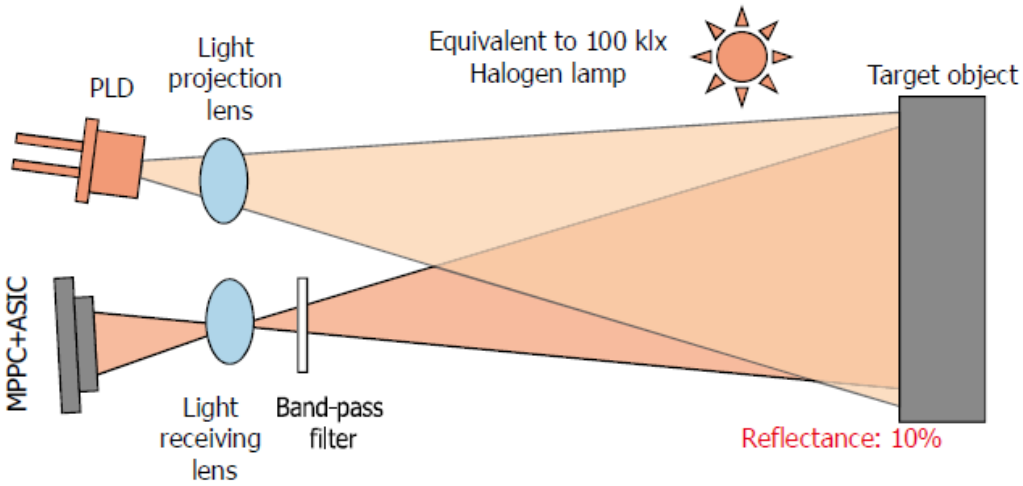
- **Higher PDE, around 905 nm**
- **Lower Long tail**
- **Wider dynamic range**
- **2D Array / Photon counting imaging**



1D S15088-0225GL-01
Available now!

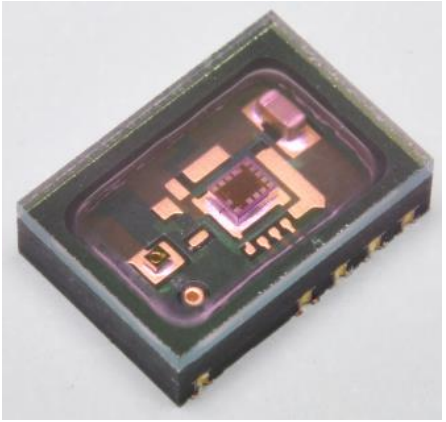


2D in development!



Future products

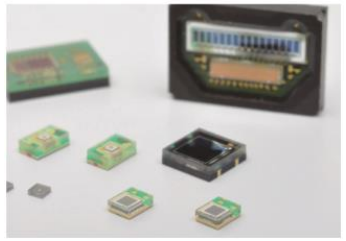
1 ch InGaAs PD and APD (array) & TIA currently in development.



- **Higher laser power availability and limited influence from sunlight**
- **Unique TIA design reducing ringing effect and temperature influence.**
- **TIA offered on same chip package as sensor**
- **Operation temp -40 to +105 degC**

Si APD 1ch and 16 ch currently available!

Hamamatsu capabilities for LiDAR

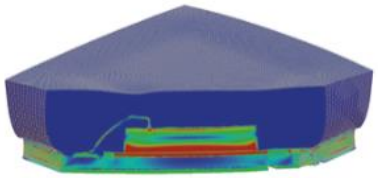


Core Device

- **Detector (PD/APD/MPPC/SPAD, Si /InGaAs)**
- **Laser (PLD/VCSEL)**
- **Band Pass Filter**

Reliability

- **Automotive standard (AEC-Q10X)**
- **Simulation technology (stress/thermal simulation etc)**



For LiDAR

Capacity

- **In-house front-end & back-end**
- **New building for higher capacity**

HAMAMATSU
PHOTON IS OUR BUSINESS

www.hamamatsu.com