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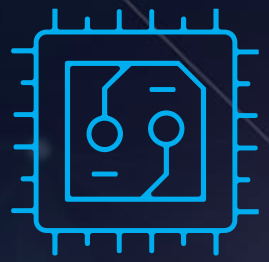
PHOTON IS OUR BUSINESS

TECHNOLOGY DAYS 2024

Welcome

TECHNOLOGY DAYS 2024



Pilot Lines

Product demos

Mini Photon Fair

Hunting in the quantum universe

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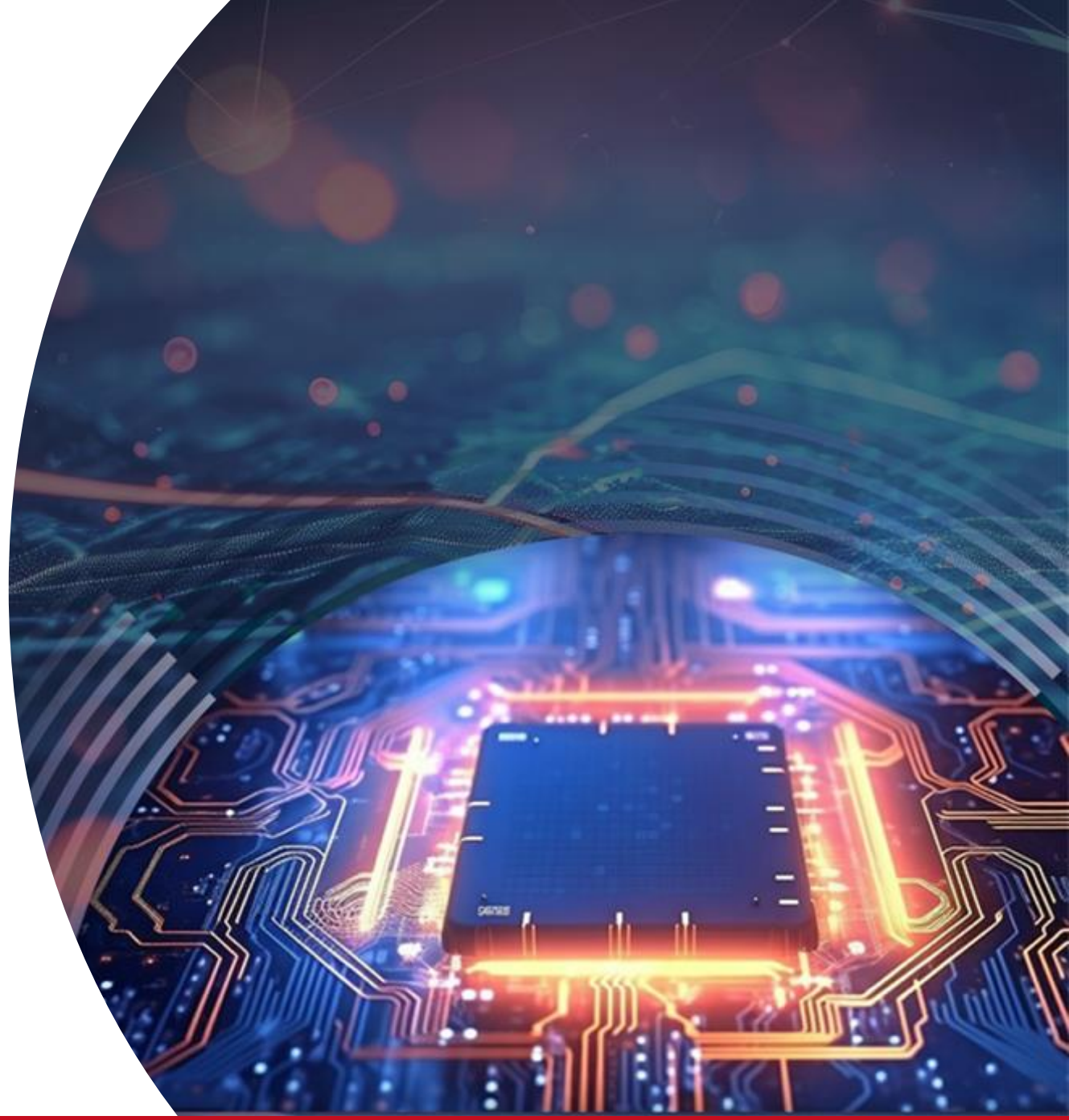
Introduction to Integrated Photonics and Pilot Lines



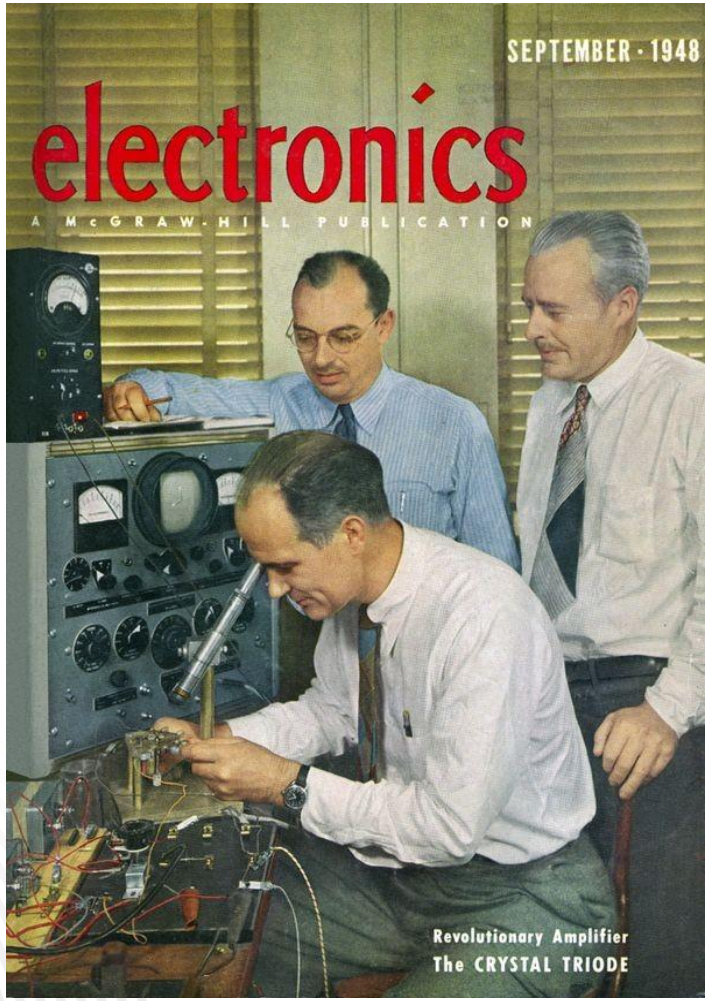
Prof. Dr. Peter Seitz

Senior Technologist Europe, Hamamatsu Photonics
Prof. em. Optoelectronics, Swiss Federal Inst. Tech. EPFL
Vice President Photonics21

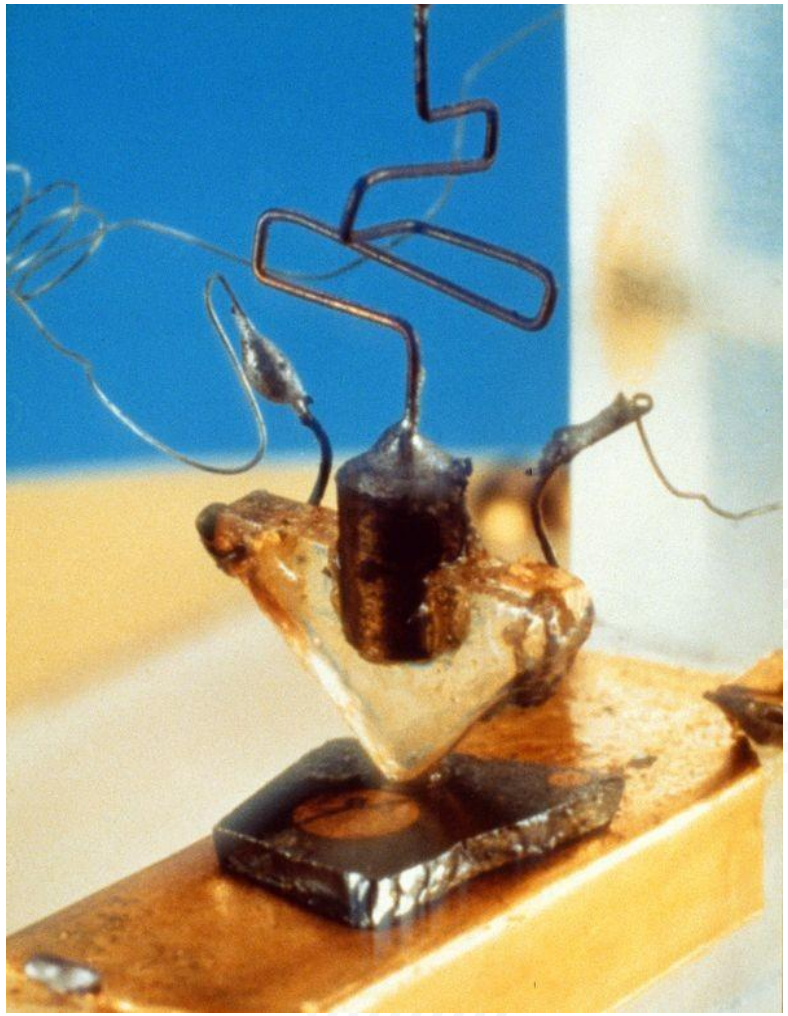
April/May 2024

- A Lesson From Microelectronics
- The PIC Revolution
- Integrated Photonic Modules and Systems
- Photonic System Design: The Art of Compromise
- Photonic System Manufacture: The Art of No Compromise

The Microelectronics Lesson: First Transistor…

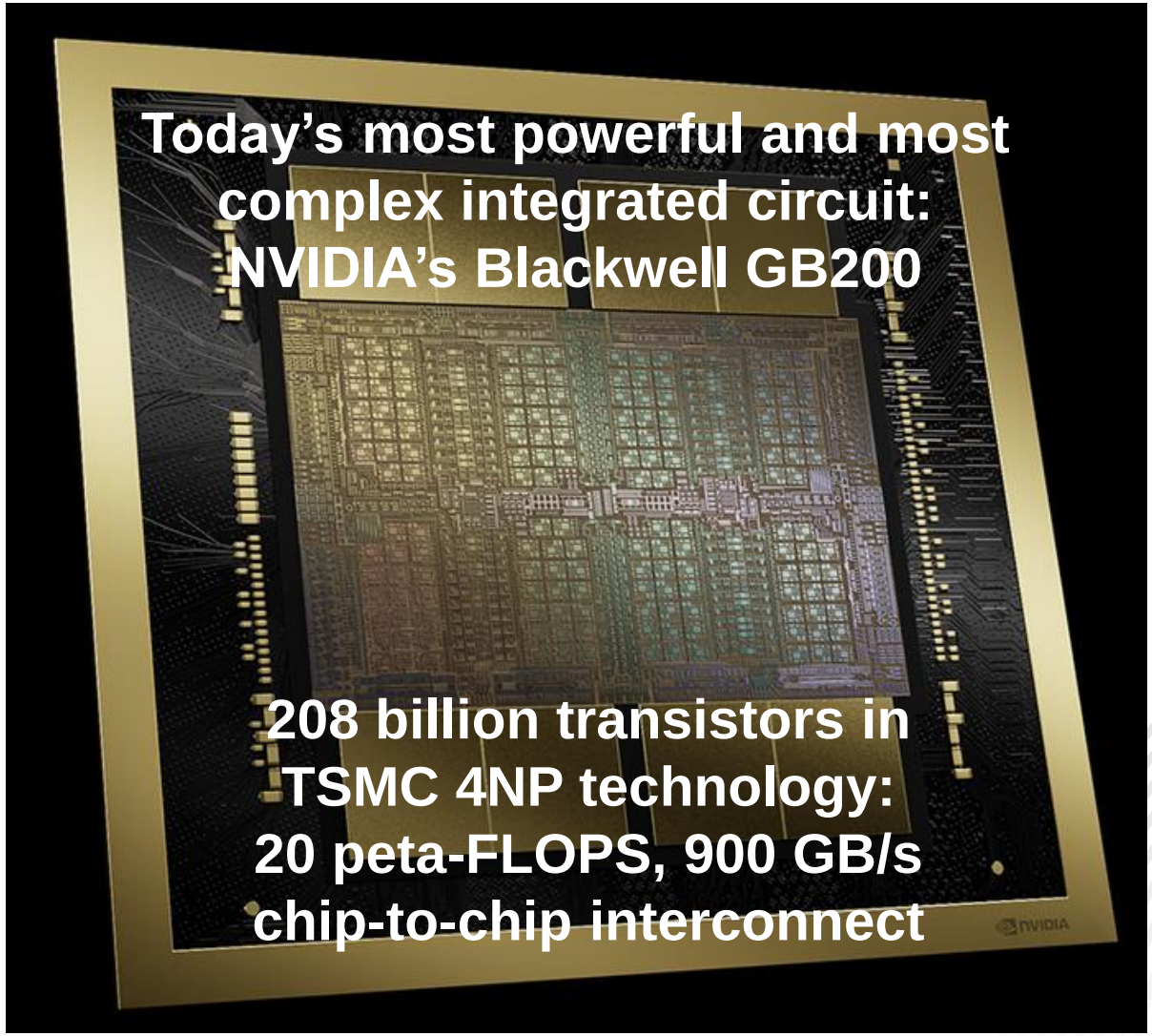


Source: https://www.computerhistory.org/



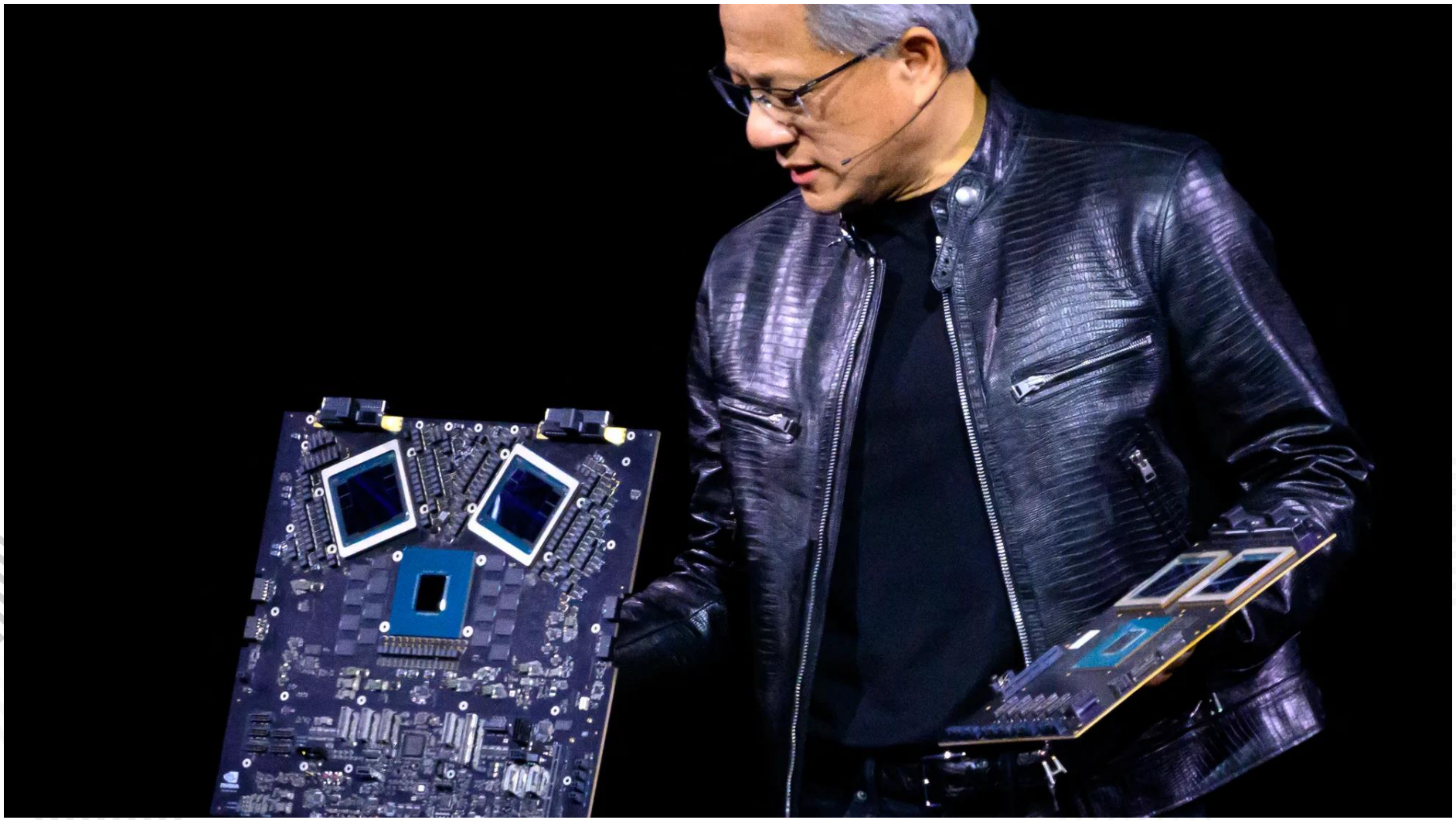
Source: https://www.computerhistory.org/

… To Integrated Circuits



Source: www.nvidia.com

The Microelectronics Lesson !



Source: https://www.zeit.de/digital/internet/2024-03/nvidia-blackwell-ki-gpu-chip

The Solution Is Almost Always A Hybrid System

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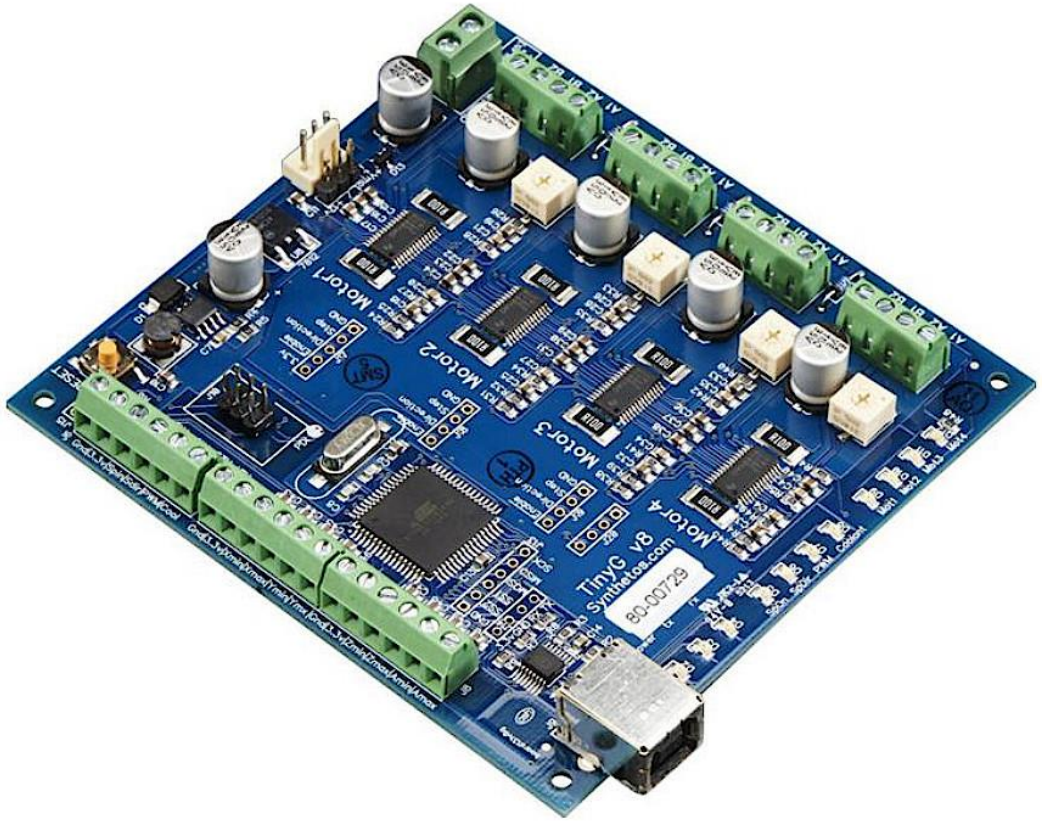
Practical product example: Cost-effective 6-axis CNC controller



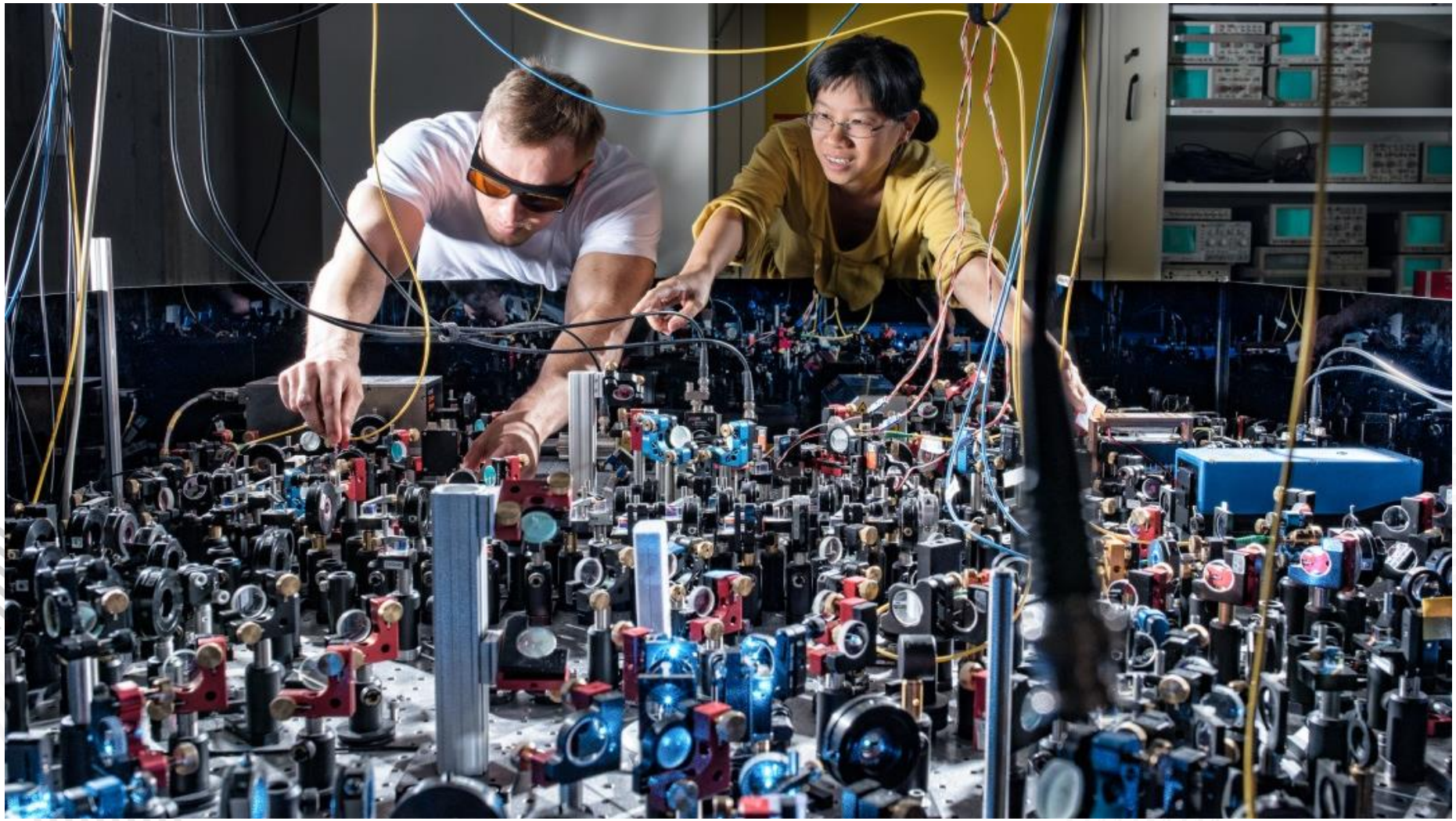
Source: www.distrelec.ch

System Design: The Art of Compromise

A system design needs to consider a large number of specifications and product aspects, which are often partially contradicting:

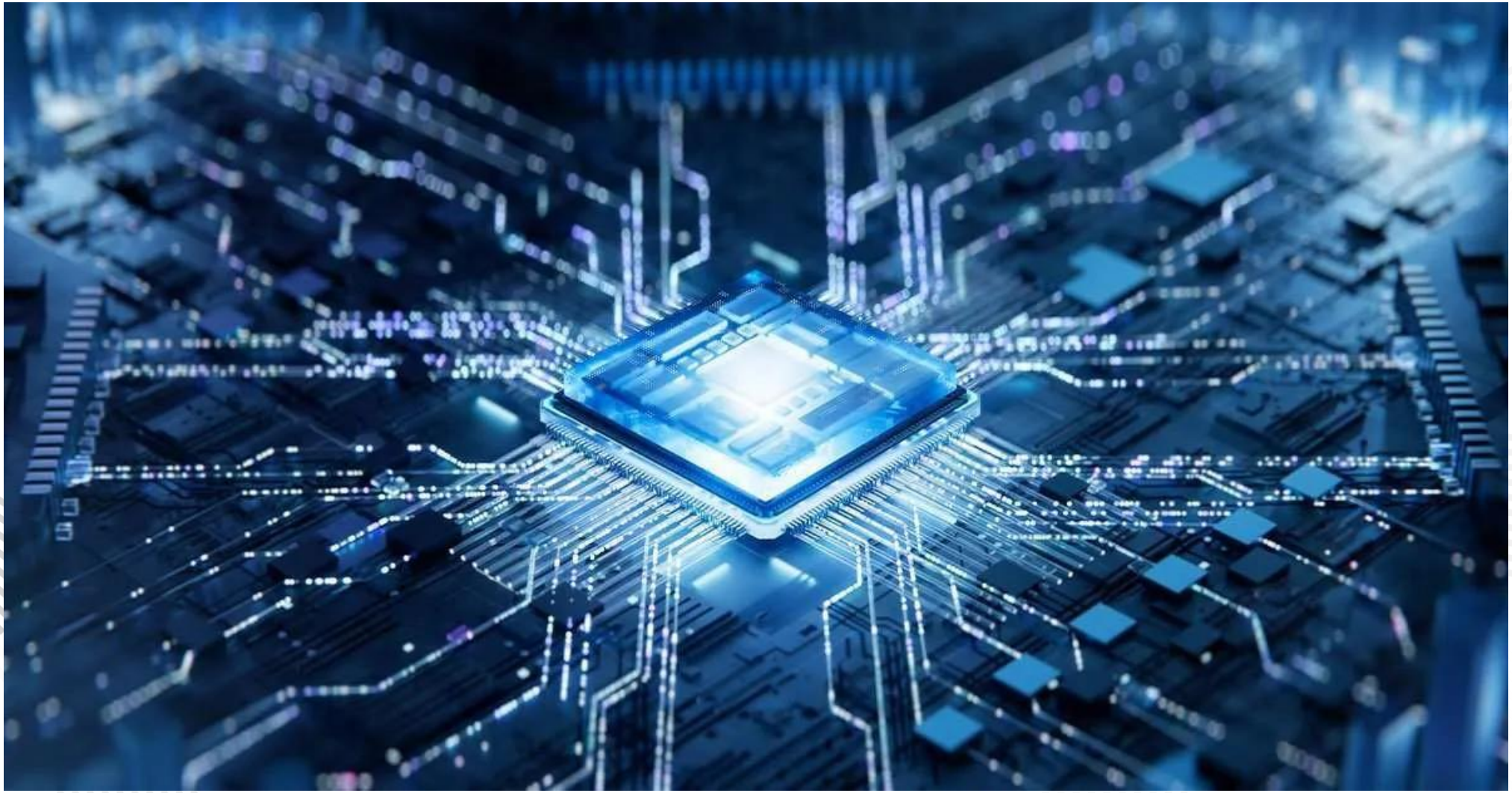
- High voltages, high currents, high dissipation power
- Functionality requiring large volume, e.g. large capacitances or inductances
- Large low-function area, e.g. photovoltaics
- Product volume and total cost (including NRE)
- Incompatible material for key functionality, e.g. quartz oscillator
- ASIC (Application-Specific Integrated Circuit) development cost
- Available floor-space or volume (reticle limitation)
- Cooling requirements
- …

PIC Revolution (Photonic Integrated Circuit)



Source: University of Stuttgart, 5th Institute of Physics, Dr. Tim Lange

PIC Revolution (Photonic Integrated Circuit)



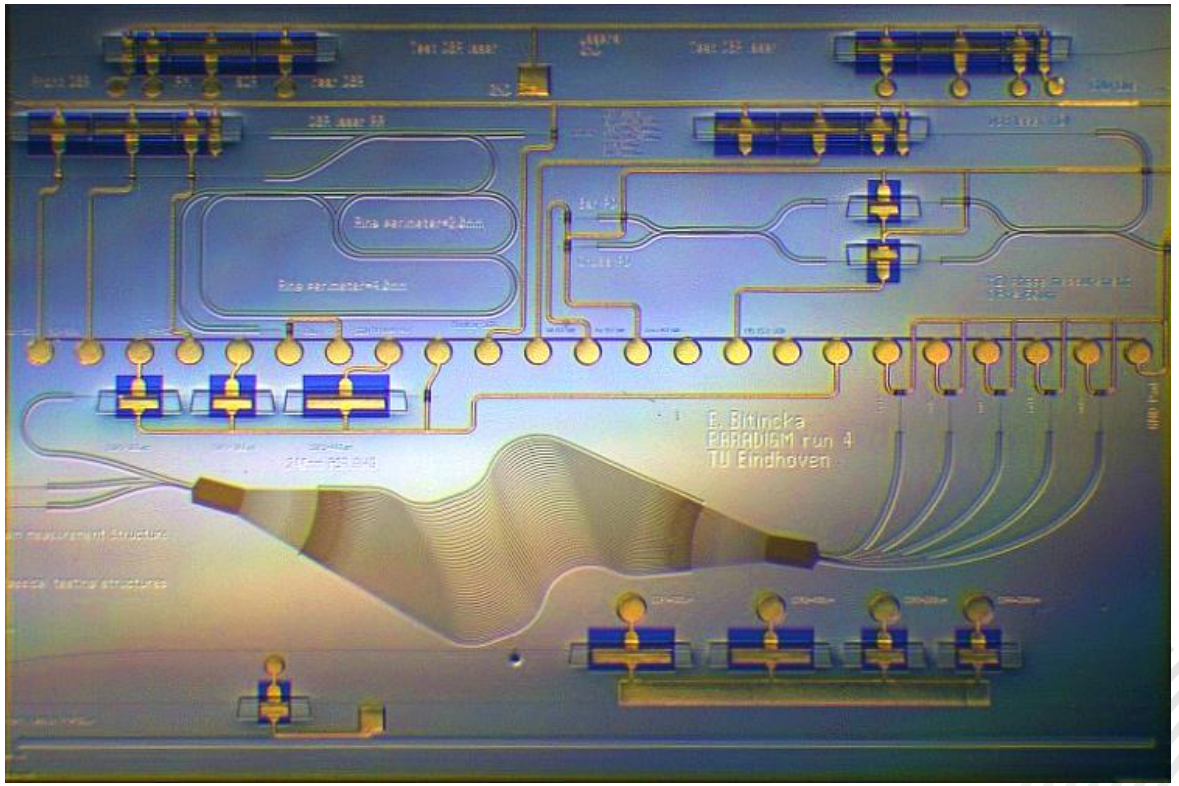
Source: https://ayarlabs.com/photonic-integrated-circuit-pic/

Amazing PICs – Example HHI InP PIC Foundry

Arbitrary combinations of active and passive photonic components with outstanding specifications can be co-integrated on one single PIC. Example from the publicly-funded InP PIC Foundry of the Heinrich Hertz Institute (Berlin, Germany):

- Waveguides (<2 dB/cm loss)
- Couplers 1x2 and 2x2 (0.5 dB loss)
- DFB lasers (20 mW@150 mA, small-signal bandwidth 20 GHz)
- DBR lasers (20 mW@150 mA, tuning range 50 nm)
- Photodiodes (3dB bandwidth: 45 GHz; sensitivity 0.8 A/W)
- Electro-optical phase modulators (30 GHz bandwidth, $U(\pi)=4V$)
- SOA – Semiconductor Optical Amplifiers (Gain > 15 dB)
- …

CAVEAT (Chip Lesson): A PIC Is Not The Solution



Source:https://www.hhi.fraunhofer.de/

Photonic System Design: The Art of Compromise

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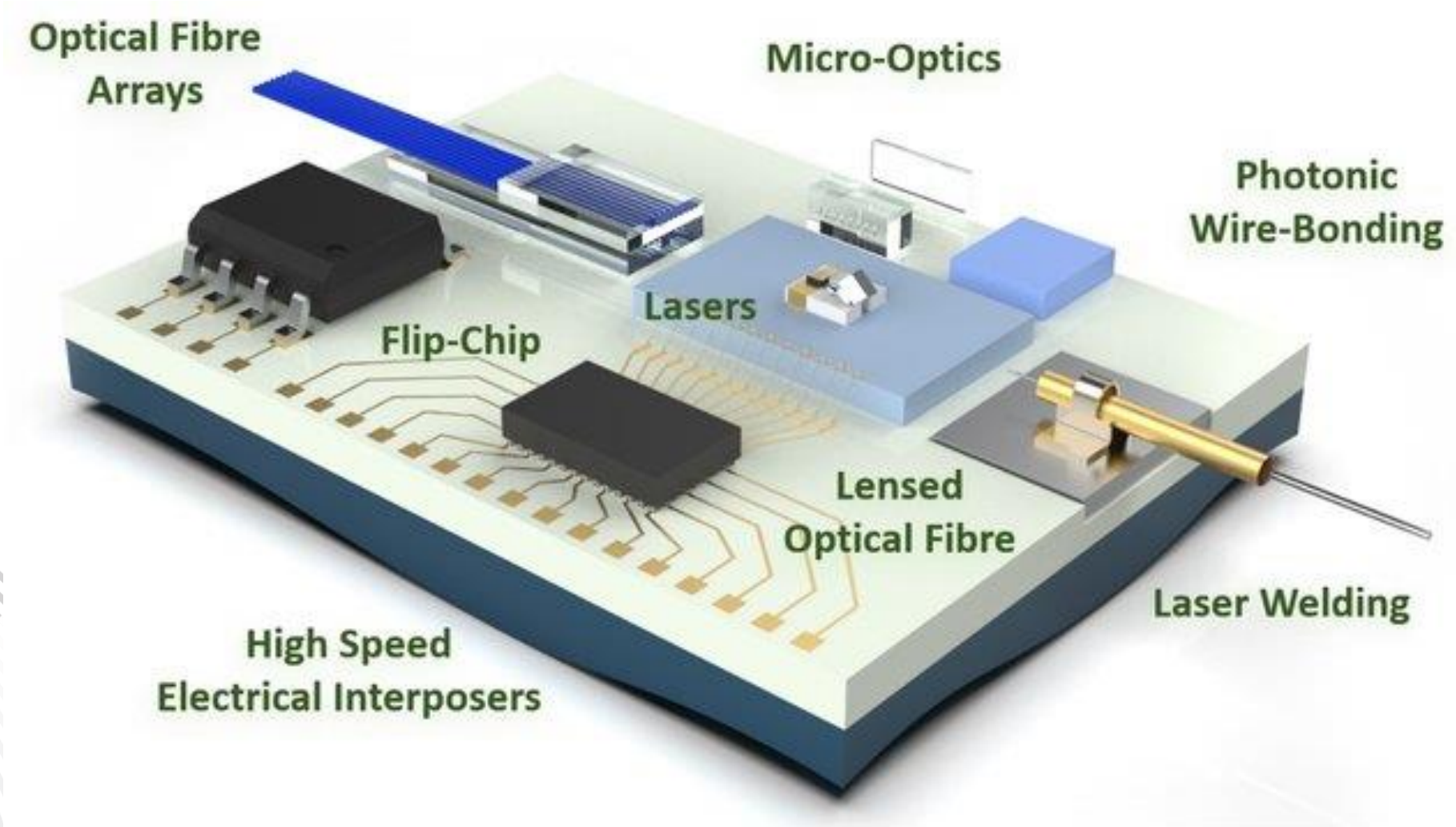
A photonic system design (with/without PICs) needs to consider a large number of specifications and product aspects, which are often partially contradicting:

- High power, high optical apertures, low losses … highest performance
- Functionality requiring large geometries (imaging, light collection, parallax, …)
- Large passive areas, e.g. light collection/focussing with a plastic lens
- Wavelength mismatch (sensing interaction, waveguide, laser/LED, sensor, …)
- Optical coupling losses for every interface between photonic components
- Extreme precision requirements of optical components and PIC interfacing
- PIC development cost (NRE)
- Total production volume and unit cost
- Cooling requirements
- Industrialization and production of hybrid photonic integrated systems
- …

An Integrated Photonic System Is The Solution

Integrated Photonics: EU Pilot Line PIXAPP ?

Integrated Photonics: EU Pilot Line PIXAPP ?



Source: https://pixapp.eu/

Fast Package Prototyping – Not Production

PIXAPP offers manufacturing services of standardised packages for optical communications, diagnosis and fiber sensing applications, ideal for companies needing pre-commercial production.

What About Photonic System ***Production*** ?

Gustave Courbet: ”The Desparate Man”

Source: Wikimedia Commons

Hamamatsu Pilot Line: Integrated Phot. Systems

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Bridging the gap between lab-scale research and full-scale manufacturing of photonics modules and integrated photonic systems

Photonic Module/System Design:

The Art of Compromise

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Photonic Module/System Production:

The Art of No Compromise

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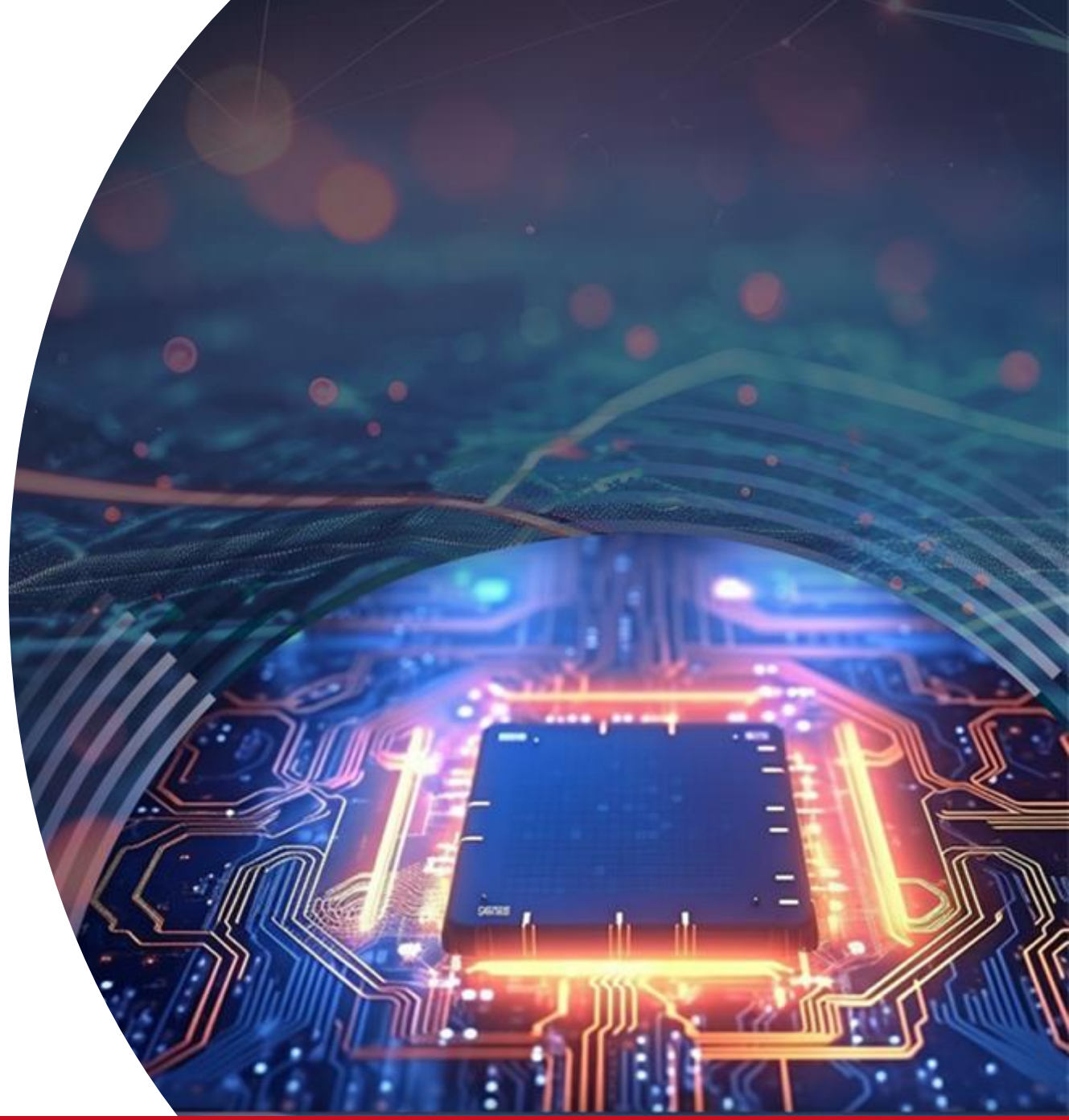
A one-stop-shop for photonics components for your Pilot Line custom module



Hamamatsu Photonics Group experts

Technical Marketing Engineers Europe

April to June 2024

Index

Hamamatsu Photonics

Medical science
Manufacturing
Life Science
Environmental science
Daily life
Fundamental research
Automotive

SINCE **1953**

10 RESEARCH & PRODUCTION FACILITIES

5,795 EMPLOYEES

221.4 BILLION

1953 2023

5.6% R&D EXPENSE

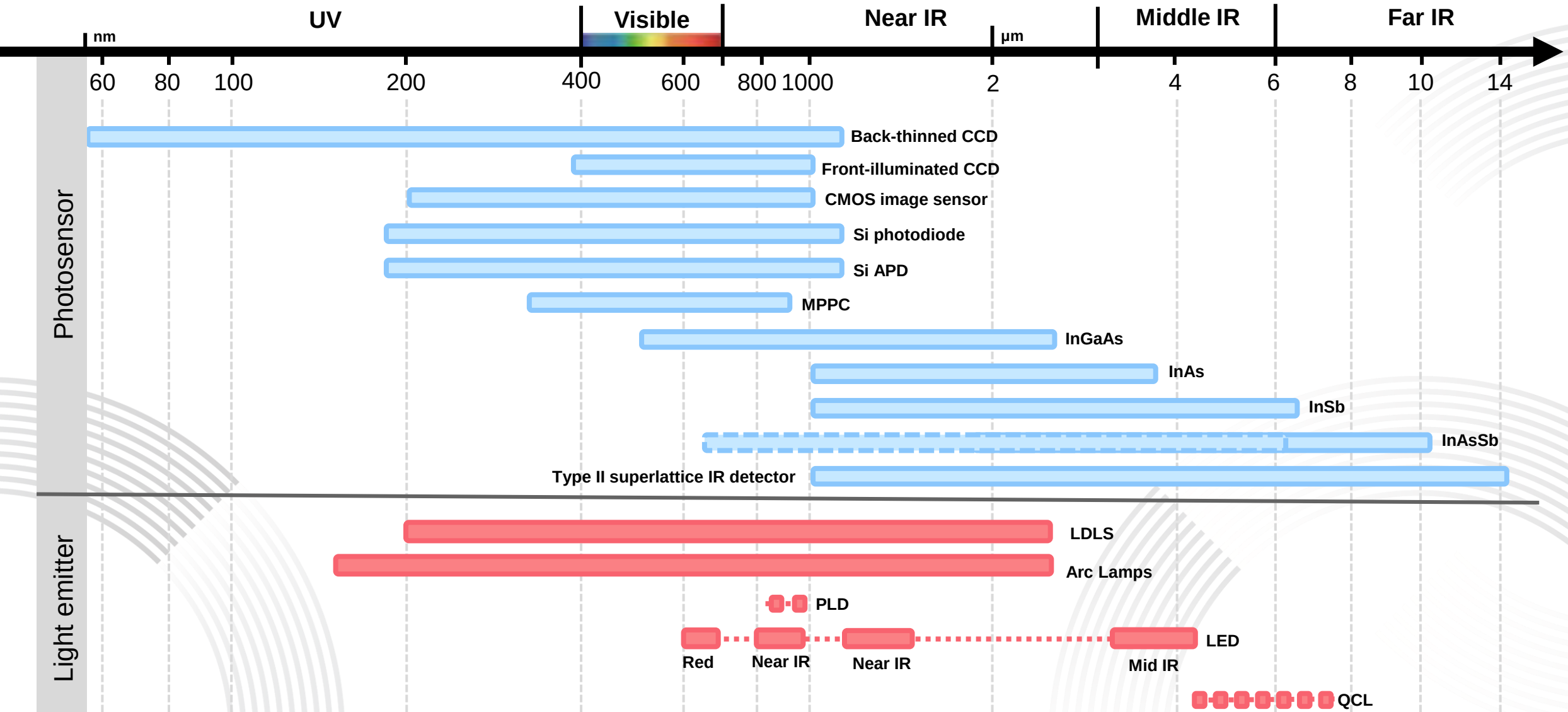
3 NOBEL PRIZE CONTRIBUTIONS

15.000 PRODUCTS

2/3 CUSTOM SPECIFIC

*Figures taken in 2023

Covers Wide Wavelength Range



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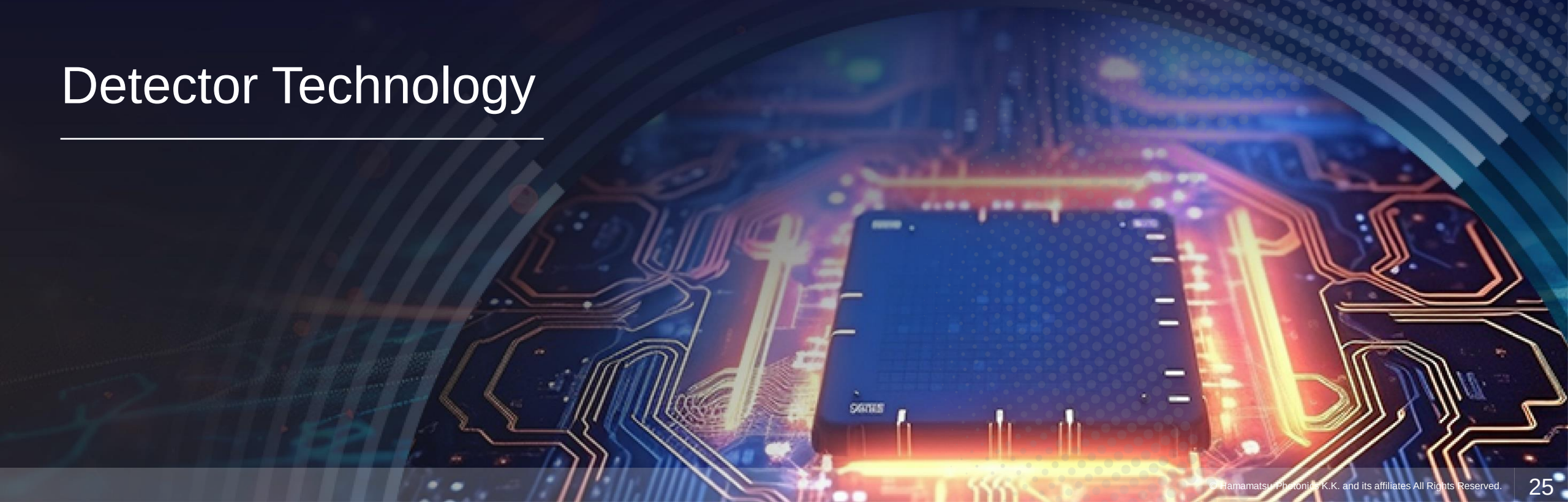
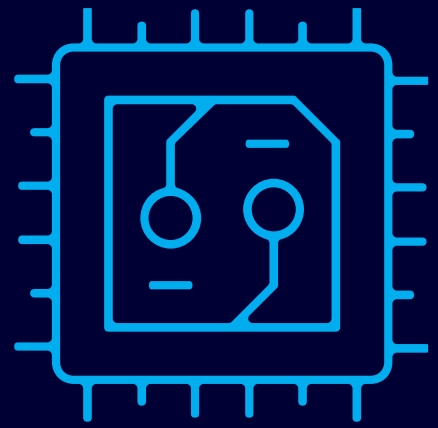
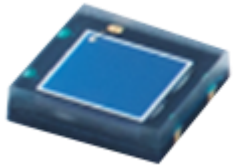
Detector Technology



SiPD, APD, SPAD, MPPC



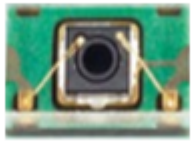
SiPD, APD, SPAD, MPPC®



PD

Photodiode

Converting photons to hole-electron pairs (w/o multiplication)



APD

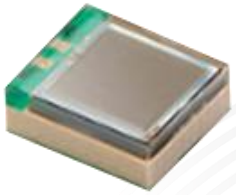
Avalanche photodiode

Electrons are multiplied by a factor of 10 to 100 through the internal electrical field.
This process is conducted in a carefully controlled state known as the linear mode.

SPAD

Single photon avalanche photodiode

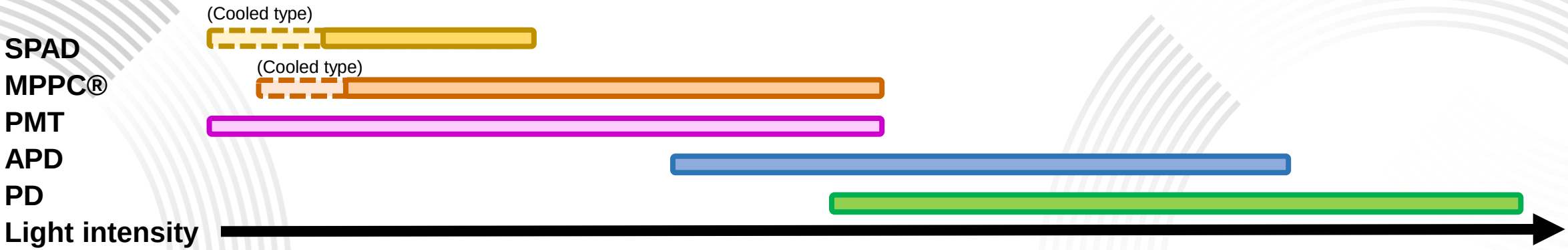
Using APD under a strong electrical field. Operated under a type of uncontrolled state known as Geiger-mode. In this mode, a single photoelectron is multiplied into 1 million electrons.



MPPC

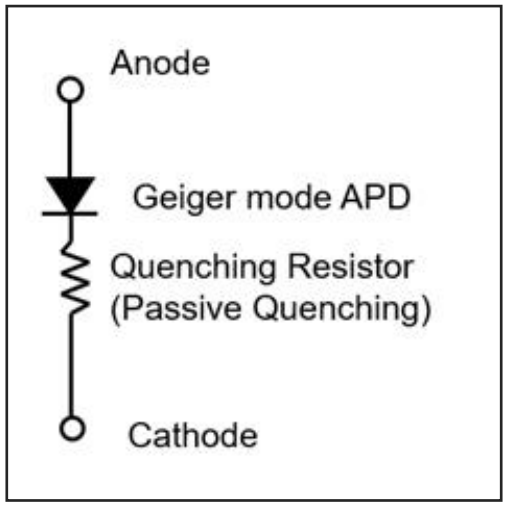
Multi-pixel photon counter*

A device comprised of numerous SPADs connected in parallel.
It can count the number of photons simultaneously.
.

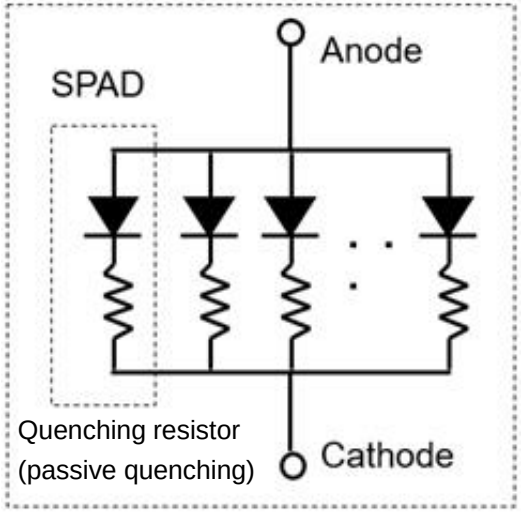


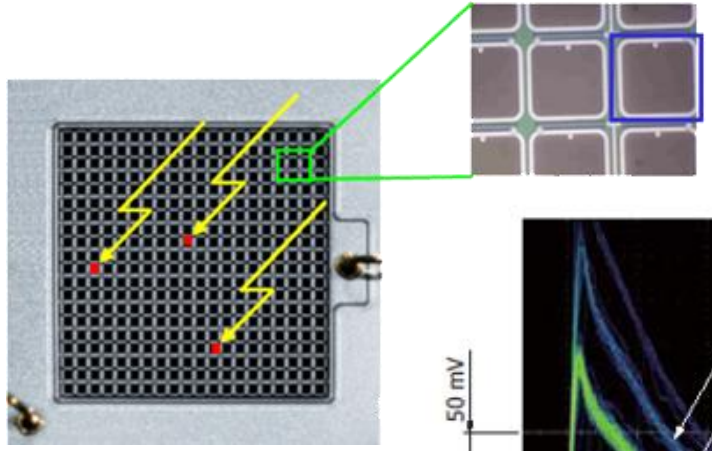
SiPD, APD, SPAD, MPPC®| Technology

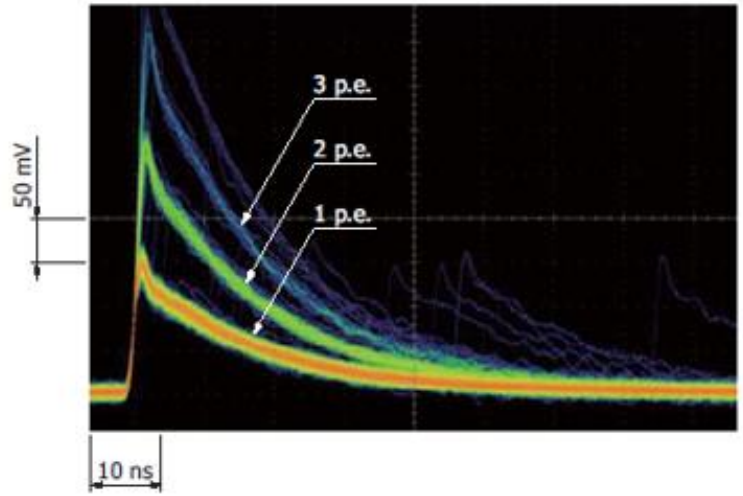
SPAD includes 1 Geiger mode APD and 1 quenching resistor in one output

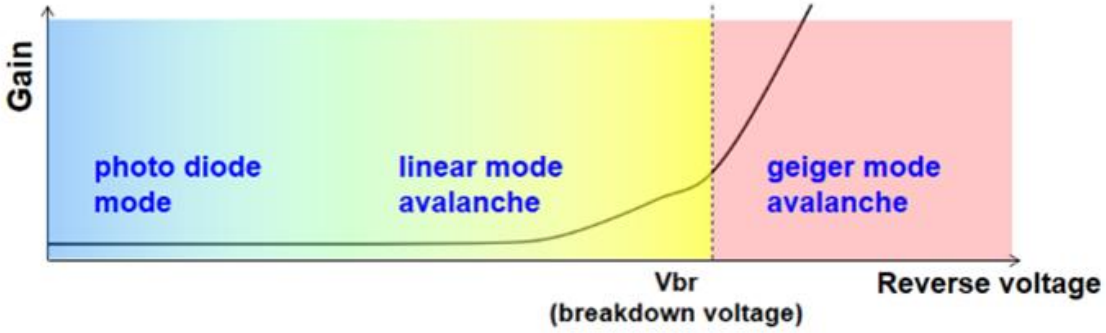


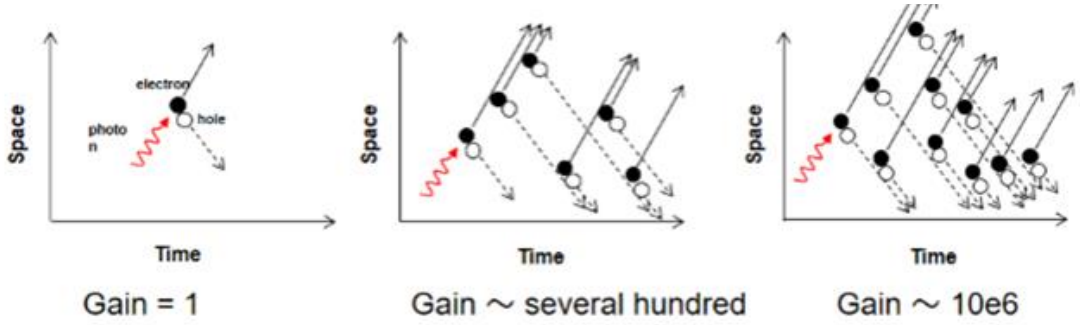
MPPC: multiple SPADs are connected in parallel in one output



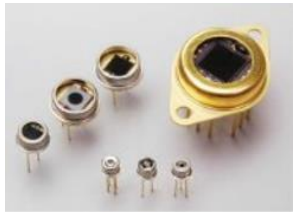




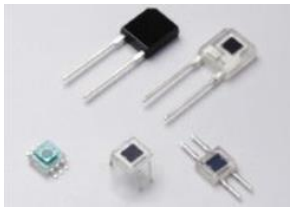


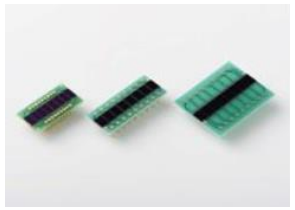


Package examples

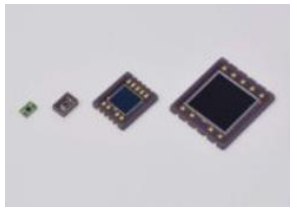

Metal


Ceramic

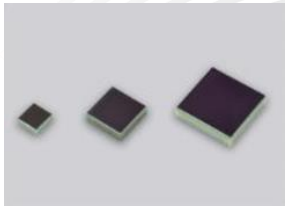

Plastic


Glass epoxy


With BNC connector


Surface mount type

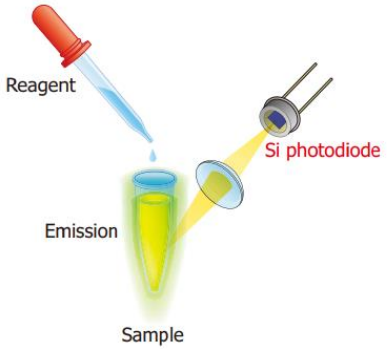

With scintillator


CSP

Measurement wavelength	MPPC		Package options				Module type MPPC module
	Type no.	Channel type	Ceramic	Metal	Surface mount	With flexible cable	
VUV/UV	On demand						
VIS	S14160 series	Single	✗	✗	✓	✓ option	✓
	S14161 series	Multi	✗	✗	✓	✗	✗
	S13360 series	Single	✓	✓	✓	✓	✓
	S13362 series	Single TE-cooled	✗	✓	✗	✗	✓
	S13360 series TSV type	Multi	✗	✗	✓	✗	✗
	S13361 series	Single	✗	✗	✓	✗	✓
VIS to NIR	S14420 series	Single	✗	✓		✗	✓
	S14421 series	Single TE-cooled	✗	✓	✗	✗	✓
NIR	S15639-1325PS	Single	✓	✗	✓	✓option	✗

SiPD, APD, SPAD, MPPC®| Markets & Applications

Si PD

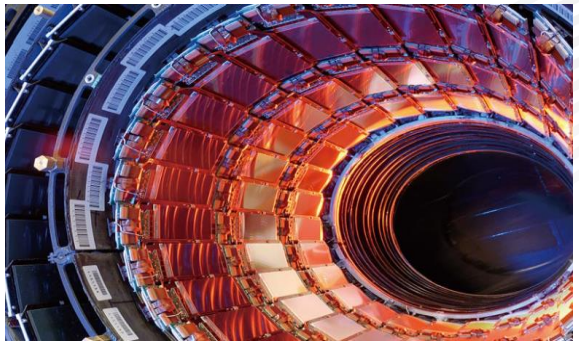


Fluorescence detection

APD

Rangefinder

SPAD, MPPC®



High energy physics

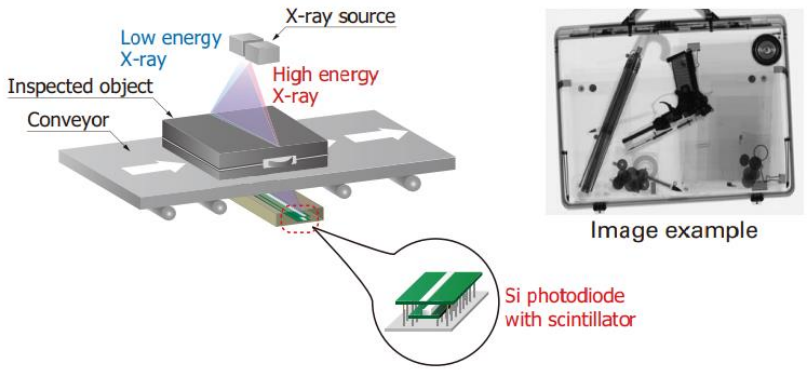


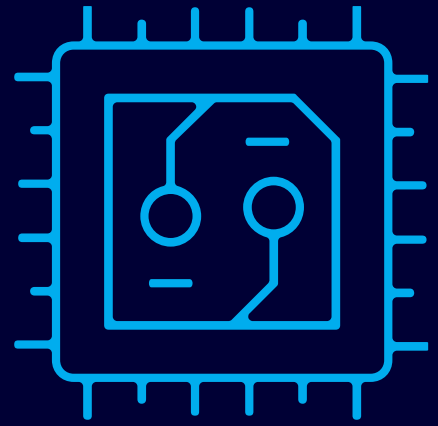
Image example

Baggage inspection

Rangefinder

PET scanner

Image sensors: VIS - NIR



VIS Image sensors | Technology

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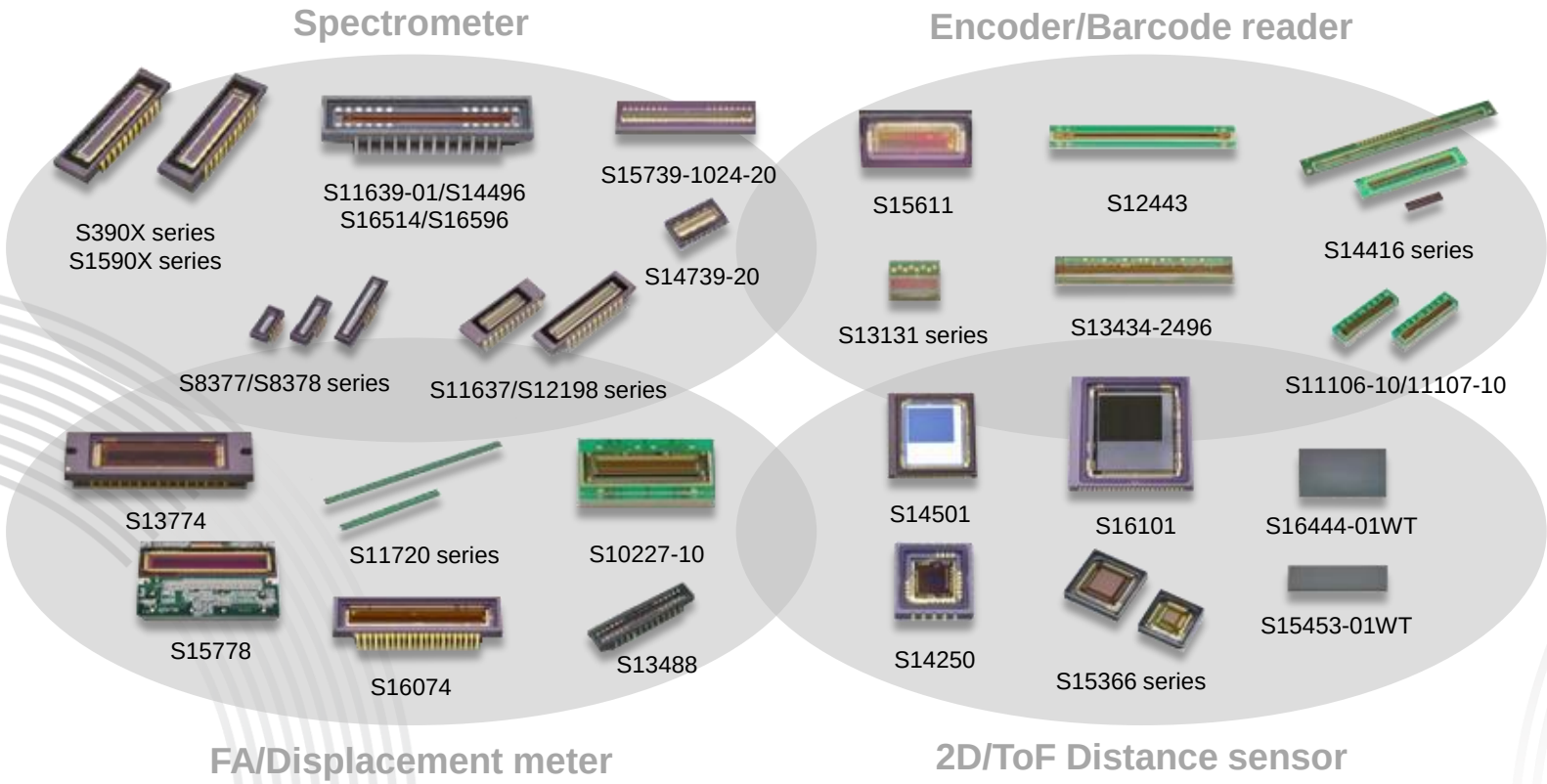
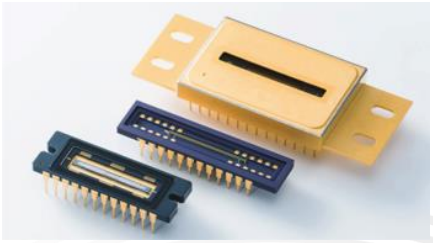
High sensitivity type

- Low noise: 20 e- rms
- High sensitivity in UV to NIR region
- Dynamic range: Middle (5000 times)

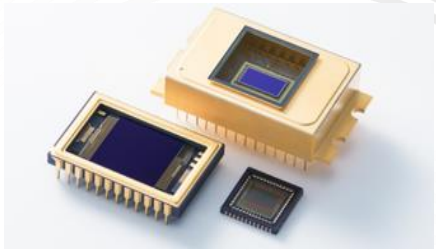
Large Full well capacity type

- Large full well capacity
- Dynamic range: Wide (180000 times)



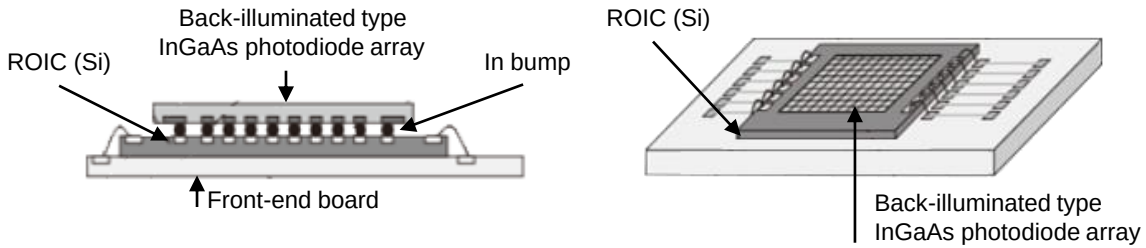


1D line sensors

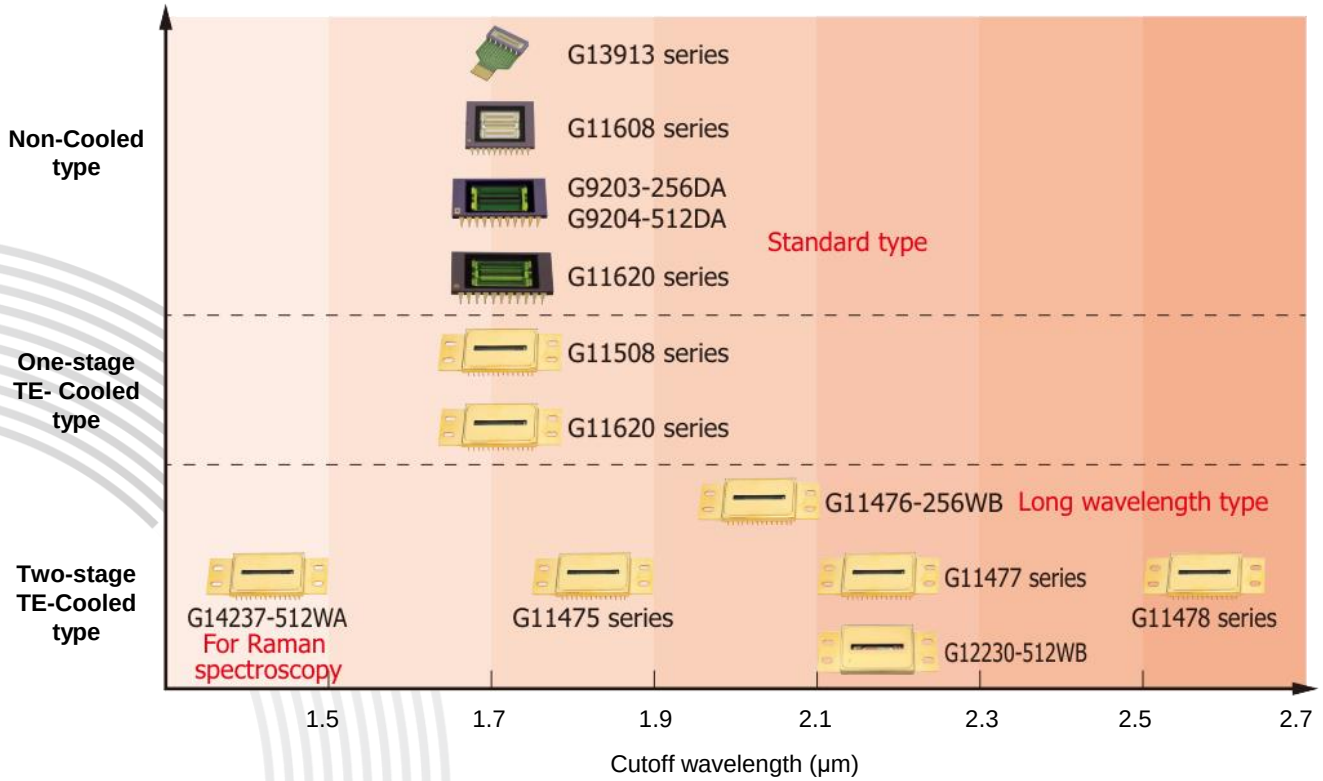


2D area sensors

NIR image sensors | Technology



InGaAs linear sensors for Spectroscopy



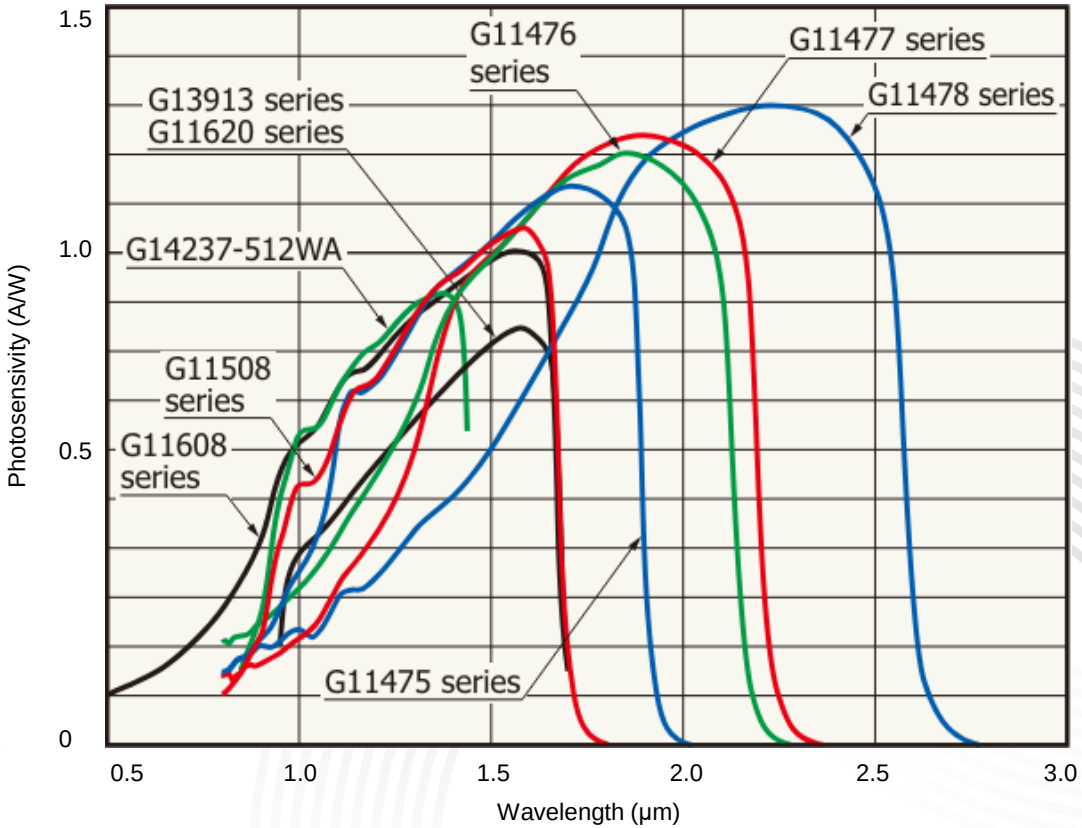


Image sensors | Markets & Applications

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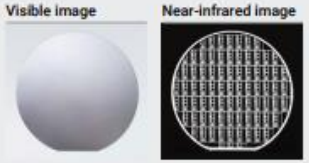
Industry

Food / beverage inspection

Small stones mixed in coffee beans are detected.

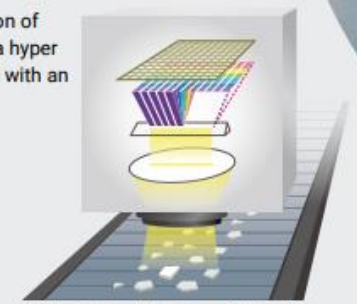
Semiconductor inspection

The pattern formed on the backside of the Si wafer is observed.



Recycle, Raw material inspection

Highly accurate identification of plastic is realizes by using a hyper spectrum camera equipped with an InGaAs image sensor.



Plastic sorting using hyper spectral imaging.

Surface inspection

In-line inspection detects holes and scratches on the surface of the fabric.

UAV / Monitoring system

UAV (Unmanned aerial vehicle)

They are applied for UAV remote sensing for agriculture, forest management, infrastructure inspection.

Monitoring system

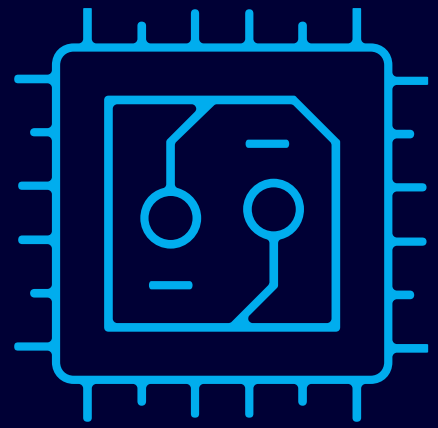
They are used for monitoring system of obstacles and shape recognition for safety and security.

Life science / Medical

Cell observation by electron microscope / Pathological diagnosis

Micron-sized mouse kidney cells are observed under an electron microscope.

MIR detectors



MIR detectors | Technology

P16112-043MF

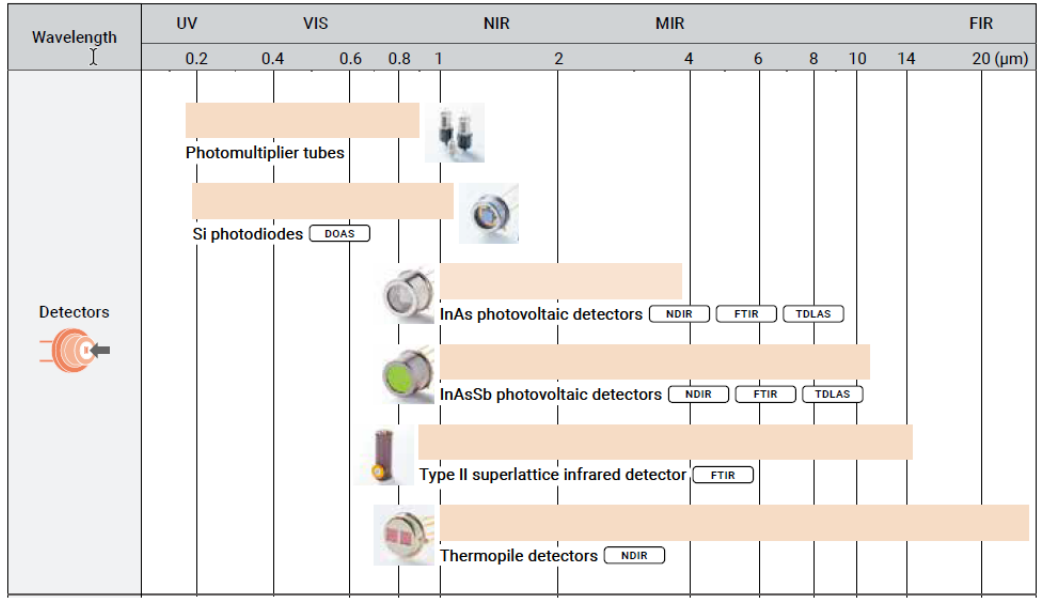
P16612-043CF

P16849-011CF

P15742-046DS

Main features

- Wide wavelength Range up to 11 µm
- Room temperature operation
- Wide linear response
- Limited temperature sensitivity
- Fast response time
- Does not contain any hazardous material



MIR detectors | Applications

Optical gas sensing

Safety

- Explosives: CH4
- Toxic: H2S, CO, CO2

Environment:

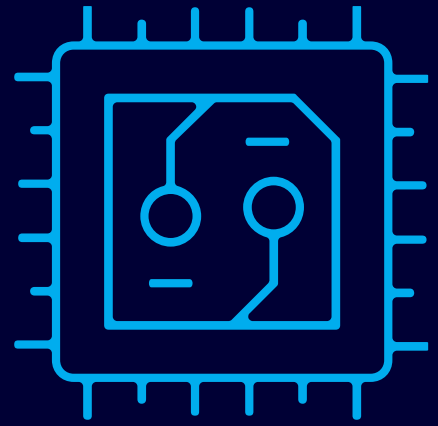
- CO2, NO2, SO2

Medical CO2 monitoring

- Anesthesia
- Reanimation

Remote temperature sensing in industrial environments

Spectrometer heads



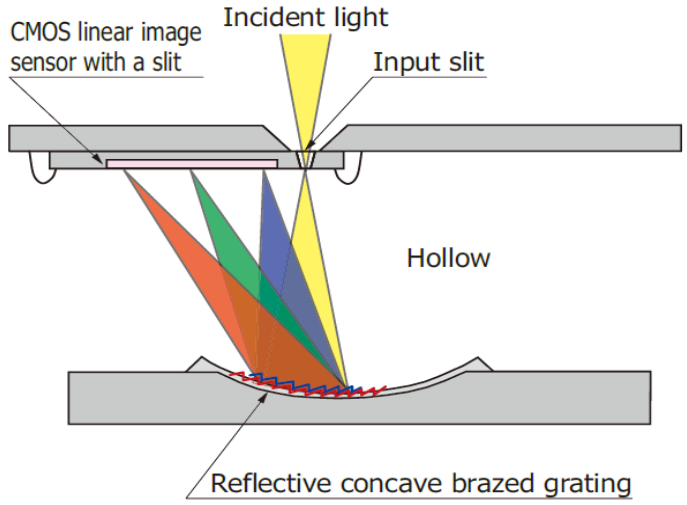
Spectrometer Heads | Technology

Spectrometer Heads

Type no.	Type	Spectral response range (nm)	Spectral resolution typ. (nm)	S/N max.	Internal image sensor	Size (mm)	Photo
C16767MA	For ultraviolet range	NEW 190 to 440	5.5	293 : 1	High sensitivity CMOS linear image sensor	20.1 × 12.5 × 10.1	
C12666MA	Wide dynamic range	340 to 780	12	5300 : 1	CMOS linear image sensor	20.1 × 12.5 × 10.1	
C12880MA	High sensitivity	340 to 850	12	291 : 1	High sensitivity CMOS linear image sensor	20.1 × 12.5 × 10.1	
C11708MA	For near IR	640 to 1050	15	5300 : 1	CMOS linear image sensor	27.6 × 16.8 × 13	
C11009MA	Wide dynamic range	340 to 780	6	5600 : 1	CMOS linear image sensor S8378-256N	28 × 28 × 28	
C11010MA	Wide dynamic range	640 to 1050	6.5	5600 : 1	CMOS linear image sensor	35 × 28 × 20	

Spectral response range (nm): UV, Visible, Near infrared; 200, 400, 600, 800, 1000

Reflective grating



Spectrometer Heads | Applications

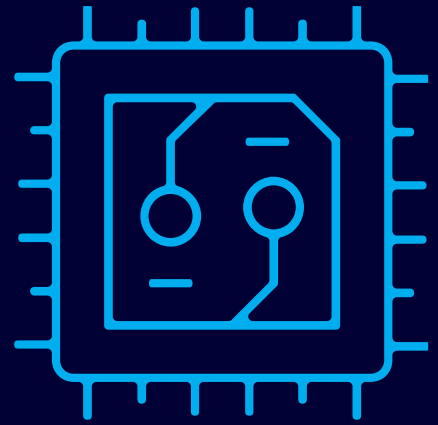
Agriphotonics

Spectroscopy

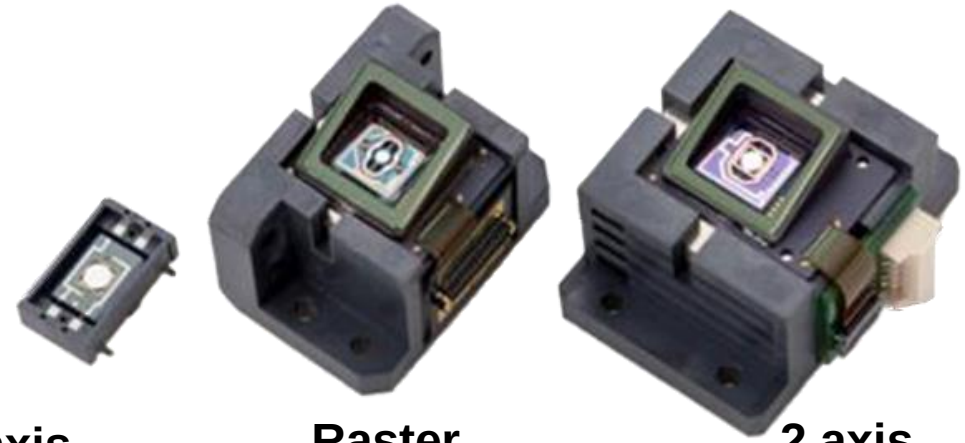
Water analysis

Light manipulation devices

MEMS mirrors & LCOS



MEMS mirrors | Technology



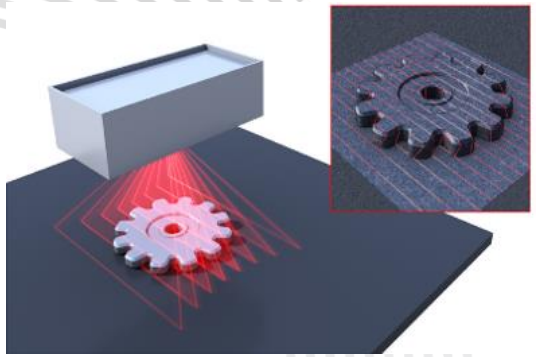
1 axis
linear

Raster
2 axis

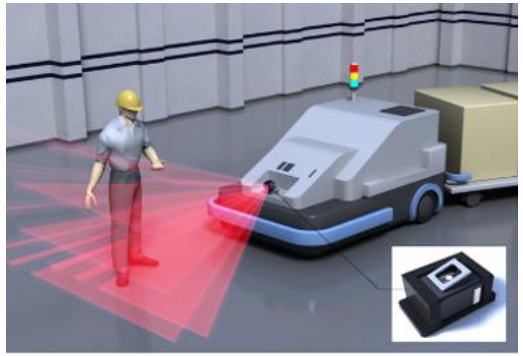
2 axis
linear

Applications

- Machine vision



- Laser ranging



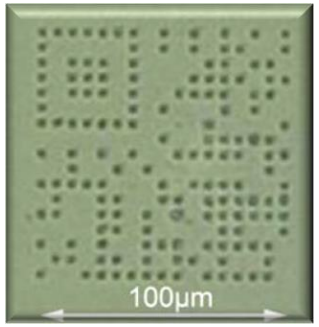
The S13973 is also available, it is a SPL version of the S13124-01 (windowless and with Au coating)

LCOS | Technology

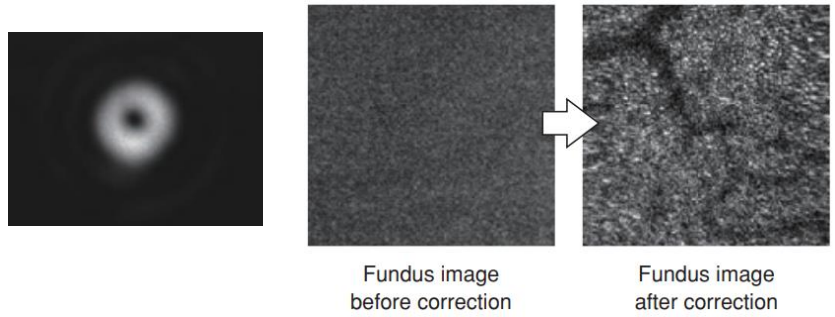
Main features

- Dynamic beam shaping
- Multi-beam or continuous shapes
- Easy software control and integration
- High damage threshold and stability

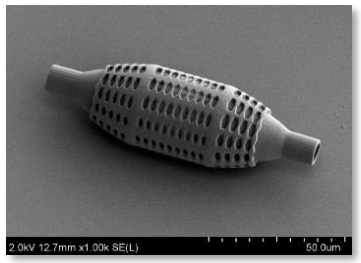
Applications



Marking

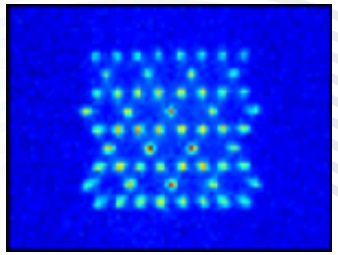


Super-resolution microscopy & Adaptive optics



3D printing by direct laser writing

3D printing by laser powder bed fusion



Cold atom traps for quantum computing

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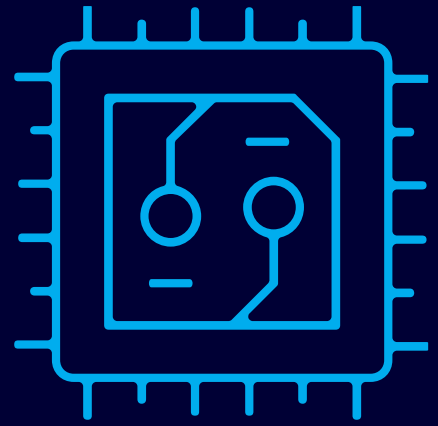
Emitter technology

Lamps



Lamps | Overview

Xenon and Mercury Xenon lamps

High power

Xenon Flash lamps

Long lifetime

Deuterium lamps

High stability

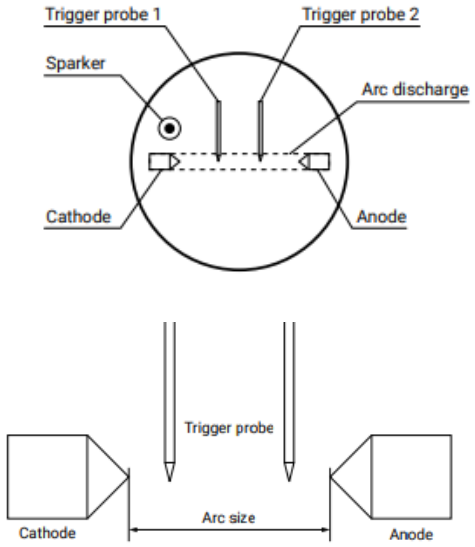
Main features

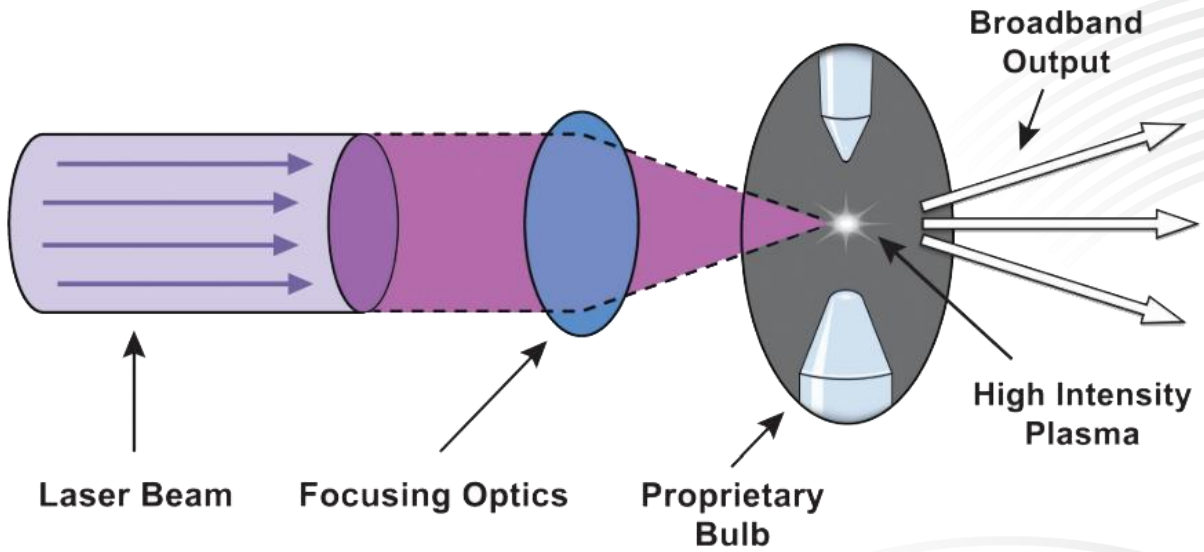
- Broadband emission (UV to NIR)
- Good stability
- High intensity/peak intensity

Applications

- Water analysis
- Chromatography
- Broadband spectroscopy
- Fluorescence measurements

Lamps | Technology evolution to LDLS





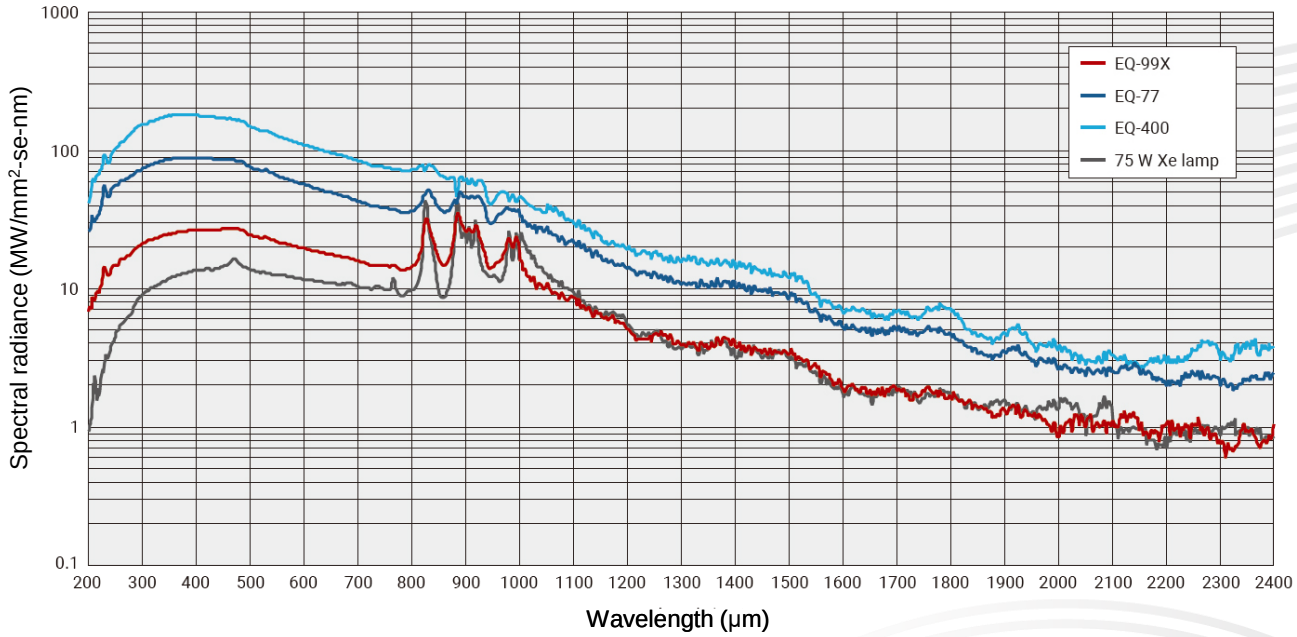
Arc lamps – traditional technology

- Glass tubes filled with special gasses
- They include an anode, a cathode, and a sparker
- High voltage generates an arc discharge

The evolution - Laser-driven light source (LDLS)

- Focused laser beam
- Maintains plasma and contains it within a small area
- Improves stability of the arc

Lamps | LDLS overview

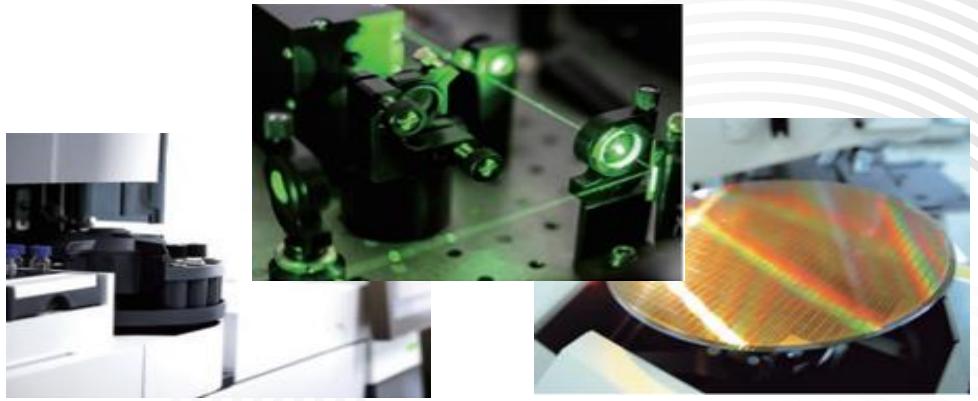


Main features

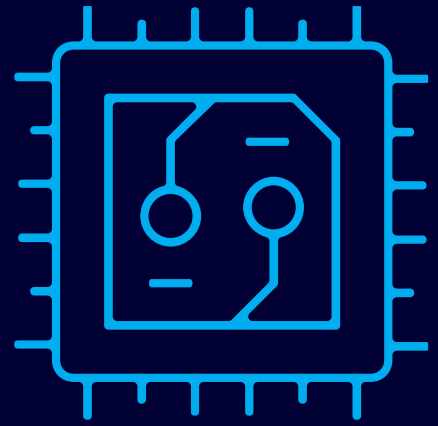
- High Radiance
- High Stability
- Small Point Source

Applications

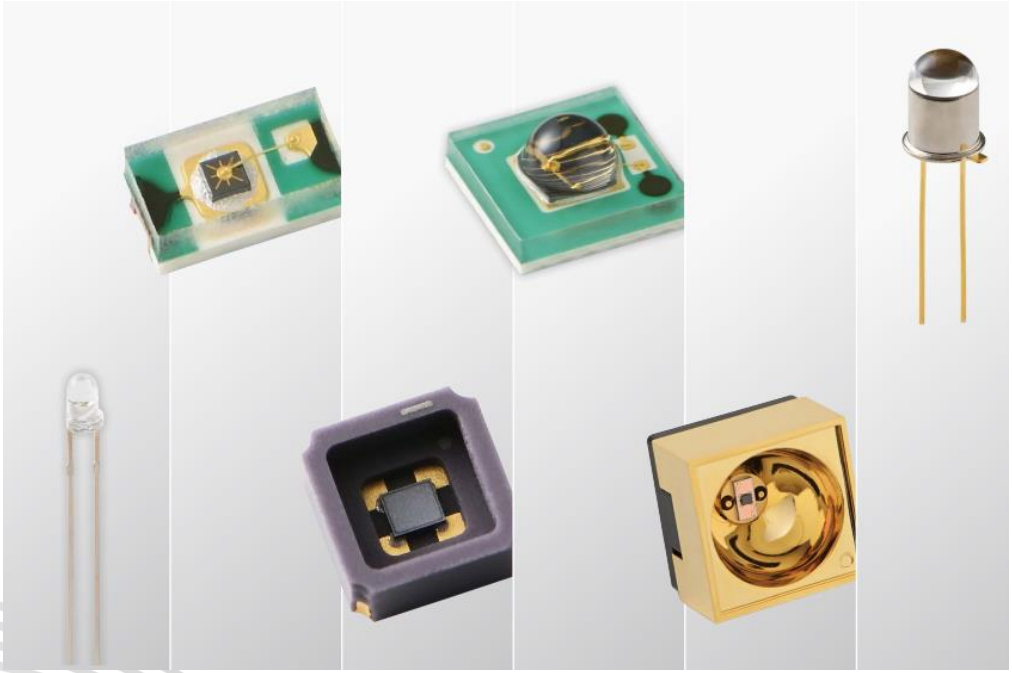
- UV-visible-NIR spectral measurement
- Evaluation of optical products
- Film thickness measurement

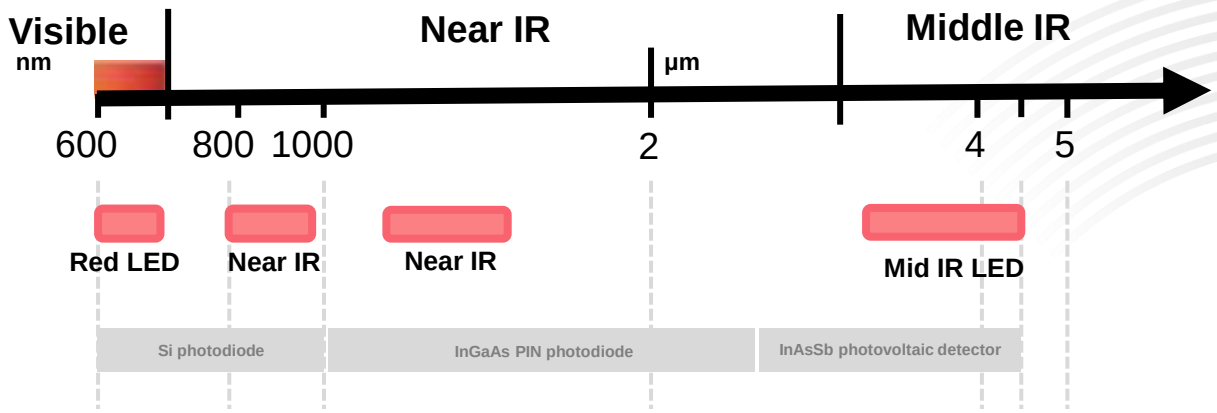


LEDs



LEDs | Overview



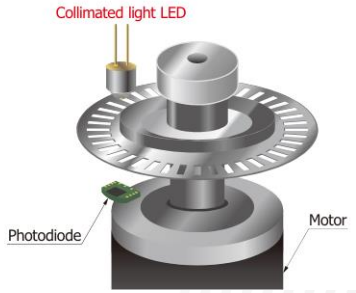


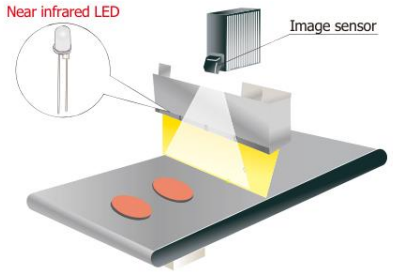
Main features

- Compact
- Low Power Consumption
- Inexpensive

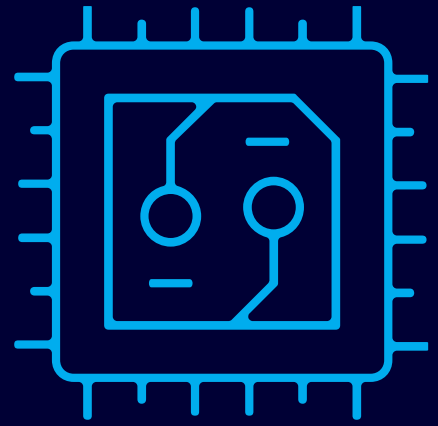
Applications

- Encoders
- Optical communication
- Lighting for infrared cameras





Lasers

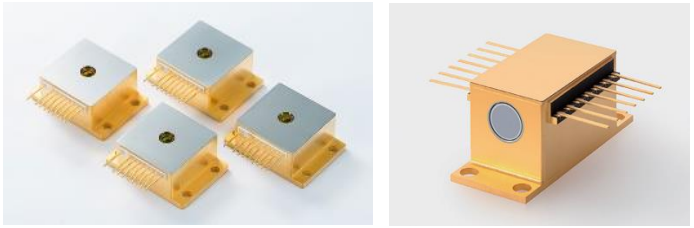


Lasers | Overview

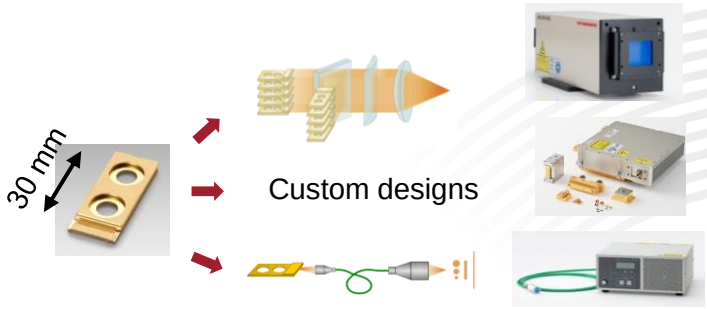
CWLD PLD SLD

Diode Lasers

DFB Tunable



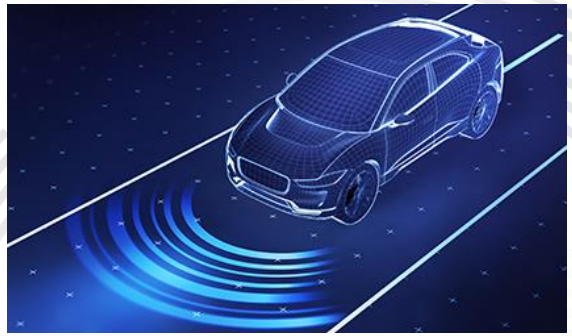
QCL
Quantum cascade lasers



Laser Diode Heaters

Main features
- Compact
- Low power consumption
- Inexpensive

Applications
- Gas analysis
- LiDAR
- Material Processing



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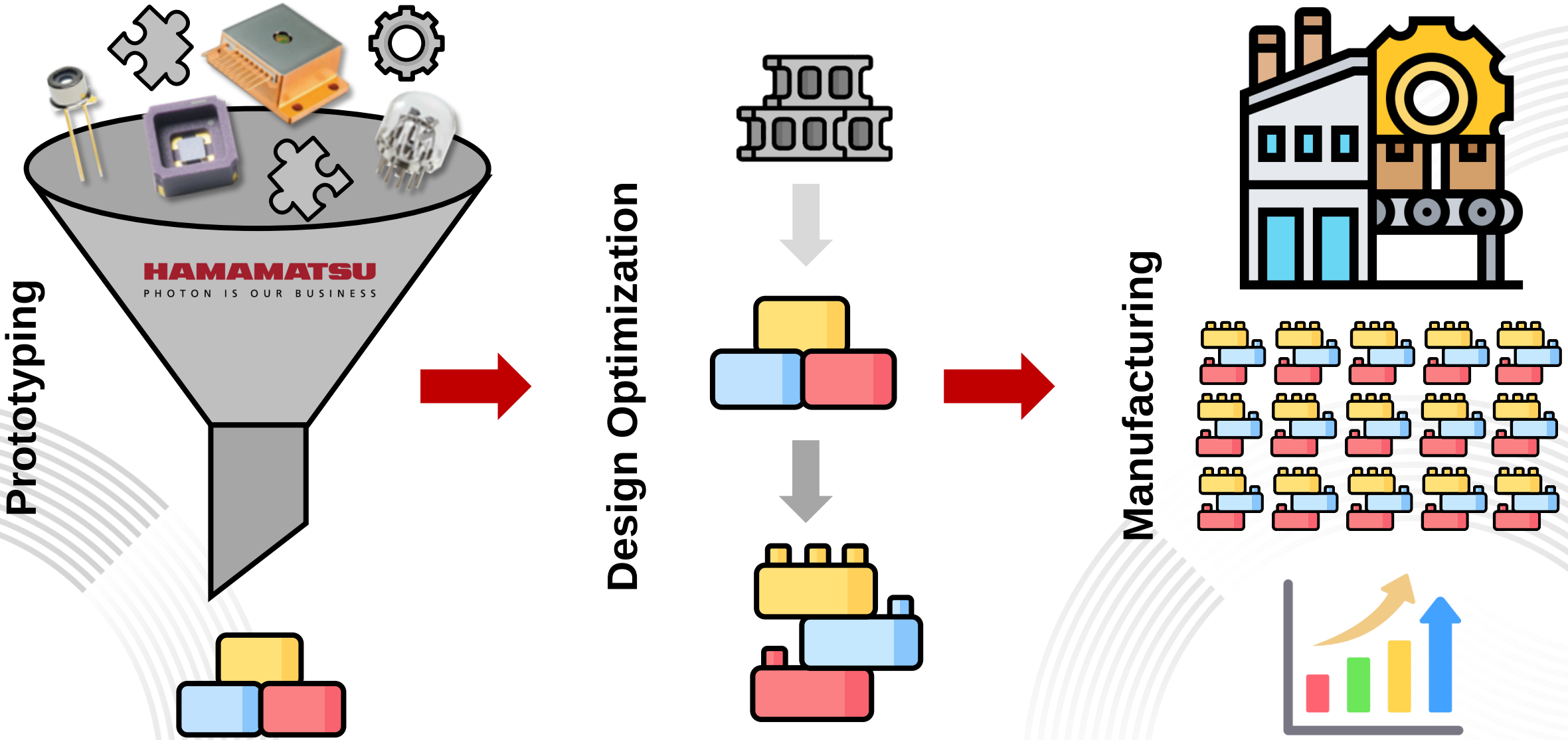
Hamamatsu Photonics

is your partner to product success!

Your partner to product success!



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Thank you!

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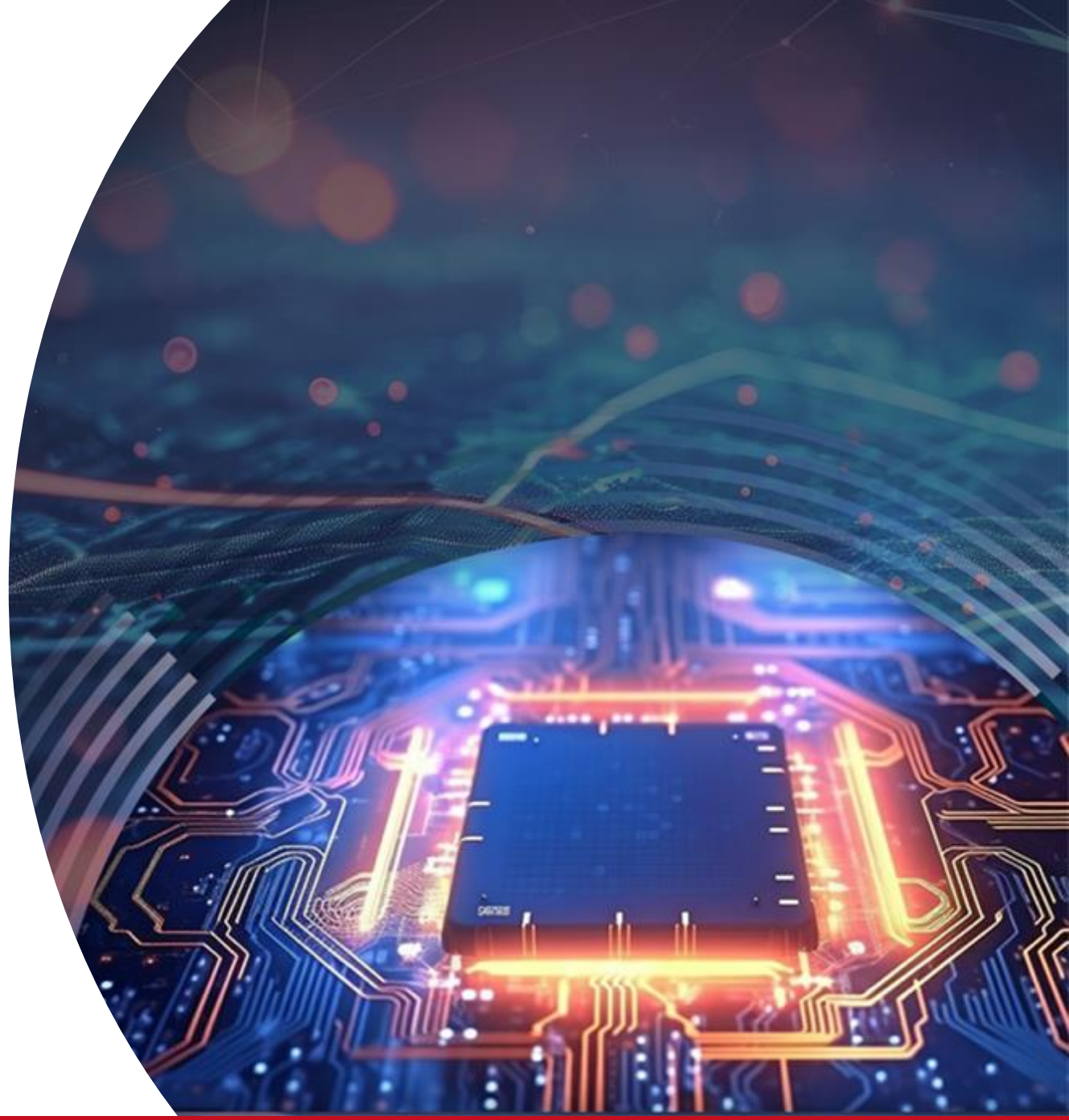
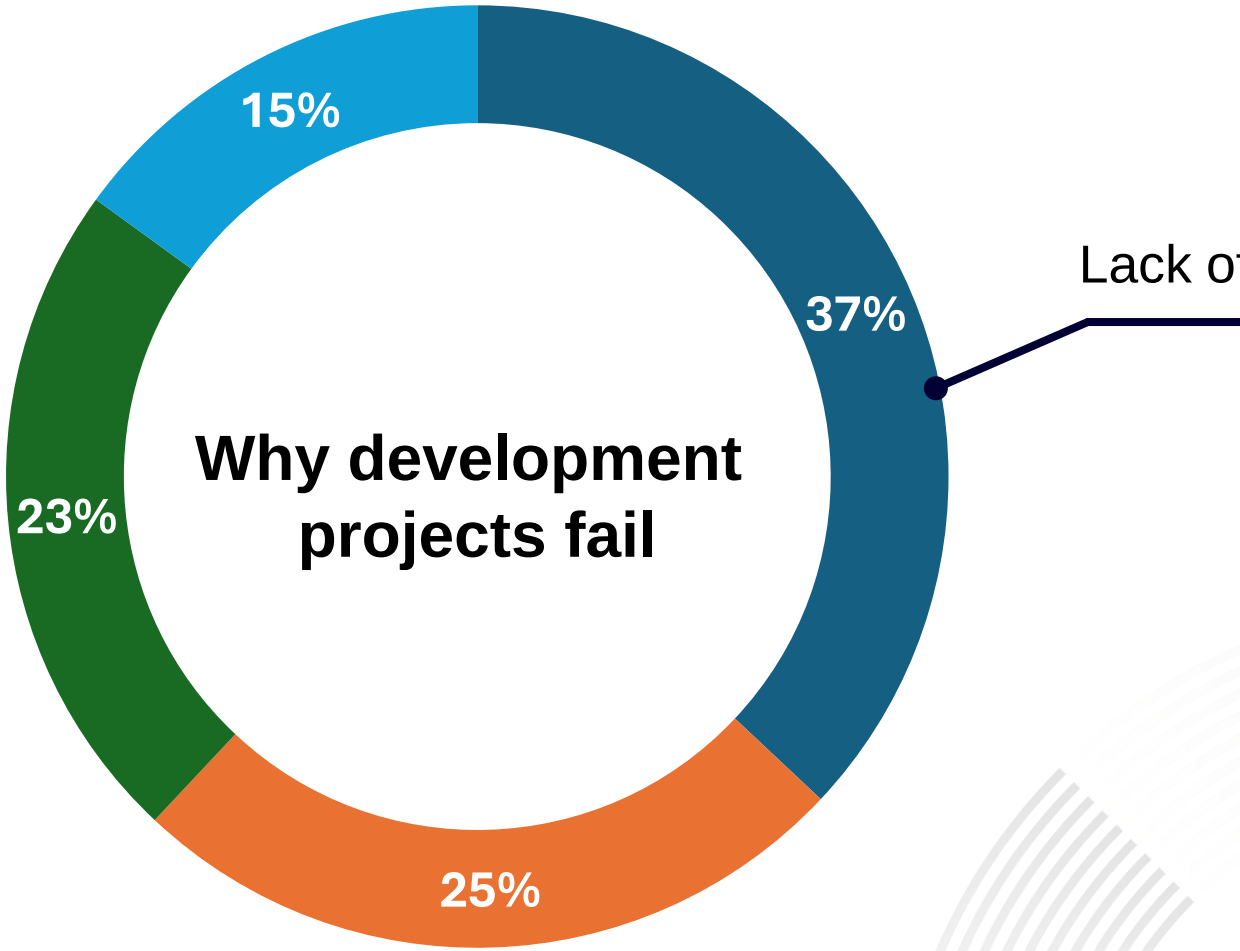


Rapid Design Group

Hamamatsu Photonics Group experts

Rapid Design Group EU

April to June 2024



Source:The Hidden Cost of Project Failure: 70% of Organizations Suffer (Linkedin.com)

Start development projects with manufacturing in mind

Why Hamamatsu Photonics?

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Leading innovation in the photonics industry for decades.

Our expertise covers light sources, detectors and optical components across all wavelength ranges.

Over 15,000 products

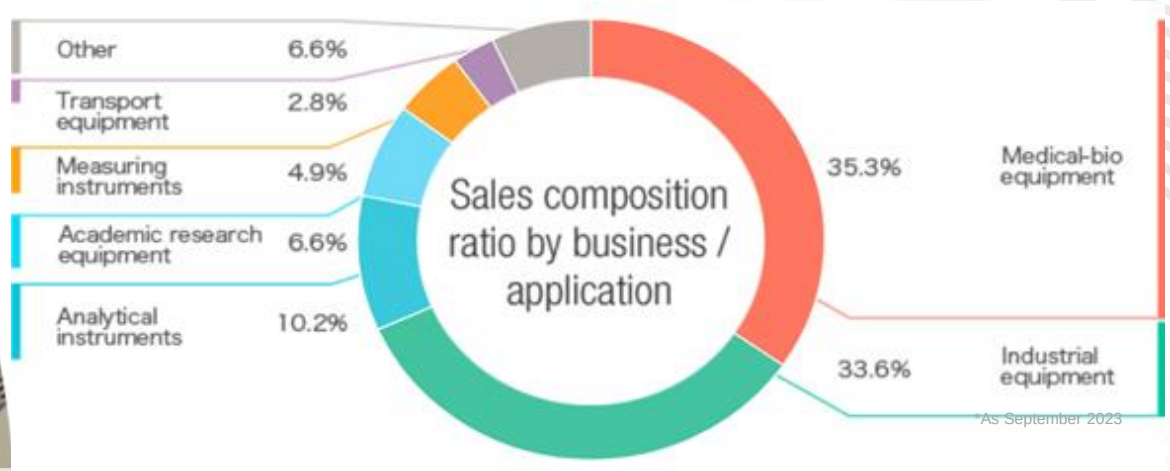
Opto-Semiconductors

Photomultiplier

Light Sources

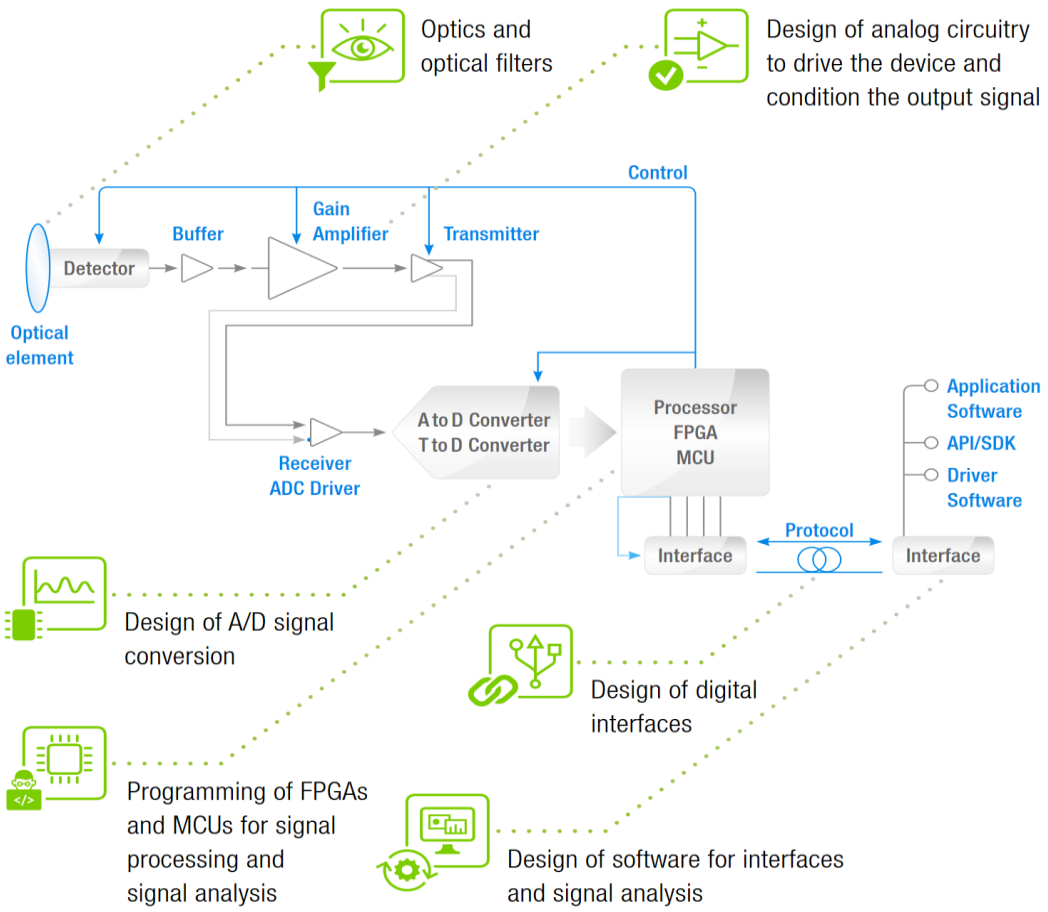
Imaging devices

Imaging and Analyzing Systems



*As September 2023

The expertise of our engineering team



- Analog/Digital circuit
- FPGA/MCU
- Driver/Application SW
- Optical/Thermal/Mechanical Simulation
- Advanced photonics design
- Interface to the R&D in Japan

Module Example 1: Electron Beam Camera

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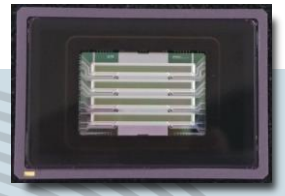
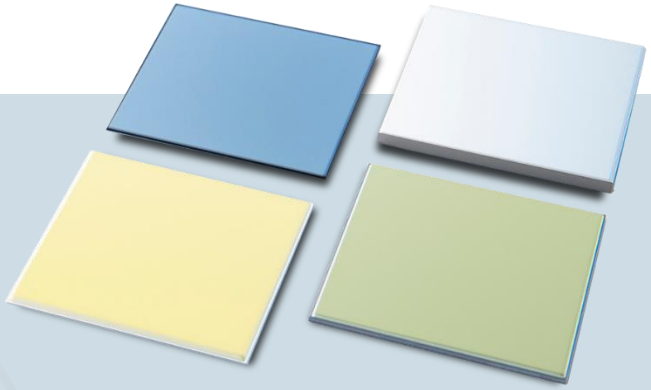
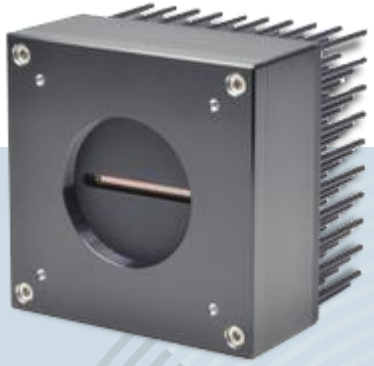
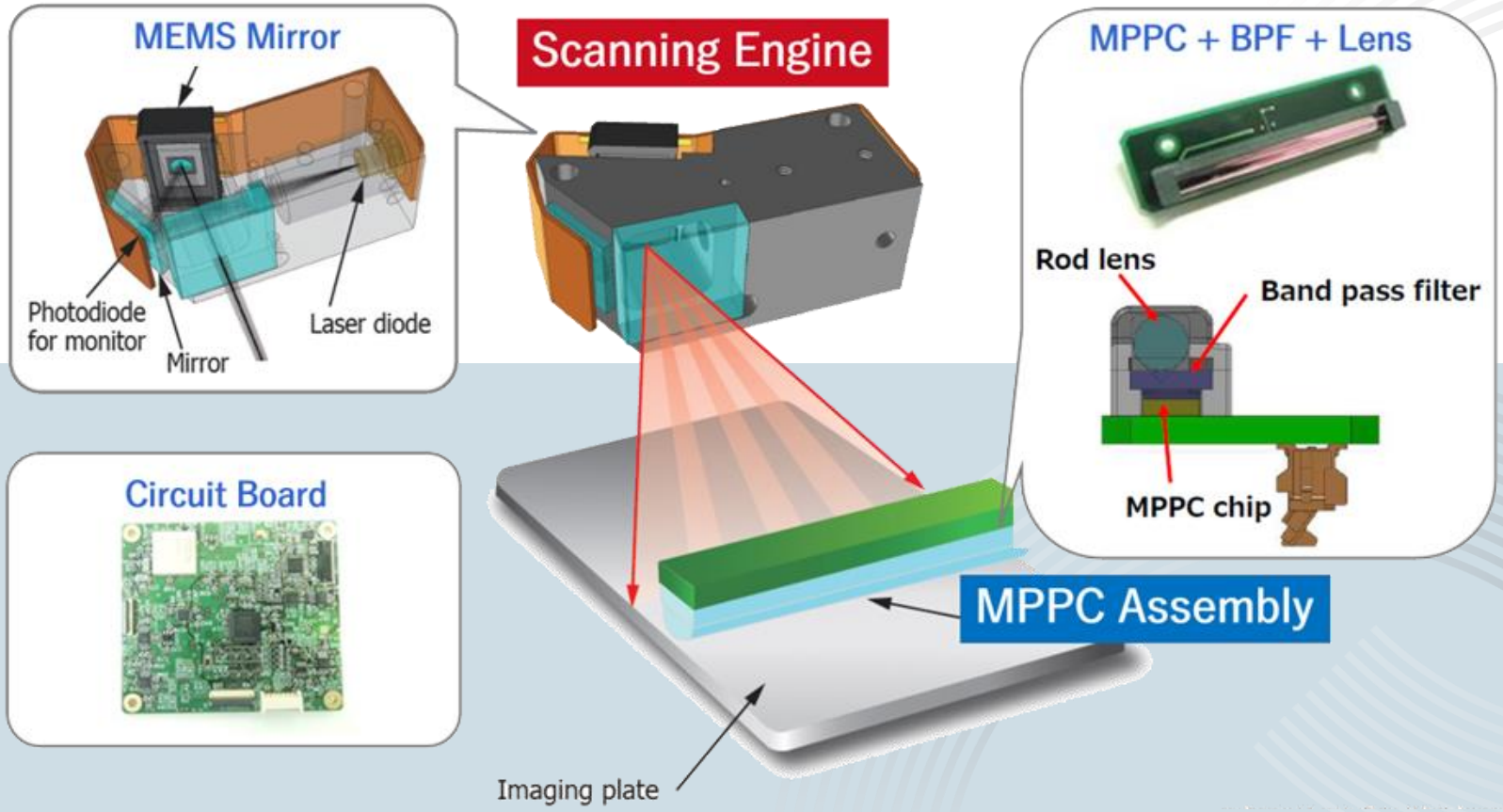
- Custom image sensor
- Optical component (Fiber Optic Plates)
- Scintillator
- TE cooling
- Custom readout circuit
- Custom Interface
- Enclosure



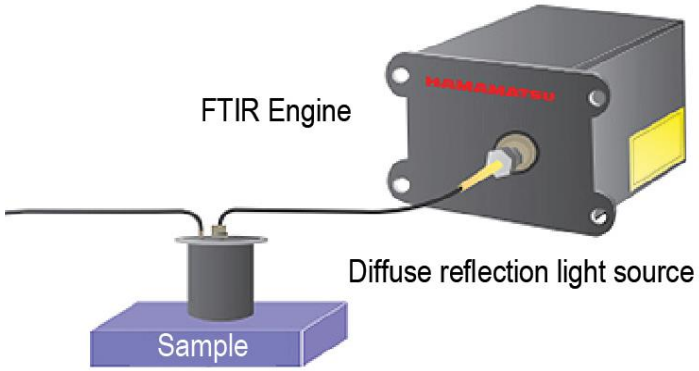

Module Example 2: Imaging Plate Reader

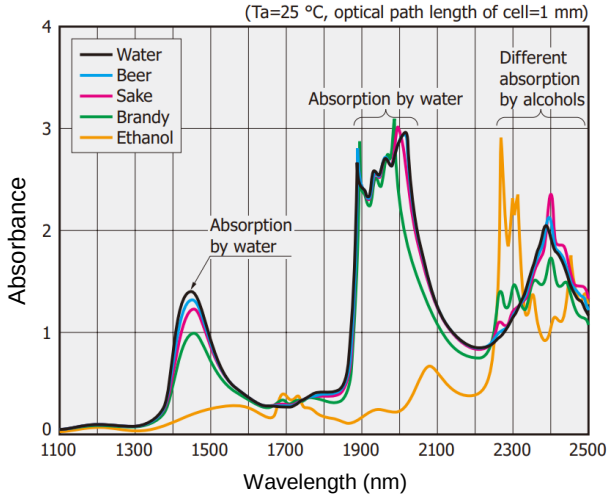
- SiPM (MPPC) sensor 1 x 38 mm with BPF
- MEMS Laser scanner
- Controller board
- Enclosure

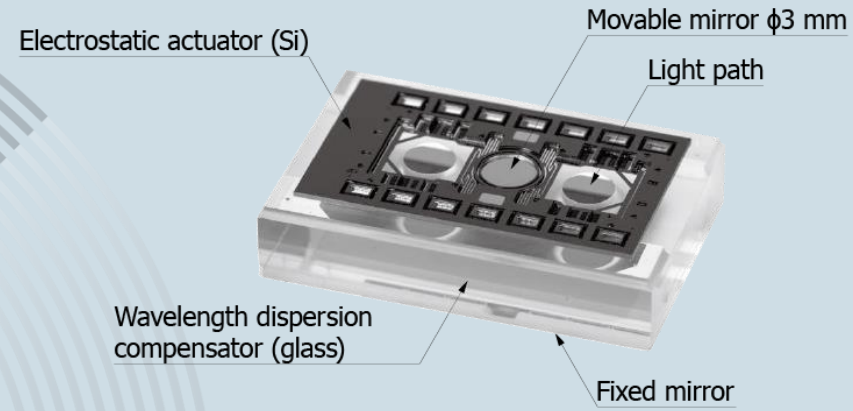


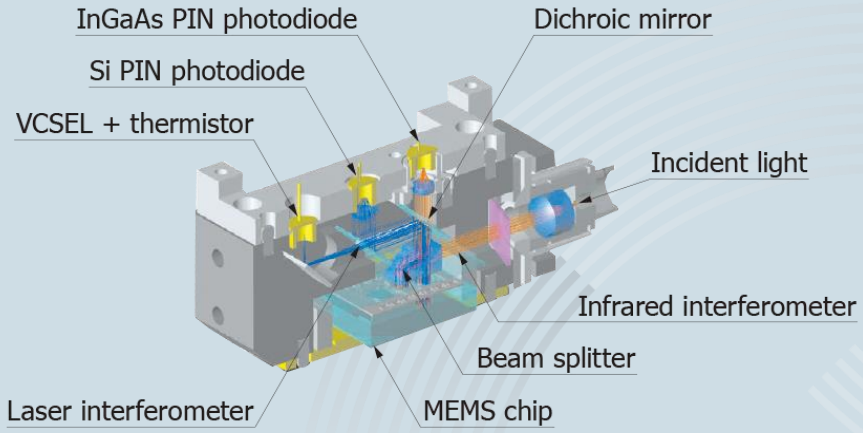
Module Example 3: Fourier-transform infrared spectroscopy engine

- VCSEL (Laser)
- MEMS mirror module
- Si/InGaAs PIN photodiode
- Optics
- GigE Interface









Together Towards Innovation

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Unite for Success

Let’s embark on a journey of innovation, with a shared vision and clear objectives.

Guidance at Every Step

From the initial concept to the final stage of mass production, we’re here to support you.

Achieve Excellence

Let us transform ideas into reality and excel in the market

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Innovation distinguishes between a leader and a follower

Steve Jobs

- Any questions – or a product idea? Contact us!

pilot.line@hamamatsu.eu

or

ndebaes@b-phot.org