HAMAMATSU

PHOTON IS OUR BUSINESS

Light-powered innovation for Smart Agriculture

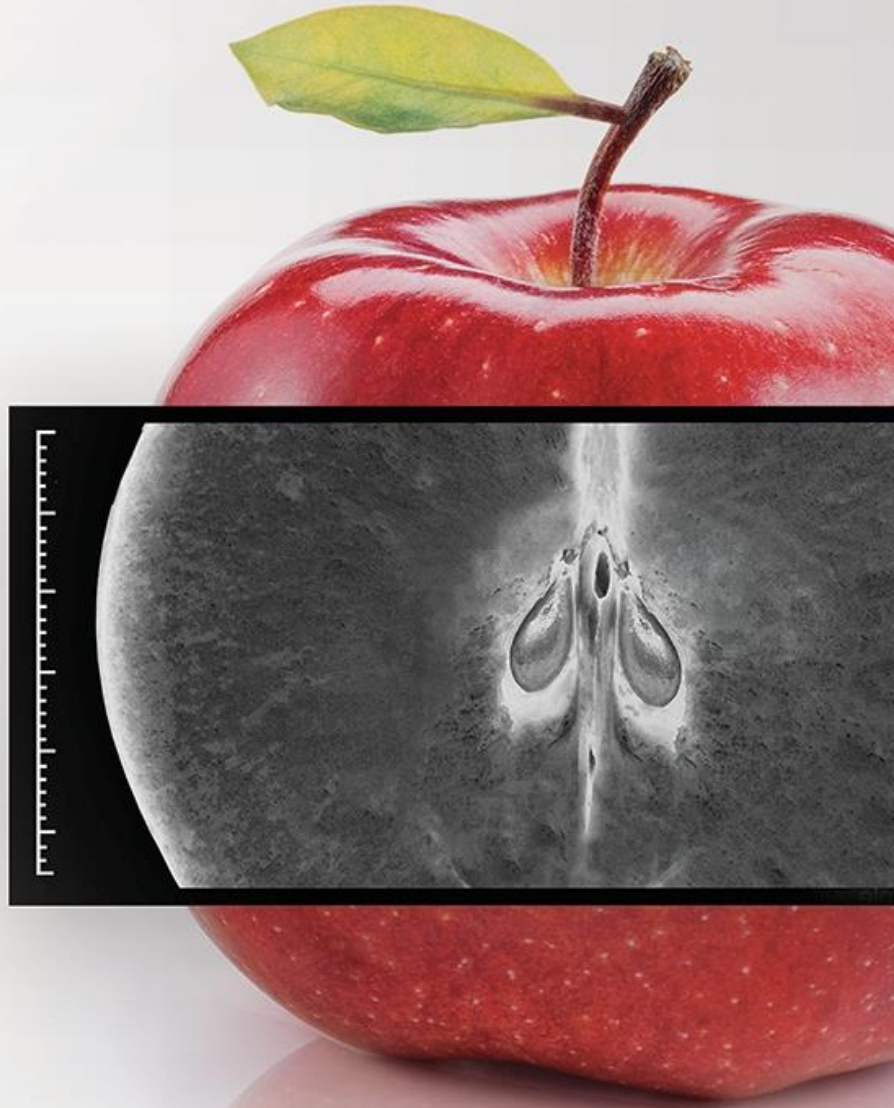
EPIC Technology Meeting

Photonics for AgriFood Industry

Julien Zichi, PhD

Technical Sales Engineer, Hamamatsu Photonics Norden

25 April 2024



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

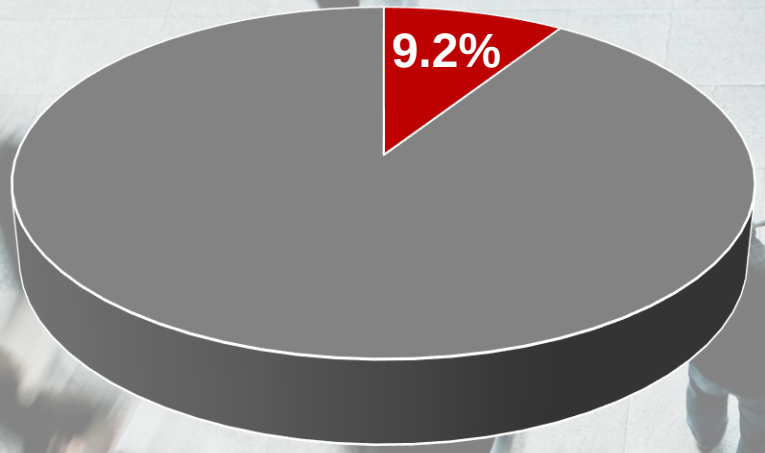
Hamamatsu Photonics: A Driver in the Industry

HAMAMATSU
PHOTON IS OUR BUSINESS

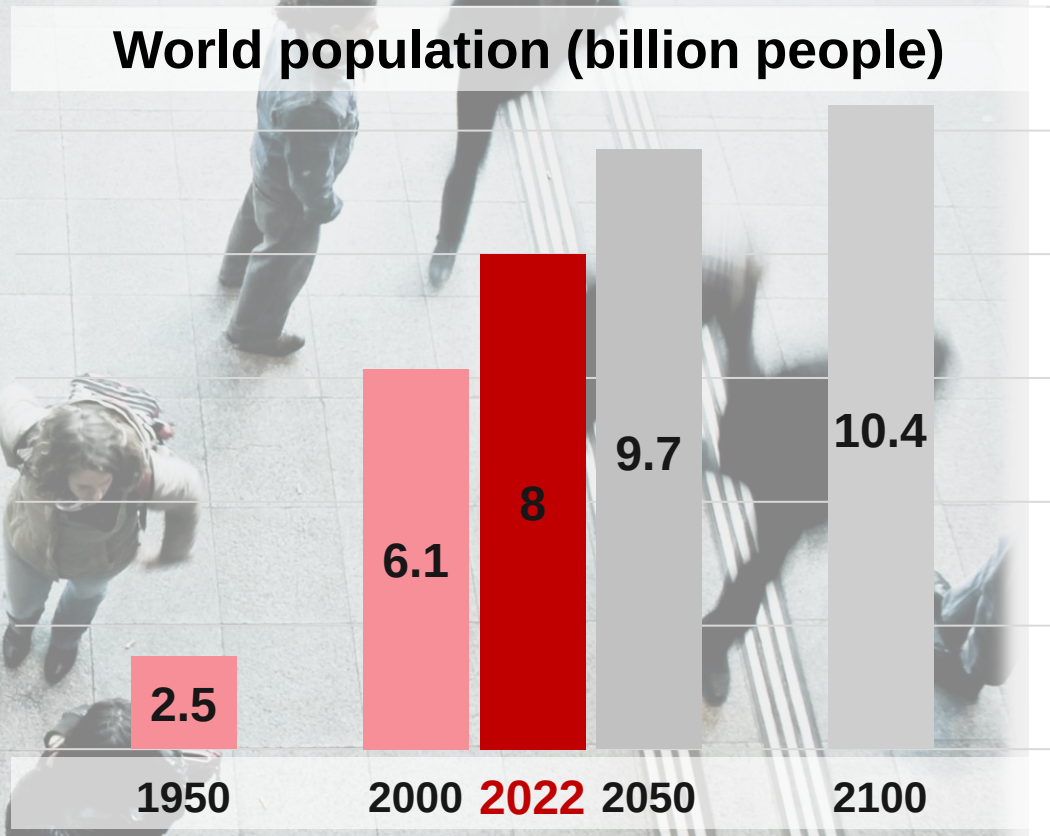
*Figures taken in 2021/2022

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Challenge of Food Quality & Supply



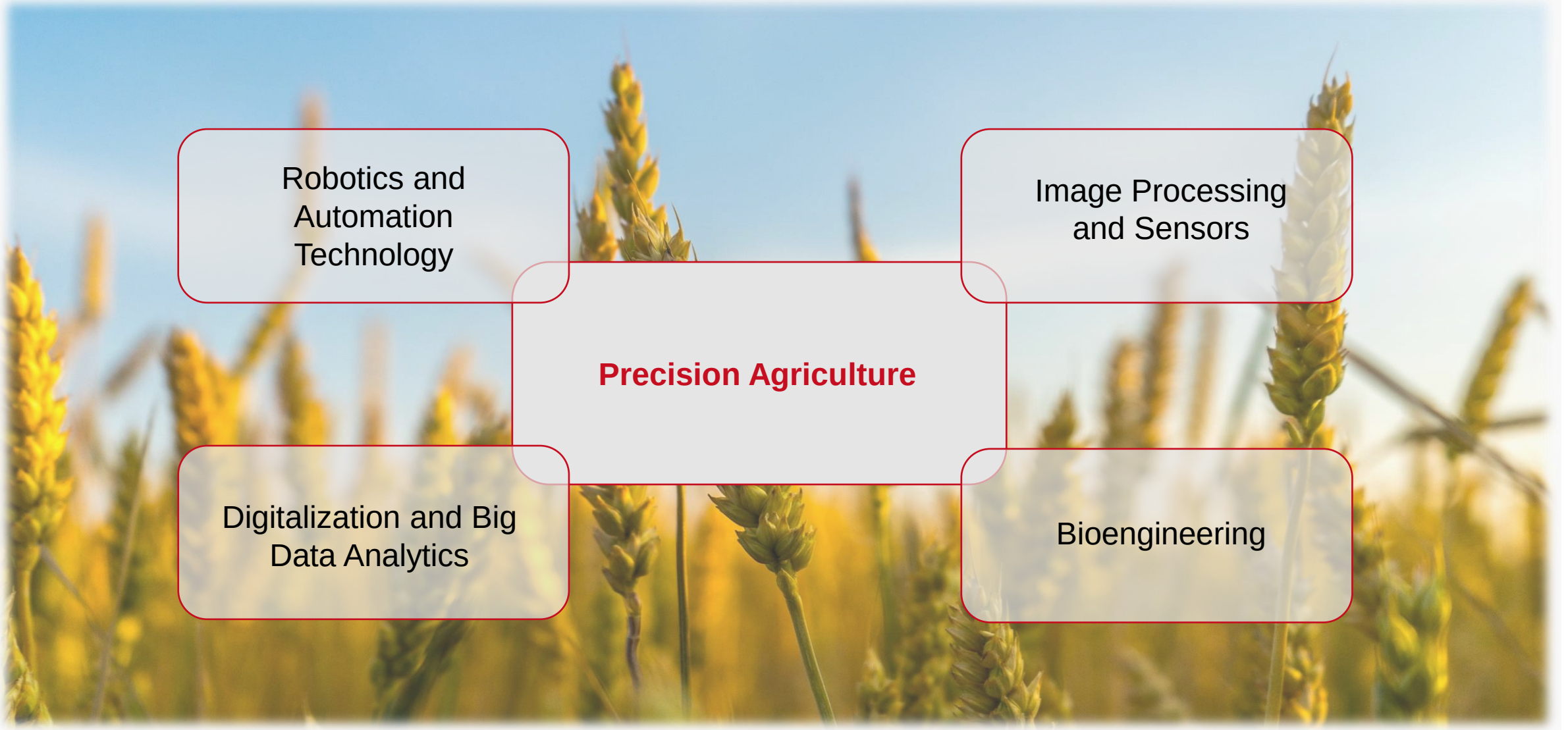
Undernourished world population (FAO, 2022)



Population increase by 30% in 2100

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Addressing Food Supply Quality & Shortage



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

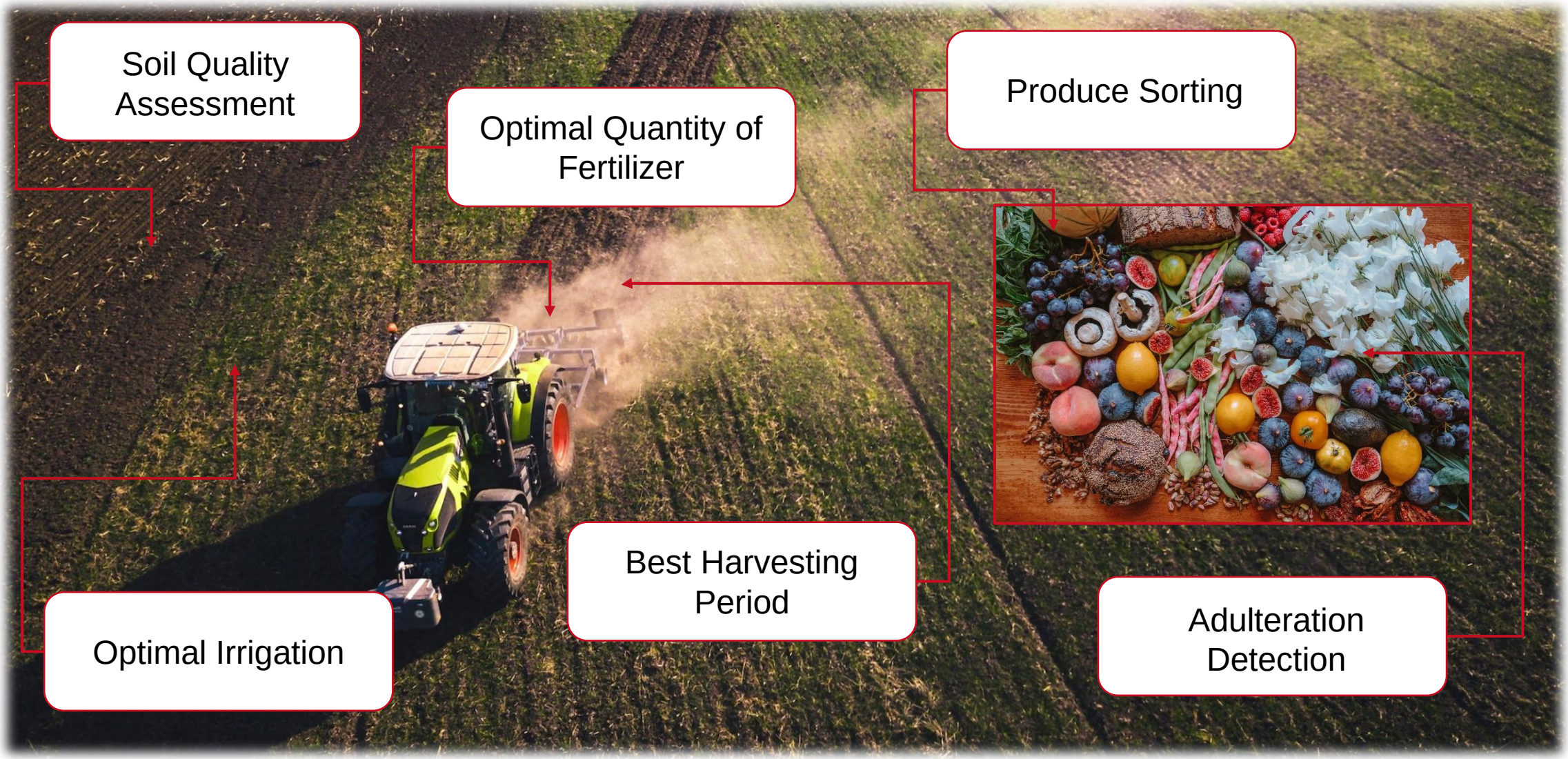
The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Role of Photonics

HAMAMATSU
PHOTON IS OUR BUSINESS



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

HAMAMATSU
PHOTON IS OUR BUSINESS

Spectroscopy

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Miniaturization in Dispersive Spectrometers Trend

HAMAMATSU
PHOTON IS OUR BUSINESS

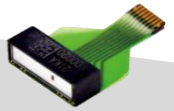
Sampling to decision time

Weeks to days

Hours

Real time

On-site laboratory instrumentation



Off-site laboratory instrumentation

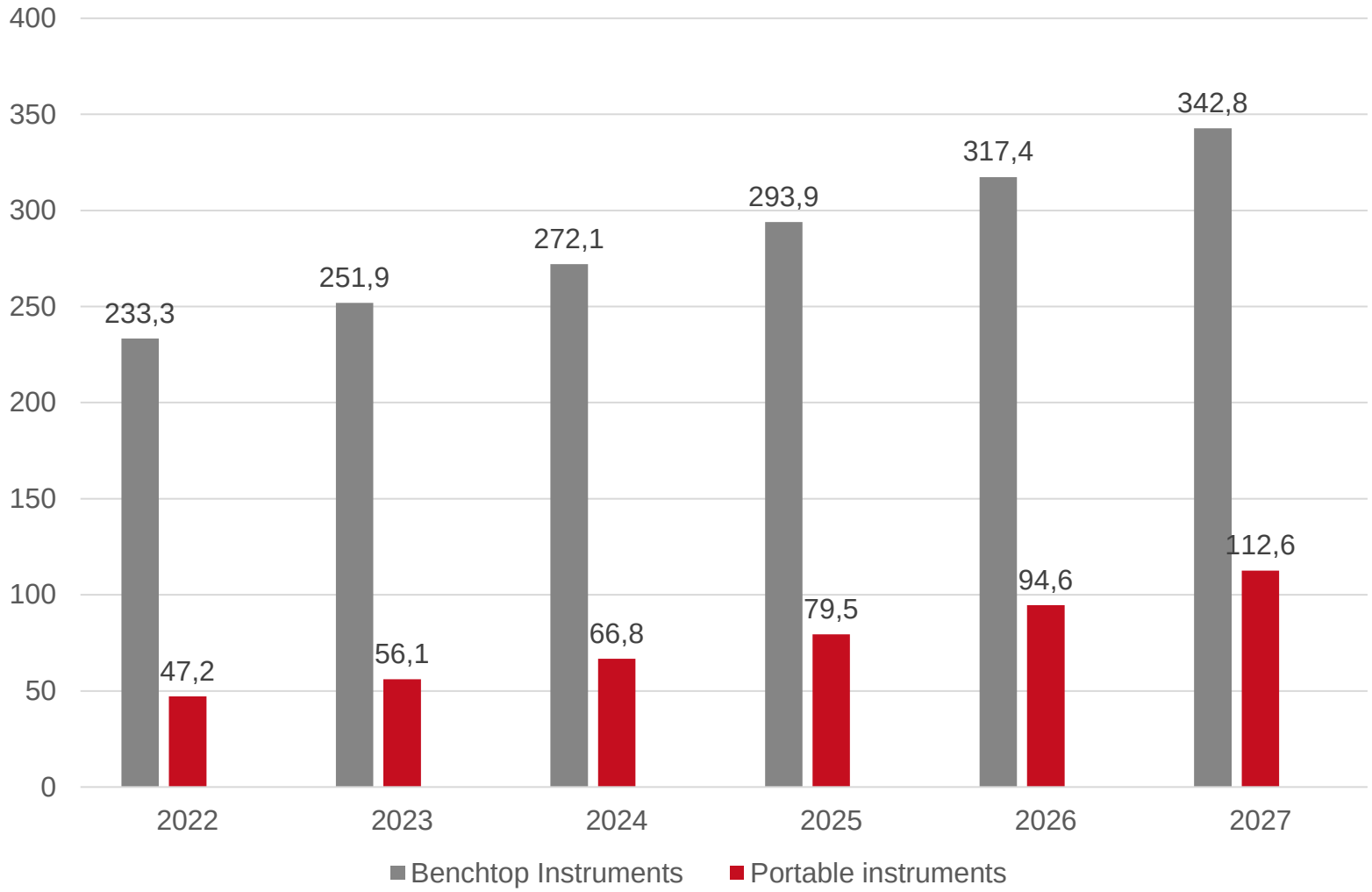
Integration into machinery

Handheld devices

Mobile applications

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Spectroscopy in Precision Agriculture



Benchtop spectrometers market is expected to grow by 8%

The handheld spectrometers market is expected to grow by 19%

Source: Photonic Technologies for Agriculture, Messe Munchen, Tematys and Spectraris, February 2023

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Challenges in Farming

HAMAMATSU
PHOTON IS OUR BUSINESS

Objectives

Optimize production yield

Minimize pollution

Minimize water waste

Solutions

On-field evaluation of crops in all phases of product growth:

- Fertilizer quantity optimization

Optimization of harvest time & fruit-picking automation:

- Produce ripeness by checking content

Monitoring of moisture content / dry matter content:

- Irrigation optimization
- Feed-quality monitoring

Vertical farming

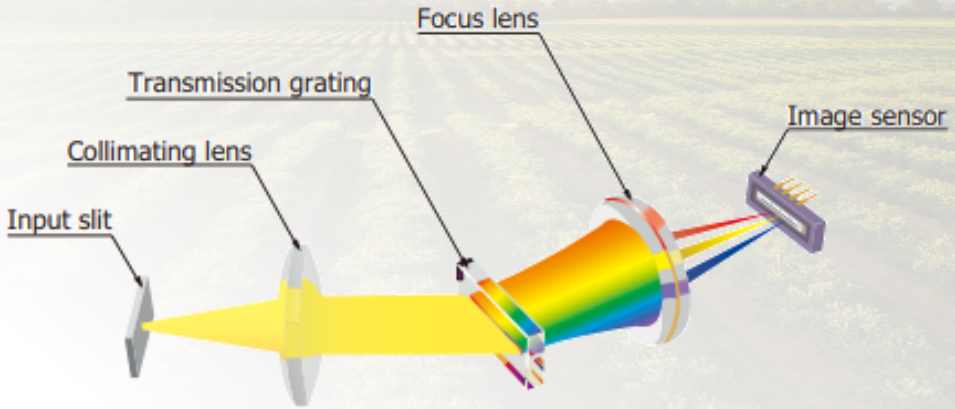
- Spectrum monitoring of growth lamps

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Farming

UV to NIR wavelength range: 200 – 1700 nm

- High sensitivity and wide dynamic range
- Up to 0.3 nm resolution
- No moving parts
- USB powered
- Dedicated control/readout software



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Farming

Compact spectrometer heads

- UV-VIS-NIR wavelength range: 190 - 1050 nm
- High sensitivity and wide dynamic range
- Up to 12 nm resolution
- Compact design
- No moving parts

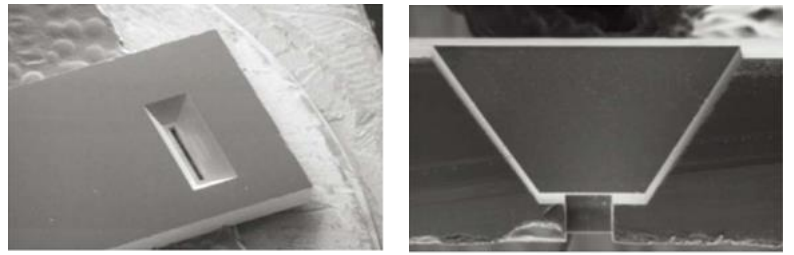
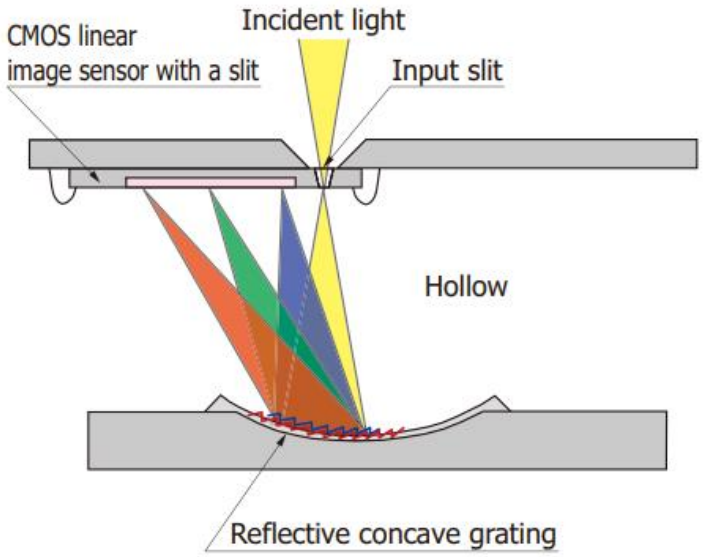
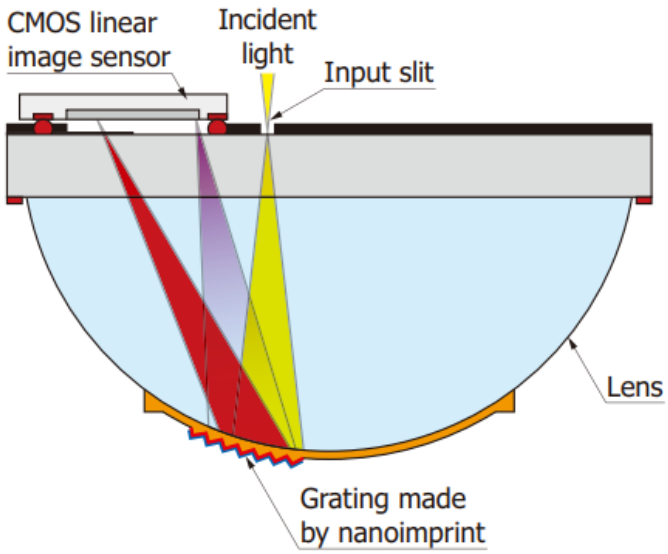
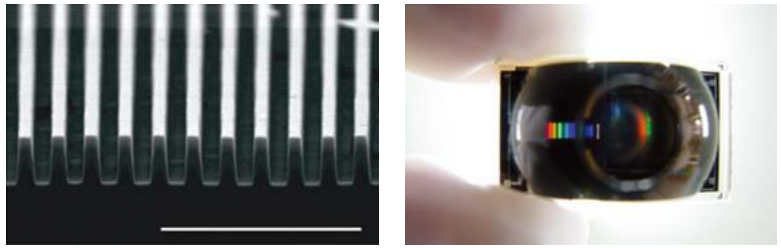


Image sensor with a through-hole slit







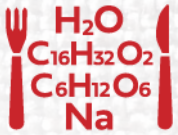
Grating that uses nanoimprint

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Challenges in Food Quality Assessment

HAMAMATSU
PHOTON IS OUR BUSINESS

Objectives



Food nutrition quality measurement (including during production)

Prevention of alduteration

Estimation of alcohol type & concentration

Solutions

Food content measurement:

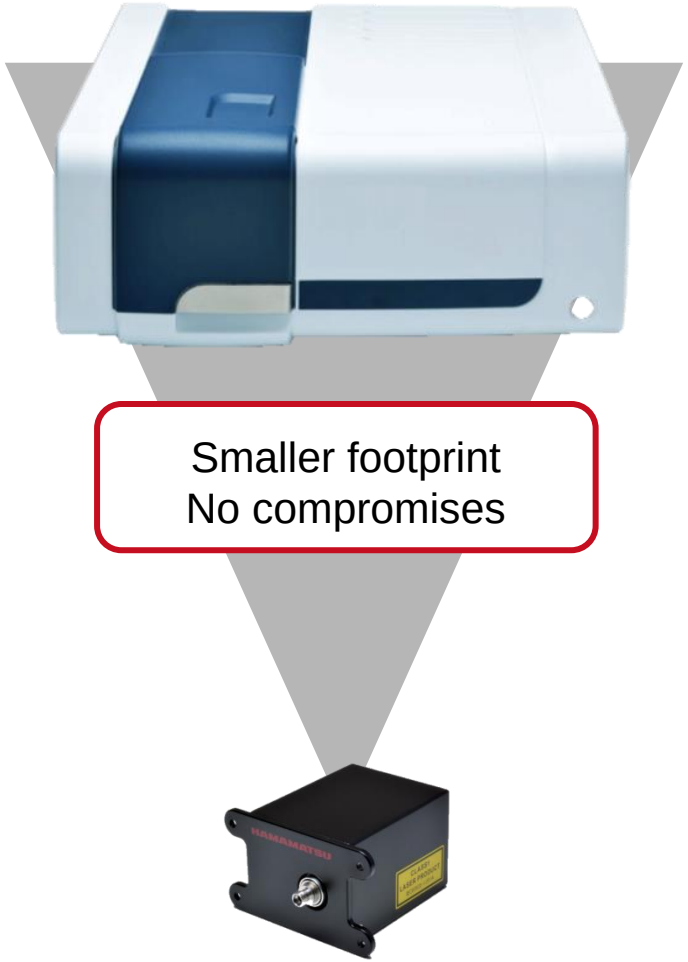
- Moisture/Water
- Lipids
- Carbohydrates
- Protein (Gluten, Lactose)

Fraud prevention:

- Olive Oil
- Wine
- Coffee
- Honey

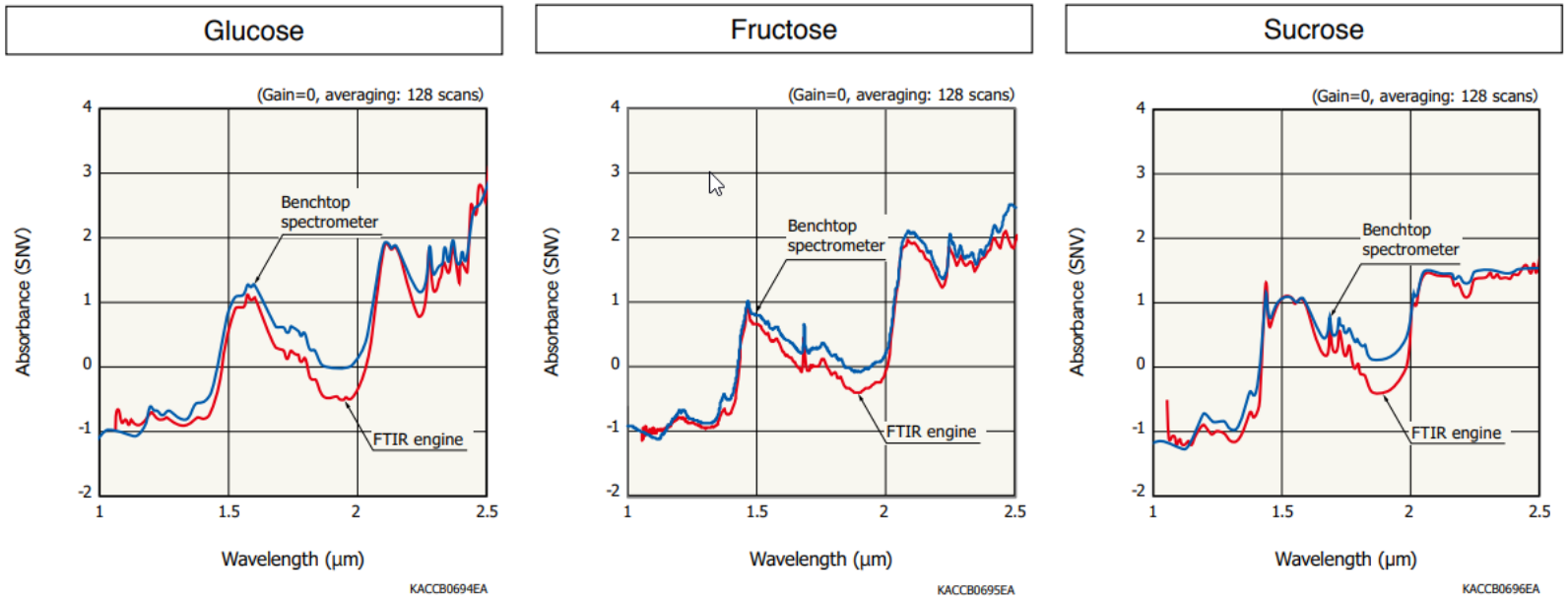
© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Miniaturization in FTIR Spectrometers Trend



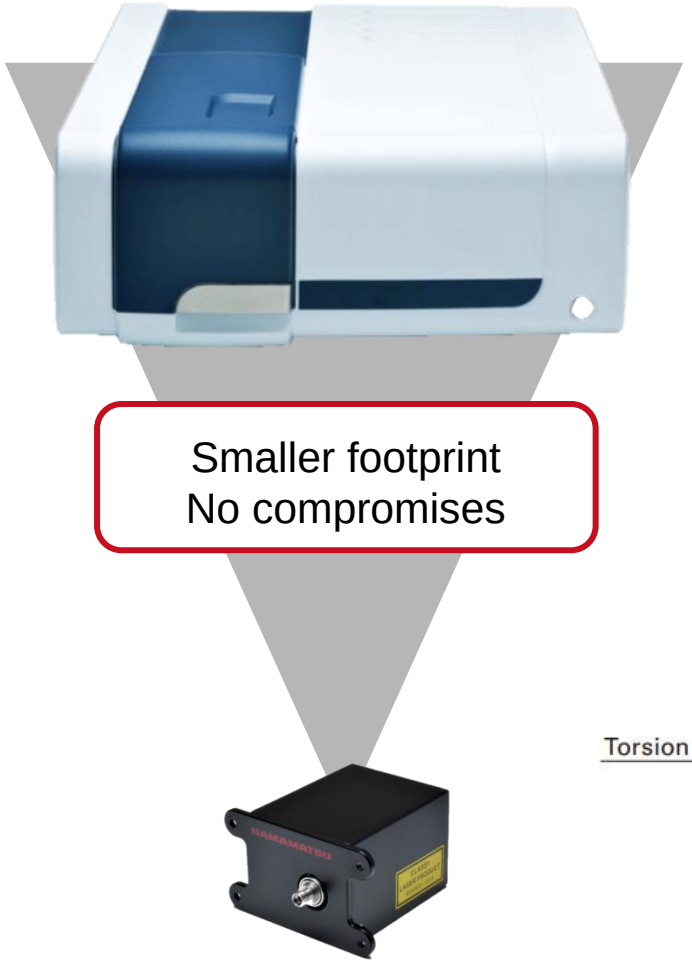
Smaller footprint
No compromises

■ **Comparison of absorbance spectra of powder sugar samples**

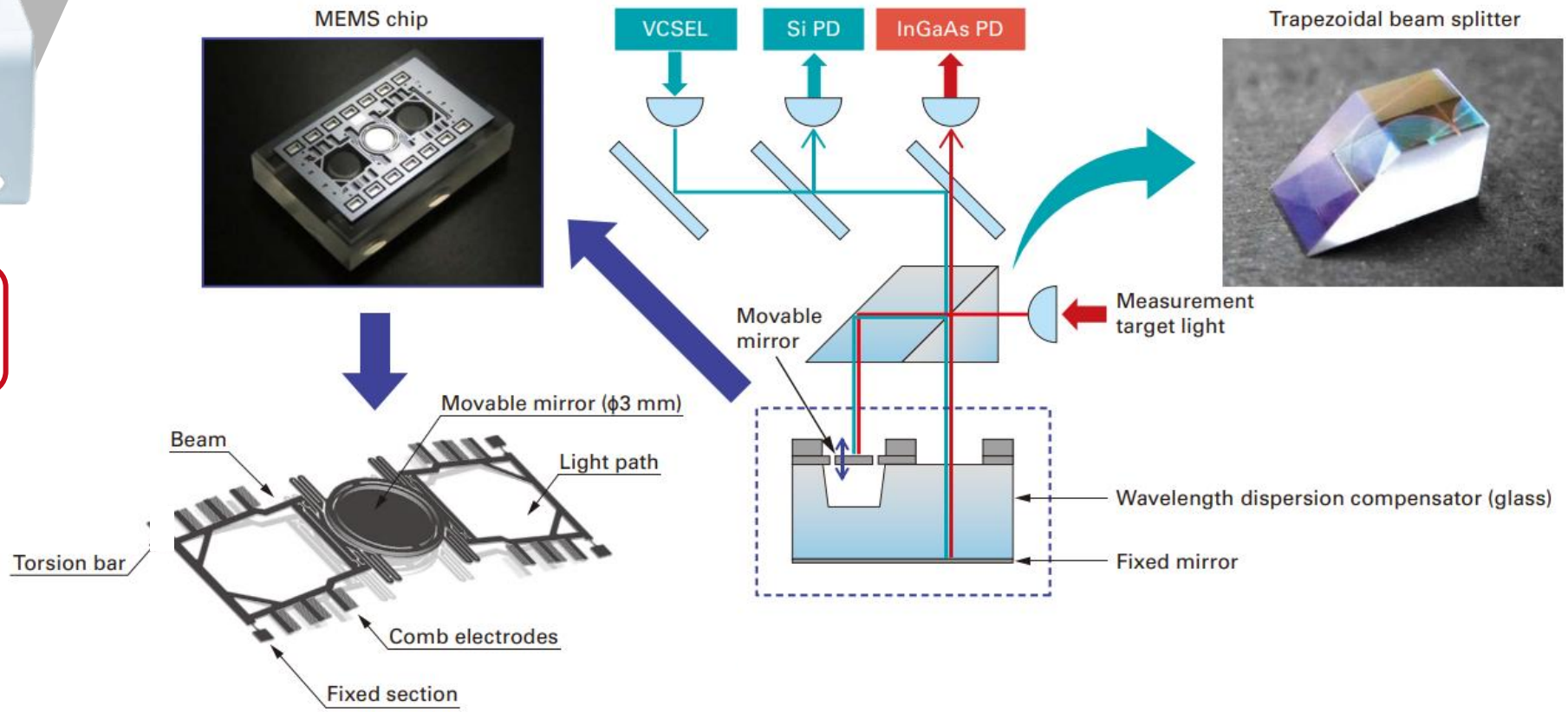


© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

The Miniaturization in FTIR Spectrometers Trend



Smaller footprint
No compromises

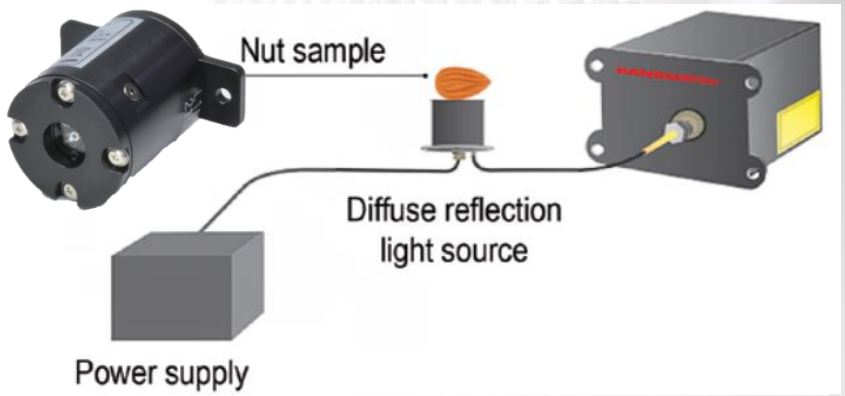


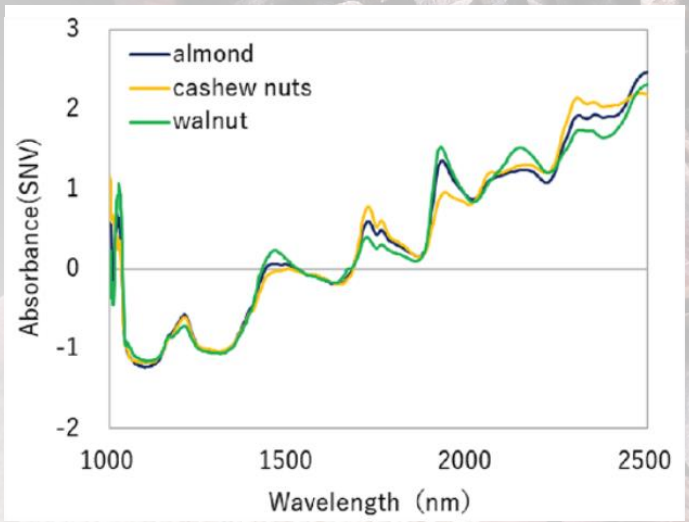
© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

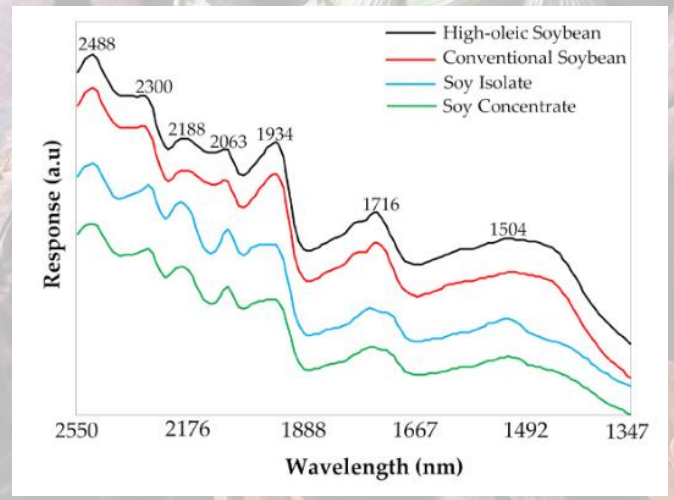
Photonics in Food Quality Assessment

HAMAMATSU
PHOTON IS OUR BUSINESS

Applications







FTIR Engine

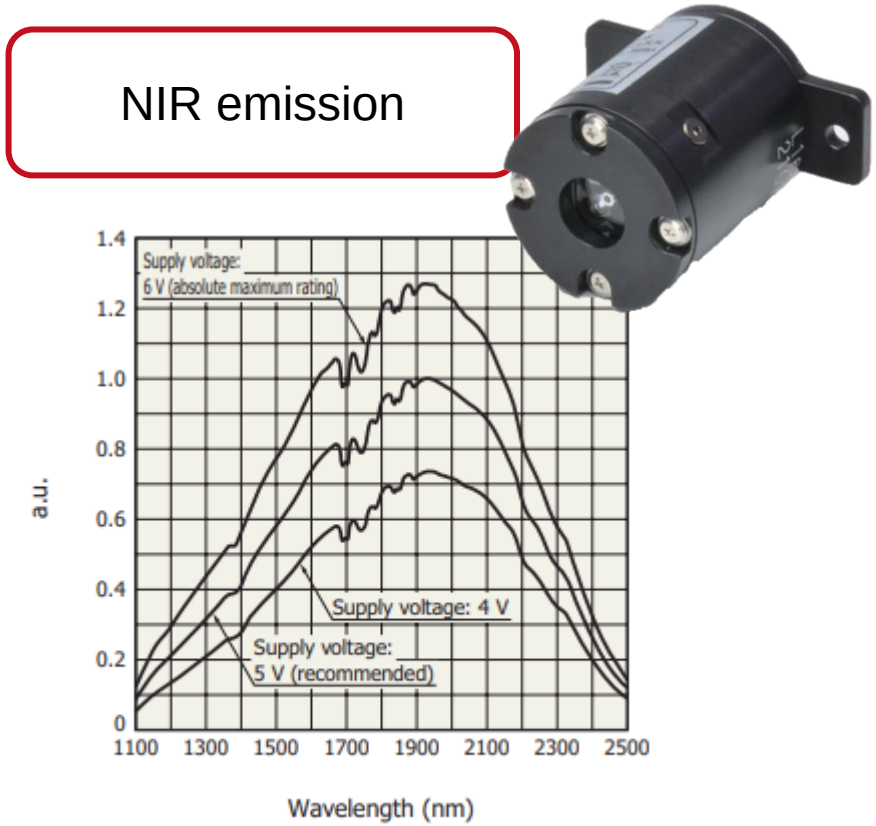
- Compact design
- Extended IR range: 1100- 2500 nm
- High SNR: 10’000
- Resolution up to 5.7 nm
- USB interface
- Fiber coupling

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

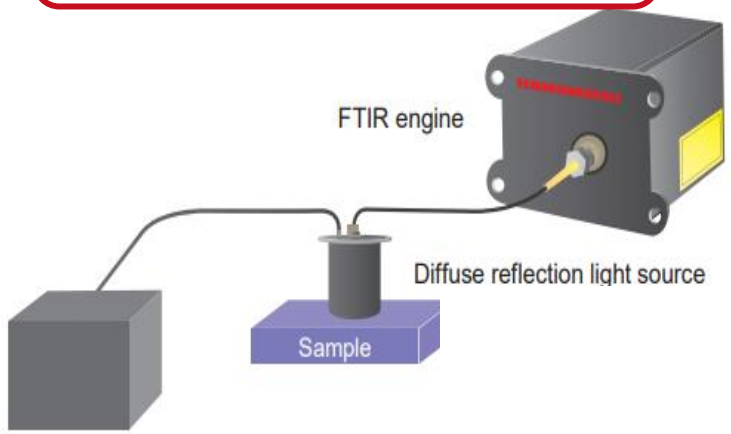
Hamamatsu’s L16462-01 improves SNR

HAMAMATSU
PHOTON IS OUR BUSINESS

NIR emission

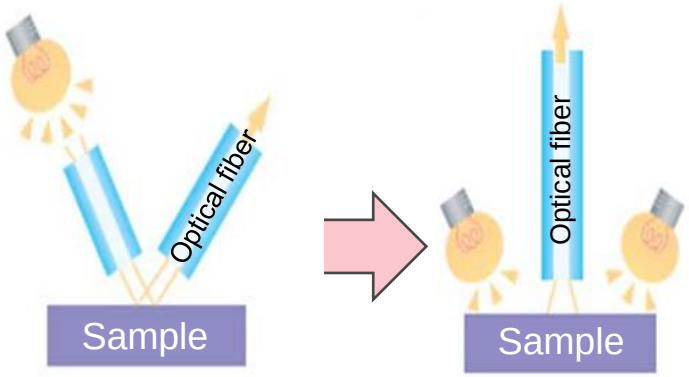


Diffuse reflection measurements



- Integrates 4 halogen lamps
- Output power: 2.5W
- Compact: 28 mm x 35.5 mm
- Long lifetime: 7000h

Improved optical design

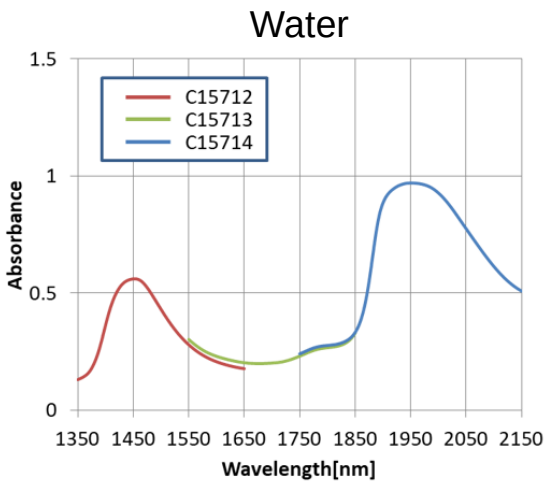


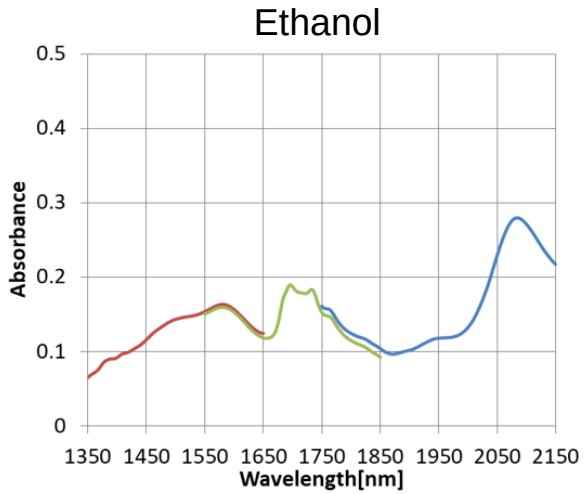
© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics at the Grocery Store

HAMAMATSU
PHOTON IS OUR BUSINESS

Applications

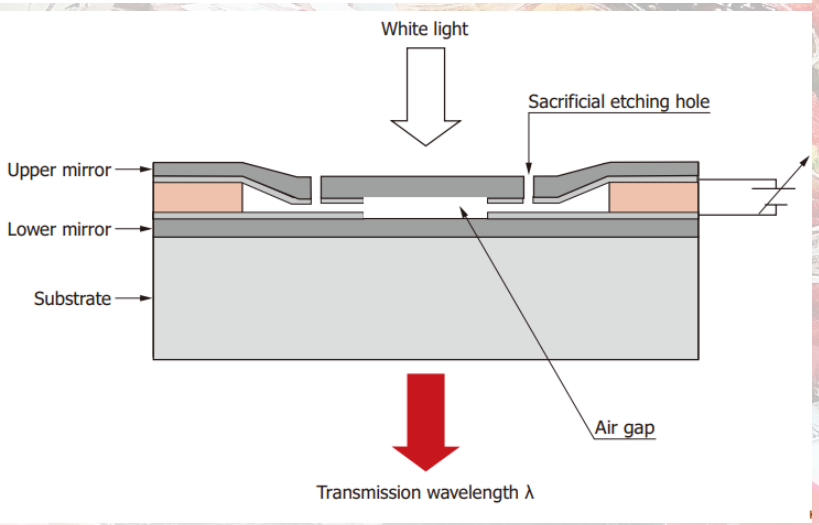




- **Moisture content measurement**
- **Food content measurement:**
  - Lipids
  - Carbohydrates
  - Proteins
  - Ethanol
- **Produce ripeness**

MEMS Fabry-Perot Interferometer

- Compact and lightweight design (5g)
- Wavelength range: 1.35 – 2.15 µm
- Resolution up to 18 nm
- Low-cost solution
- Hermetic package



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Challenges in Water quality analysis

Objectives

Environmental monitoring
Pesticides | Pollutants | Nutrient imbalance

Measurement of drinking water quality

Solutions

Continuous monitoring and early detection of pollution events

Real time measurement in the UV-VIS

- **Nitrate or nitrite concentration**
- **Dissolved Organic Matter**
- **Total Oxygen content**
- **Disinfectant in drinking water**

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics for Water Quality Analysis

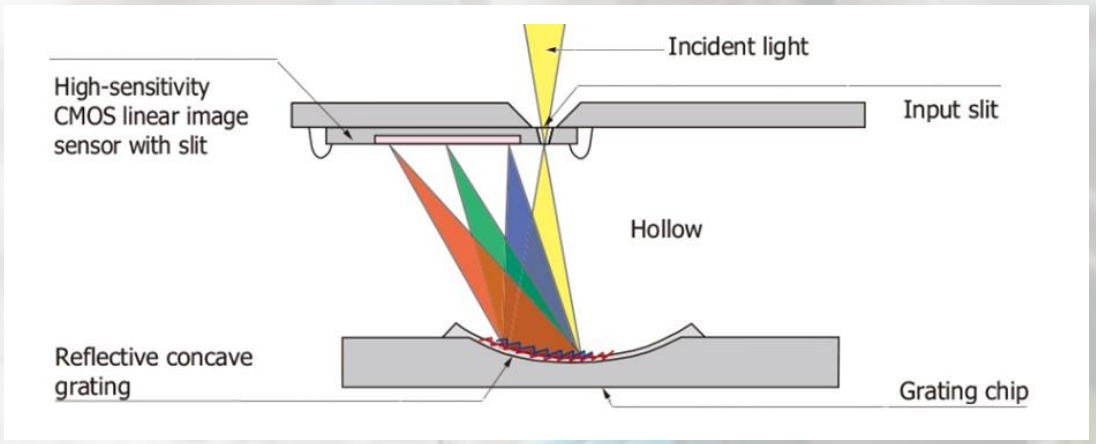
HAMAMATSU
PHOTON IS OUR BUSINESS

Main requirements

Suitable spectrum (UV), brightness & sensitivity, reliability & lifetime, short warm-up time, low power consumption, compact.

UV sensitive mini-spectrometer

- 190 to 440 nm
- 8 nm resolution
- Compact and lightweight at 5 g
- High UV resistance



UV photodiode with interferometric filter

- 220 nm - Nitrate
- 254 nm - Dissolved organic matter (DOM)
- 10 nm spectral linewidth
- High UV resistance

Xenon Flash lamp modules

- From 2 W to 20 W compact modules
- Pulsed emission with high peak power
- Continuous spectrum from UV tro MIR
- UV glass or MgF2

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

HAMAMATSU
PHOTON IS OUR BUSINESS

Imaging

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Food Sorting – SWIR imaging

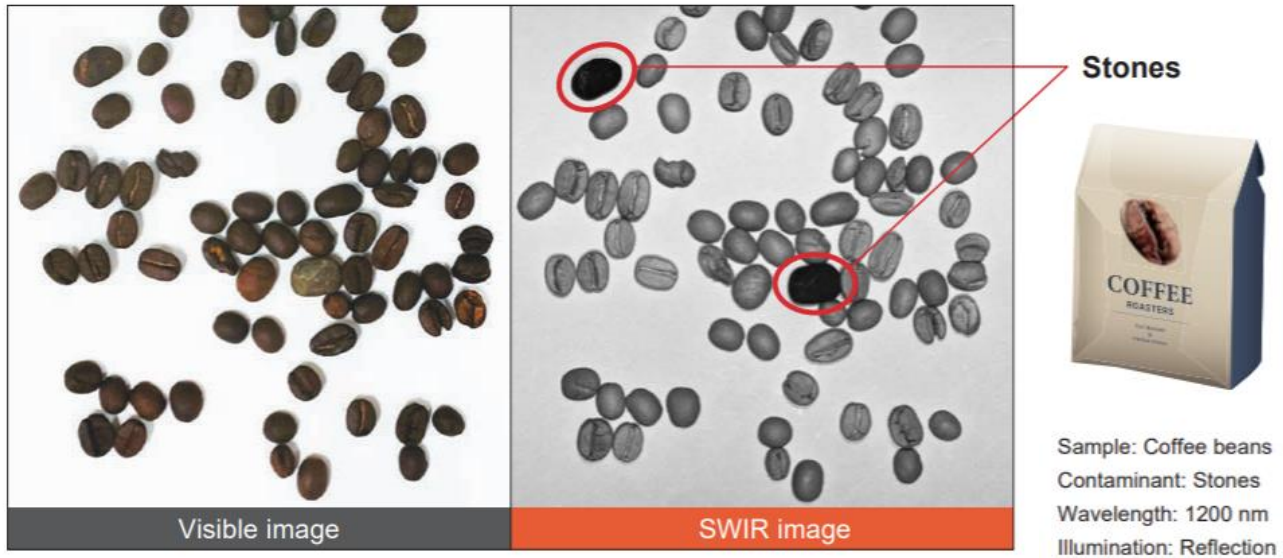
HAMAMATSU
PHOTON IS OUR BUSINESS

Applications

Identification of foreign objects

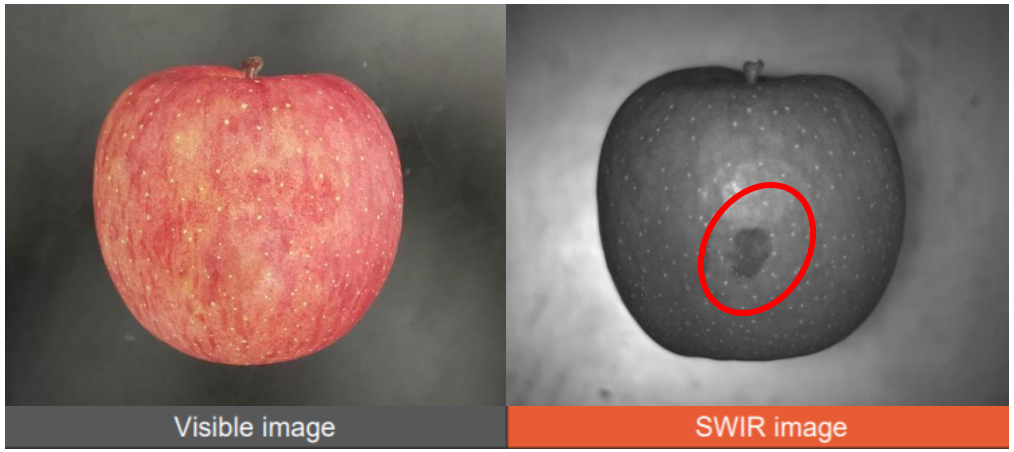
Non-destructive testing

Defect detection



InGaAs Modules

- Driver circuit
- Interface
- Housing
- Lens mount
- Cooling



Detection of damaged produce by finger pressure

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Food Packaging: SWIR imaging

HAMAMATSU
PHOTON IS OUR BUSINESS

Applications

Liquid level detection

Package defect detection

InGaAs Cameras

- High SWIR sensitivity: 950 -1700 nm
- Fast line rate: up to 40 KHz
- Compact design
- Calibration function

Visible image

SWIR image

Sample: Instant noodles
Wavelenght: 1200 nm
Illumination: reflection

Visible image

SWIR image

Liquid level detection

© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Food Sorting: Hyperspectral Imaging

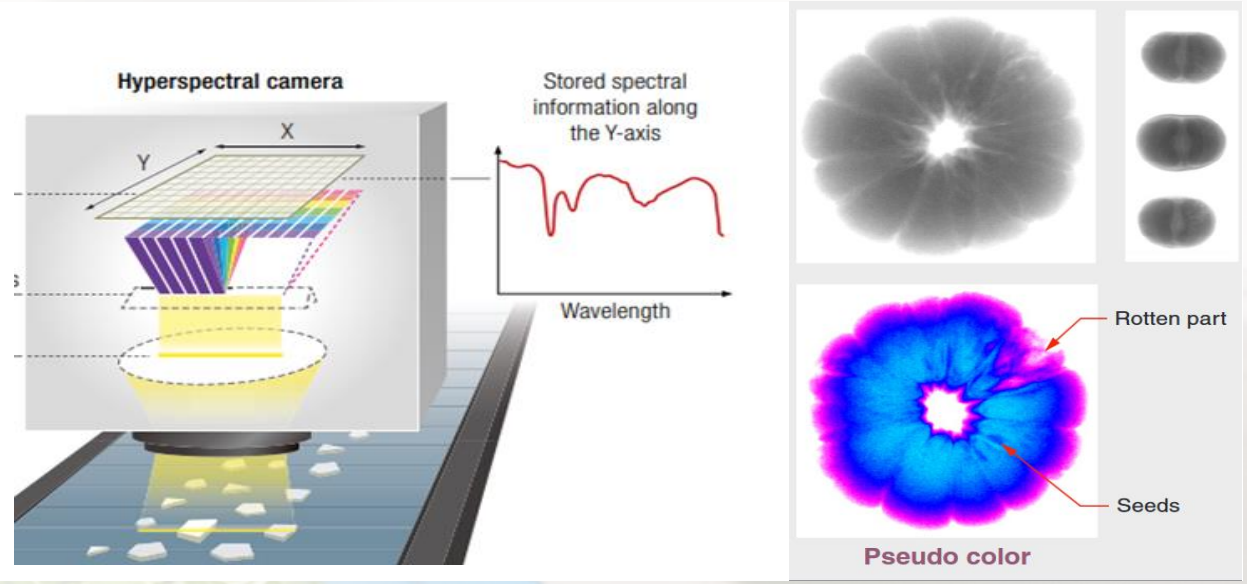
HAMAMATSU
PHOTON IS OUR BUSINESS

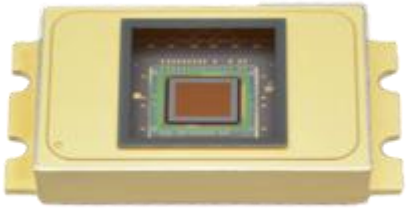
Applications

Identification of foreign objects

Food sorting

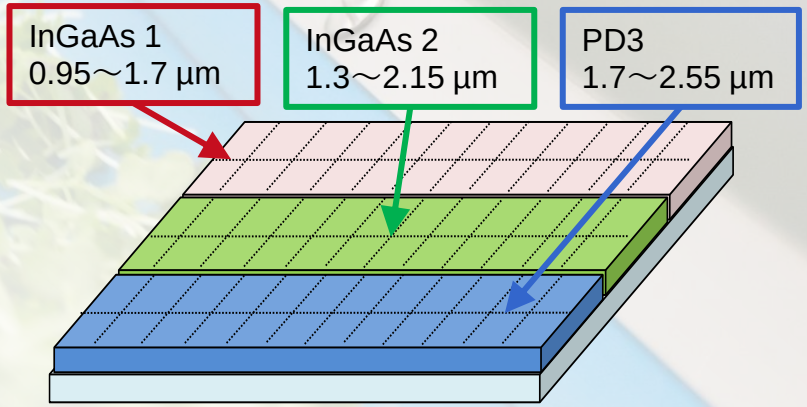
Plastic sorting





InGaAs Sensor

- Line and area sensors
- Wide wavelength range: 950–2600 nm
- Line rate up to 40k lines/s
- Low dark current and readout noise
- Customized InGaAs 2D detector



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Photonics in Food Sorting: X-ray Imaging

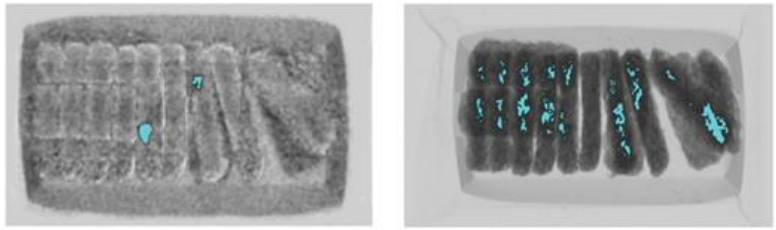
HAMAMATSU
PHOTON IS OUR BUSINESS

Applications

Identification of foreign objects

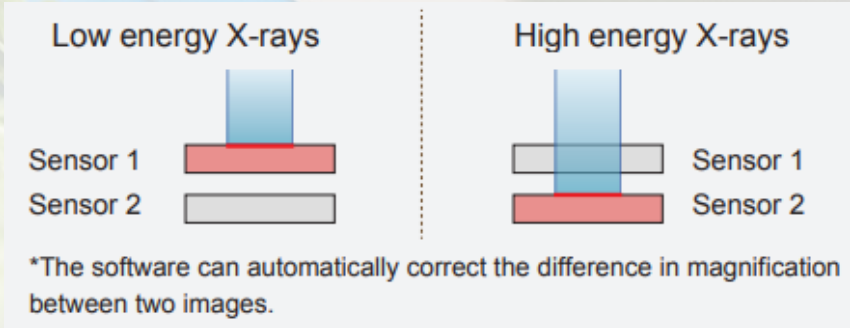
Package defect detection

Non-destructive testing



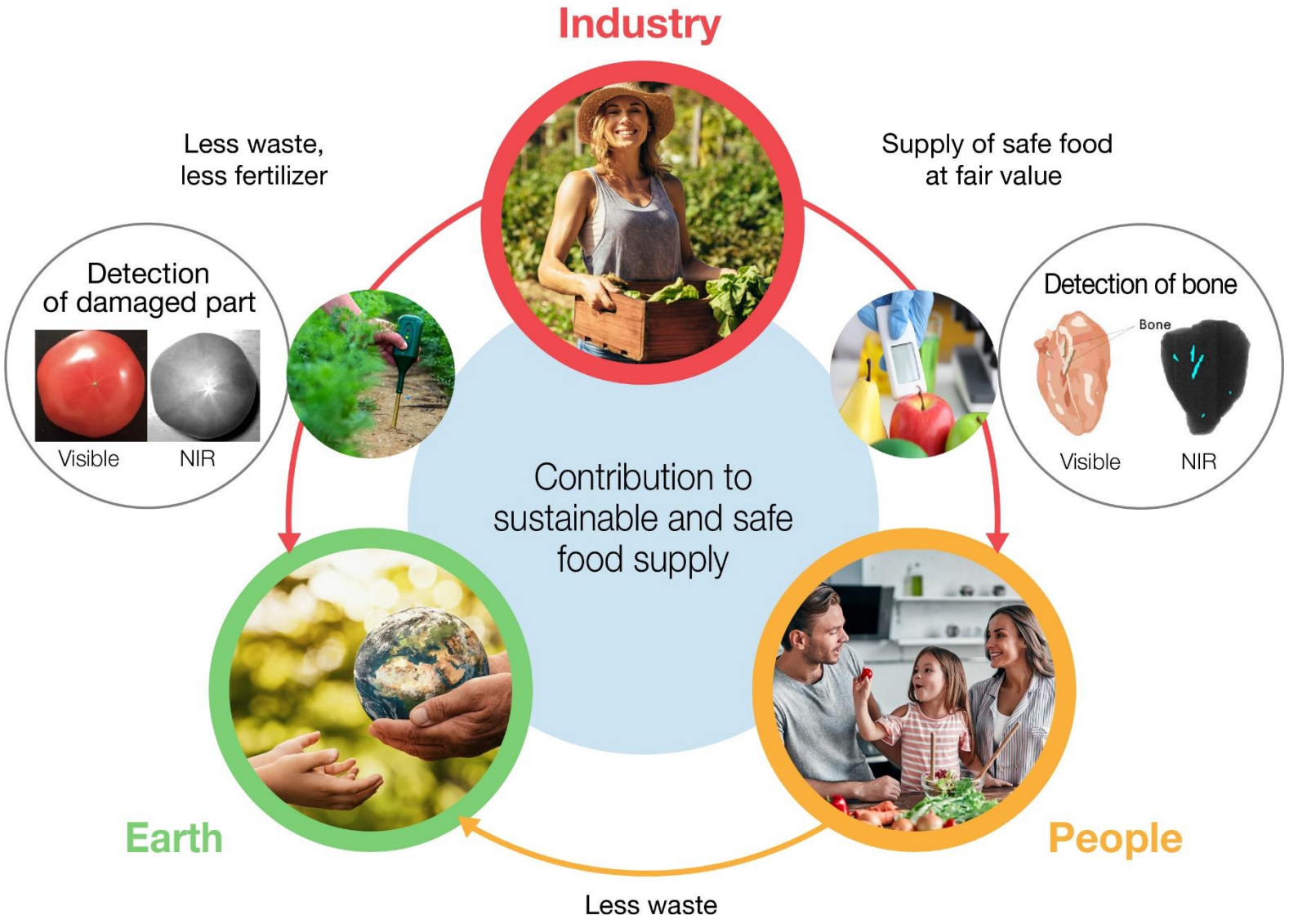
Dual Energy X-ray line scan module

- Single and dual energy sensors
- Detection of low density or thin contaminants
- X-ray sources
- Up to 100 m/min scan speed



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

Hamamatsu for the Industry, People, and Earth



© Hamamatsu Photonics K.K. and its affiliates All Rights Reserved.

HAMAMATSU
PHOTON IS OUR BUSINESS

TECHNOLOGY DAYS 2024

Register now!

www.technology-days.com

© Hamamatsu Photonics K.K. and its affiliates. All Rights Reserved.