ALRAD
50 YEARS 1970 - 2020

ALRAD
Instruments Ltd

Making a difference for 50 years

AUTOMATION AND PROCESS CONTROL APPLICATIONS IN VISIBLE AND NON-VISIBLE (THERMAL) WAVELENGTHS

MACHINE VISION CONFERENCE 2022

ALRAD Instruments Limited
Company Overview

Website
www.alrad.com

- Established 1970
- Providing high quality Components and Systems to the OEM market, Industry and research for the past 50 years
- Six Technology Divisions

Components and Systems for Imaging Outside of the visible spectrum

In recent years imaging applications making use of the wavelengths beyond the visible spectrum have become more popular, especially in the near infrared region which can be imaged with a standard low cost camera using CMOS image sensor technology. Shortwave infrared (SWIR) is also becoming more popular as the cost of InGaAs sensors is starting to fall and we are also seeing Thermal (MWIR and LWIR) making a debut in machine vision applications such as looking at heat signatures in automation processes and of course with the very topical rise of Temperature screening for health applications.

In addition to cameras operating in the above wavelengths ALRAD Instruments also provides systems operating in the Ultraviolet and TeraHertz wavelength regions.

These technologies allow us to access important information which is not apparent in visible spectrum imaging and are helping to revolutionise the industrial, medical and scientific inspection markets.

All of these technologies also share one important benefit and that is that where they need illumination (MWIR and LWIR being the exception) they are able to provide imaging results without the need to use ionizing radiation as a source of illumination and hence can be implemented and used safely in a wider range of applications.

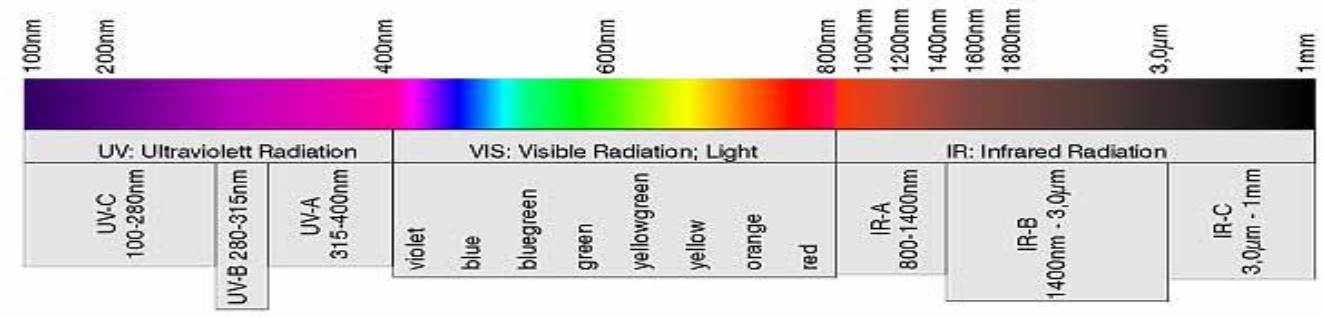
Overview and Contents

ALRAD Instruments provides a wide portfolio of imaging components and systems covering the electromagnetic spectrum from Deep-UV through Visible, NIR, SWIR, MWIR & LWIR to TeraHertz Imaging.

This presentation is a brief overview of some of the typical applications which can be solved with the components and systems ALRAD Instruments provides to the Automation an Machine Vision markets

Contents:

Imaging applications in the Near Ultraviolet NUV or UV-A region 315~400nm



The majority of CMOS image sensors have useable sensitivity down to the sub 400nm region, however, this can be attenuated by the coverglass used on the sensor, by removing this and using quartz optics, CMOS sensors can be utilised at the Near Ultraviolet NUV or UV-A region wavelengths.
Other methods include adding a UV sensitive coating on the CMOS sensor to increase sensitivity in the UV-A region.

Imaging applications at these wavelengths include:

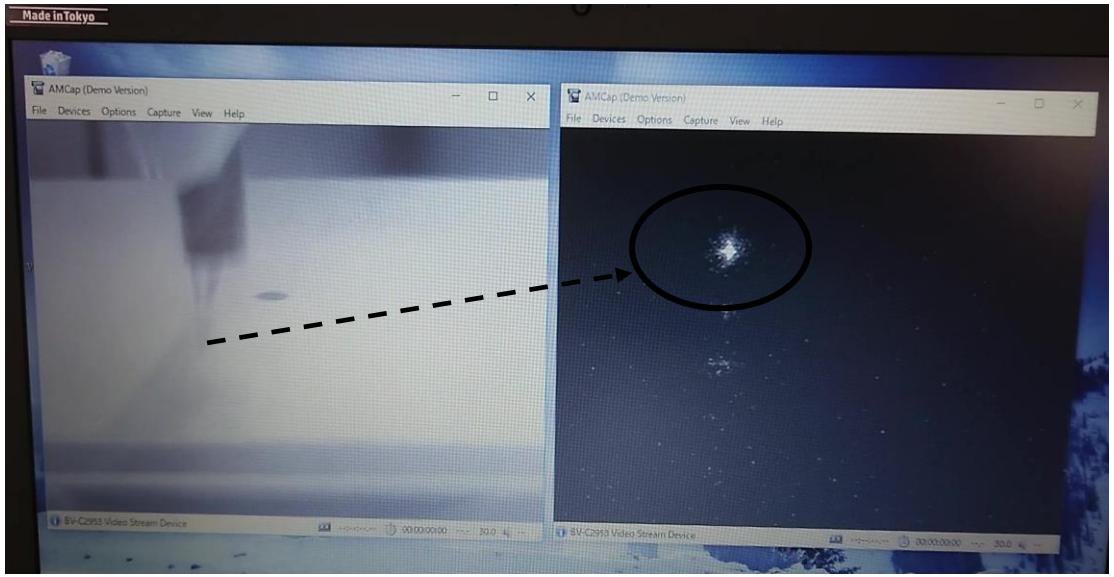
- Electrostatic Discharge (ESD) monitoring
- Semiconductor wafer, chip and parts inspection and process control
- Printing inspection
- Bottling inspection for cosmetic and pharmaceutical markets
- Medical equipment
- Powerplant safety checks.

Bluevision BV-C2953 Specifications:

Wavelengths:	390nm (NUV) to 700nm visible
Sensor:	640(H) x 480(V) CMOS image sensor
Interface:	USB3.0 microB x 1port (YUV422 (YUV2))
Synchronization:	Internal sync
Dimensions:	35 x 35 x 48 mm
Weight:	96g

Near Ultraviolet Imaging NUV or UV-A region 315~400nm

BlueVision



Display of ESD discharge location

Prism Spectroscopic Near-UV (NUV) Camera

The Bluevision BV-C2950 captures UV rays generated at the time of electrostatic discharge. This ultra-sensitive camera can monitor where and when Low Voltage ESD damage from hundreds of volts upwards was happened.

This camera uses spectroscopic technology consisting of a mirror to disperse the visible light with 400nm to 700nm wavelength and UV rays with 250nm to 300nm wavelengths. The BV-C2950 employs two sensors: a visible sensor with 640 x 480 pixels, an ultra-sensitive UV sensor and one fixed focal lens.

NUV Flourescence Imaging

Near Ultraviolet or NUV Flourescence imaging is a technique used to image and reveal details that are not generally clear in the visible spectrum.

Often used in combination with fluorescent dyes or markers, the dyes or markers are applied to the subject which is then illuminated (excited) with Ultraviolet light.

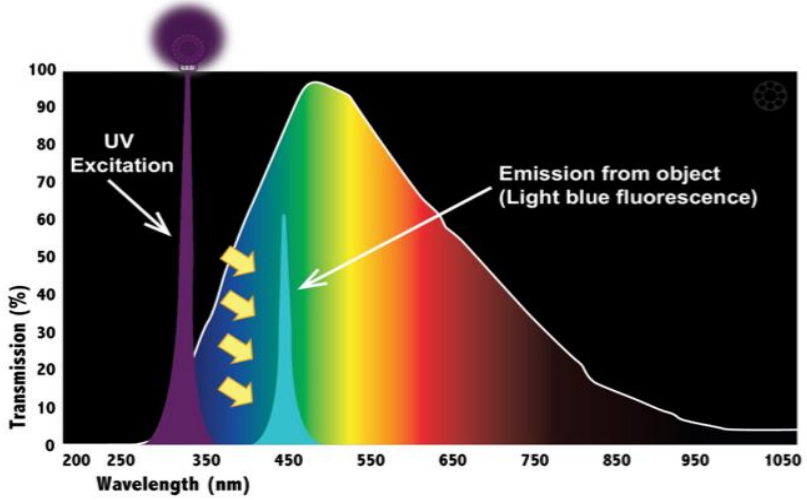
The material in question affected by the marker and ultraviolet light then fluoresces at a wavelength just inside the visible spectrum, generally around 400nm.

Using a blue bandpass filter the contrast can be improved by cutting out emissions above and below the target peak fluorescing wavelength allowing previously difficult to see features to become clearly visible.

The following two slides show some good examples of the benefits of combining bandpass filters with a UV camera to achieve good imaging results in the Near Ultraviolet NUV or UV-A region

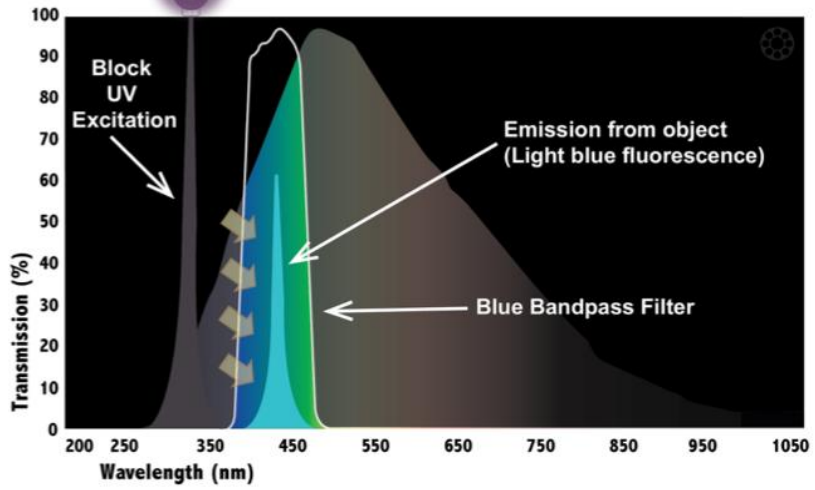
Increasing the contrast in NUV Flourescence Imaging

No Filter, 395nm UV Light



Without the use of filters, the Excitation light source interferes with weaker emitted fluorescence:

395 UV Light with MidOpt BP470 Blue Bandpass Filter



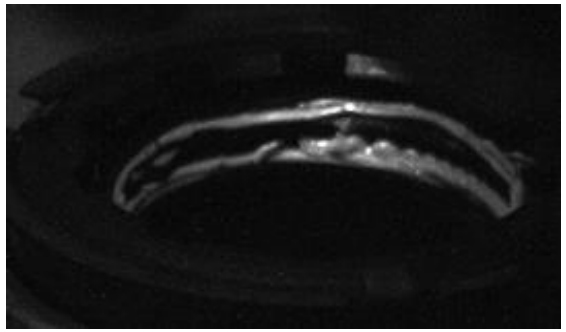
With filters, the interference is removed and the contrast of the emitted fluorescence is enhanced

Courtesy of Midwest Optical Systems Inc.

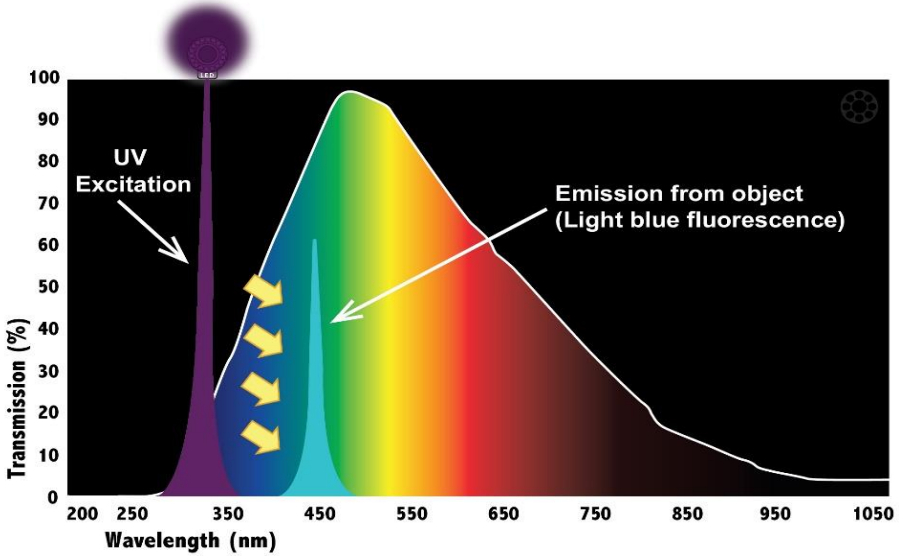
Increasing the contrast in NUV Flourescence Imaging

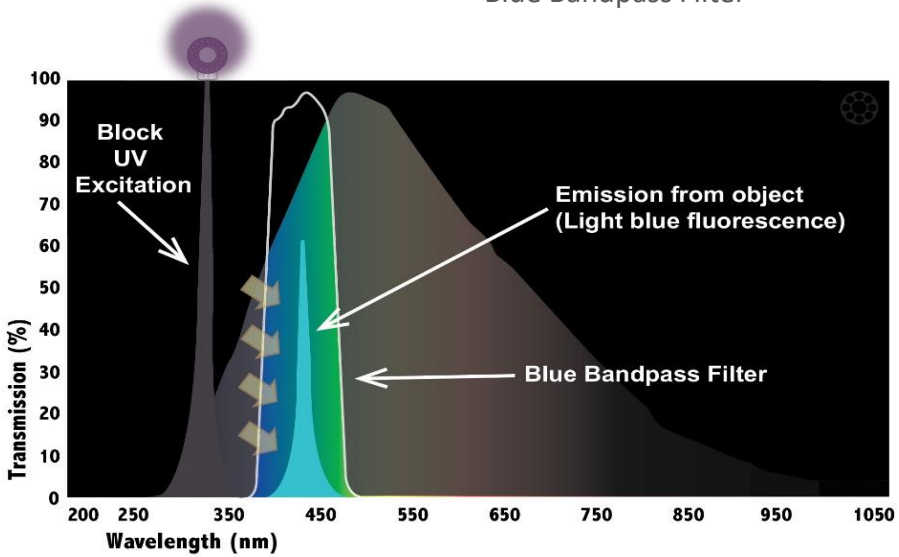
Original Color Image

No Filter



With MidOpt BP470
Blue Bandpass Filter





Without the use of filters, the Excitation light source interferes with weaker emitted fluorescence:

Courtesy of Midwest Optical Systems Inc.

Visible Region Cameras and Components For Machine Vision and Automation

ALRAD's traditional portfolio for Machine Vision and Automation includes a wide range of Area and Line Scan Industrial cameras including USB 2.0, 3.0, 3.1, GigE, 10 and 25 GigE, CameraLink and CoaXPress interfaces. In addition Analog, Ethernet and Fibre interface options are available.
Options include Monochrome, Colour and Polarised with Resolutions ranging from VGA to 50 Megapixels

www.alrad.com

ALRAD Imaging

Acquisition Components
For Machine Vision and Automation

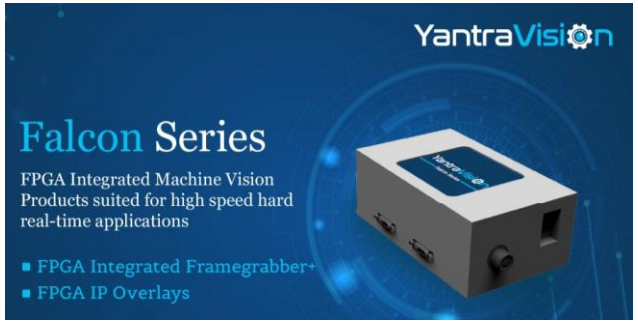
ALRAD is a long established partner for BitFlow and EPIX Frame grabbers, in addition we acquisition boards from The Imaging Source, Emergent Vision and the FPGA integrated Compute Module from Yantravision

THE IMAGINGSOURCE
TECHNOLOGY BASED ON STANDARDS

emergent
vision technologies

BitFlow™

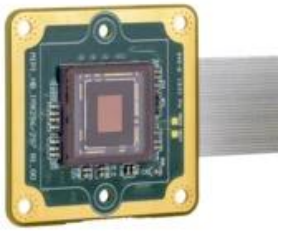
EPIX



Embedded Cameras and Components For Machine Vision and AI

ALRAD's Embedded portfolio includes MIPI and FPD-Link interfaced board and housed cameras and a range of NVIDIA Jetson based AI and Deep Learning Development Kits from The Imaging Source.

In addition we distribute the YantraVision FPGA Integrated Camera Module and FPGA Integrated frame grabber.



Cameras and Components For Microscopy and Metrology

ALRAD Instruments provides a wide range of Microscopy Imaging systems to Industry, Research and Academia. In addition to a wide selection of hardware we also supply software for Measurement and Inspection applications for all platforms.

Our expert team based in Newbury can advise the best systems for your application.

Cameras and Components For Microscopy and Metrology

Microscopy applications:

Differential Interference Contrast (DIC)
Phase Contrast
PCB & Semiconductor Inspection
Pathology
Histology
Live Cell Imaging
Petrology
Academic and pharmaceutical research
Clinical medicine
Microbiology
Genetics

Metallurgy
Embryology
Metallography
Micrometrology
Mineralogy & Geology
Forensic Medicine
Paint Analysis and Dirt Analysis
Gemological Laboratories
Sperm Analysis
In Vitro Live Cell Tissue Imaging

Microscopy Software

µScope is a streamlined image analysis application that offers a wide range of unique image reading, measurement and enhancement tools designed exclusively for Pixelink® digital cameras.

Components for Imaging

Supporting our Imaging Cameras, ALRAD has a full portfolio of accessories including Lenses, Lighting, Cables and Software.

Board and Fisheye Lenses

Fixed Lenses

ITS Lenses

Lens Accessories

Macro Lenses

SWIR Lenses

Telecentric Lenses

Varifocal Lenses

Zoom Lenses

Weblinks:

ALRAD Lenses
ALRAD Cables
ALRAD Lighting

Polarisation-based Industrial Cameras

Sony's Polarsens™ 5.1 MP global-shutter CMOS image sensors (IMX250MZR/ IMX250MYR) capture visual data which cannot be obtained using other standard monochrome and color sensors. The sensor's Polarsens technology uses four-directional (0°, 45°, 90°, 135°) nanowire micro-polarizers placed in front of each 2x2 pixel array (calculation unit) to deliver multi-directional polarized images. Many materials, such as plastics, glass, metals and liquids display intrinsic polarization properties. The sensors' polarization filters make use of this to visualize material stress and surface scratches as well as to reduce unwanted glare, improve edge detection or to enhance contrast in low-contrast materials.

The supplied IC Measure software supports various methods of processing the 2x2 pixel arrays. The 5.1 MP cameras are available as color and monochrome variants with either a GigE (max. 24 fps) interface or a faster USB 3.0 interface (max. 75 fps).

Polarisation-based Industrial Cameras

Sony recently introduced its first polarized sensors featuring the novel PolarsensTM technology. These sensors create images of physical properties that are otherwise not visible using standard imaging sensors. Using a Pregius CMOS (5.0 MP: IMX250) sensor as a base, Sony has integrated a polarization array between the on-chip micro lens and the pixel array to create a Four-directional, On-chip Polarizing Sensor with Global Shutter (Fig. 1, below).

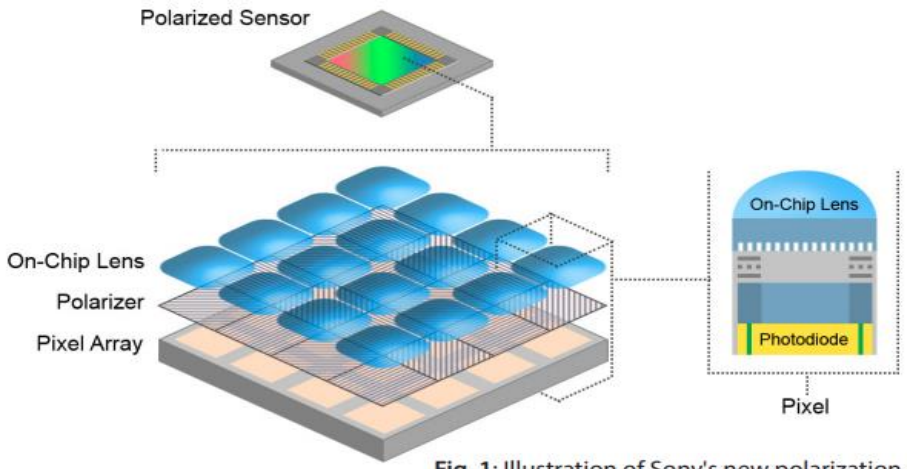


Fig. 1: Illustration of Sony's new polarization sensor

A four-directional polarization image is achieved by dividing the polarization array into four different wiregrid directions (90°, 45°, 135°and 0°) - with one grid section per pixel (Fig. 2, right).

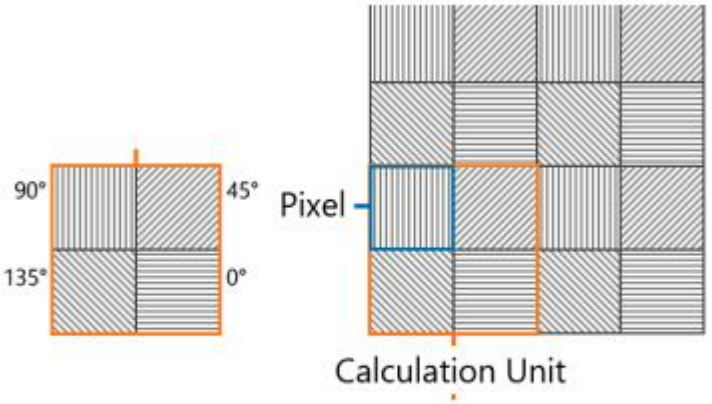
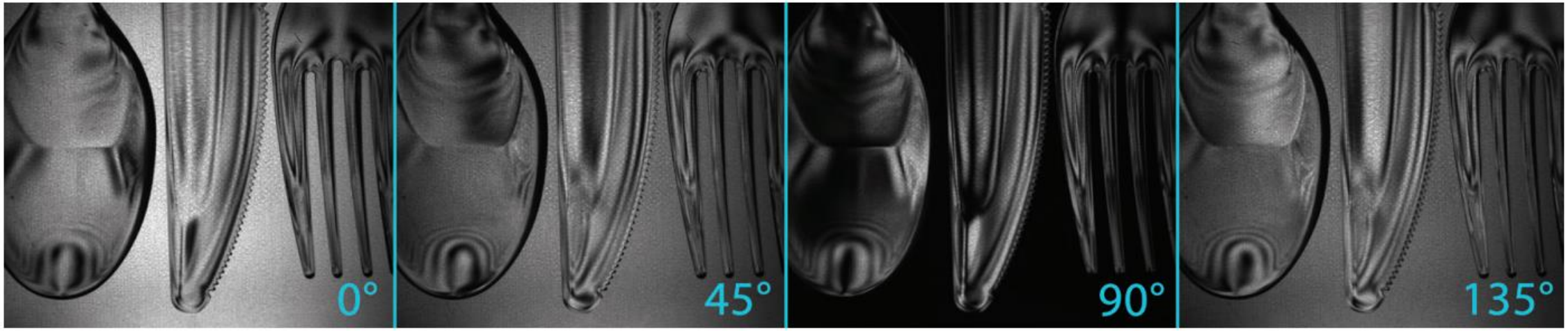


Fig. 2: Polarization array with detail.

Polarisation-based Industrial Cameras

Significantly, Sony's polarization sensor can capture a four-directional polarization image in one shot as shown below.

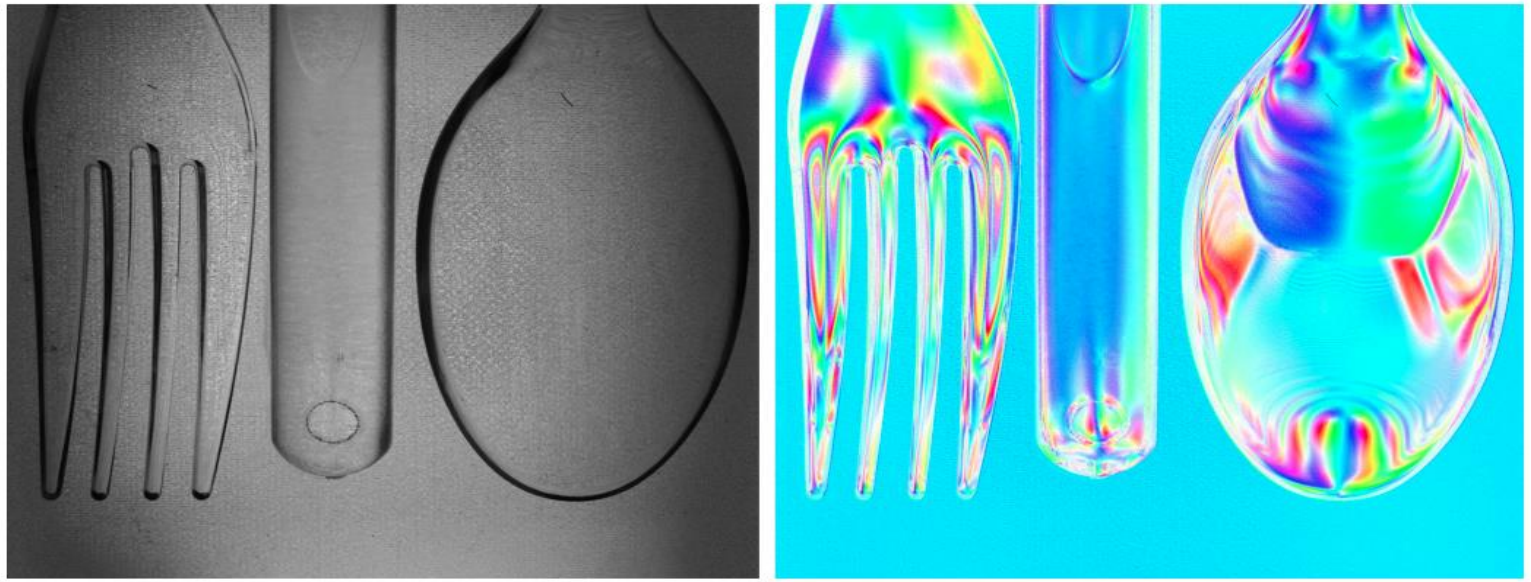
Additionally, the degree of polarization and the polarization angle can be calculated in real-time at high frame rates.



Polarisation-based Industrial Cameras
Application: Stress Inspection

One application for Polarisation cameras is to evaluate stress (birefringence) in transparent materials

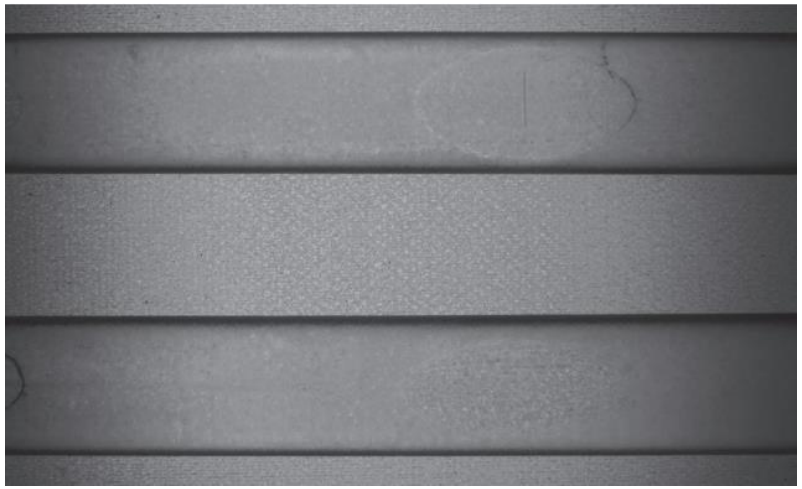
Because the sensor captures four linear polarizations at once (producing elliptically or circularly polarized light), particularly stressed areas of an object can be dynamically visualized under mechanical stress in real-time.

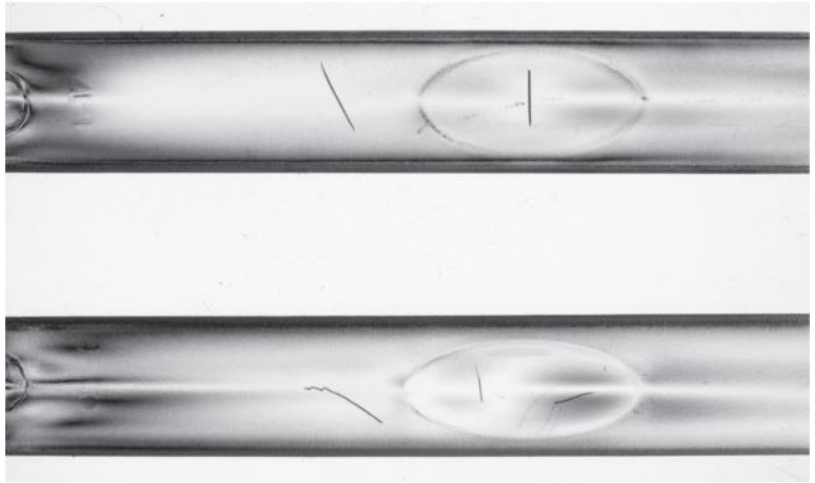


Intensity image (left), Image from DZK 33UX250 (right), using AoLP processing of the polarization data and HSV colormapping to show residual stress in plastic (birefringence).

Polarisation-based Industrial Cameras
Application: Scratch Inspection

With conventional methods, it can be difficult to identify defects or irregularities in material surfaces, such as scratches.
Polarized images can help detect such defects as shown below. Other inspection challenges may include highly-reflective or low-contrast surfaces.





Intensity image (left) shows little contrast, making visualization of defects difficult. Right image made with DZK 33UX250 using DoLP processing shows improved contrast, making scratches visible

Polarisation-based Industrial Cameras
Application: Surface-reflection Elimination

Polarization information can be used to suppress unwanted reflections from smooth, non-metallic surfaces. Light with vertical polarization is reflected with greater intensity from non-metallic surfaces when the angle of reflection is between 30° and 40° to the surface (close to the Brewster angle). If the polarization filter is correctly aligned, the reflected light waves are suppressed. This allows an elimination of disturbing reflections from windows and water surfaces. Using the four-directional wire-grid polarizer on the polarization sensor, it is possible to remove reflections in multiple planes. This is shown in the example picture below. Not only the reflections from the windscreen of the car are reduced, but also those from the side windows.

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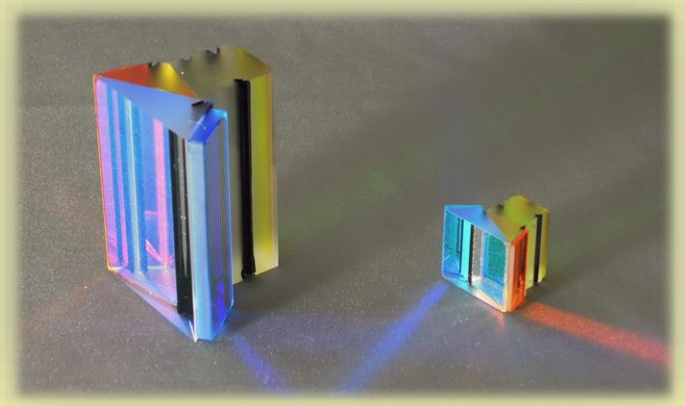
Overview of Prism Spectroscopy Technology for multi-sensor NUV, Visible, NIR and SWIR imaging

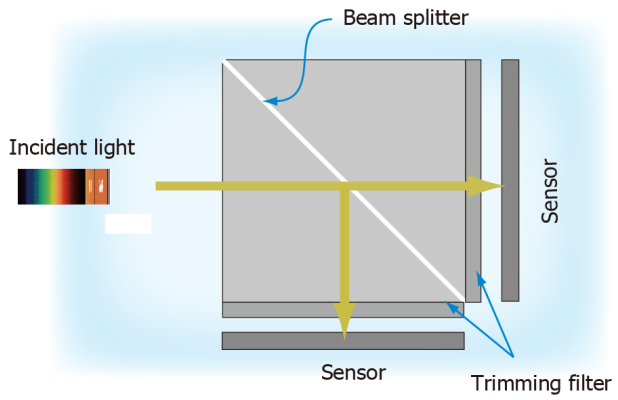
BlueVision



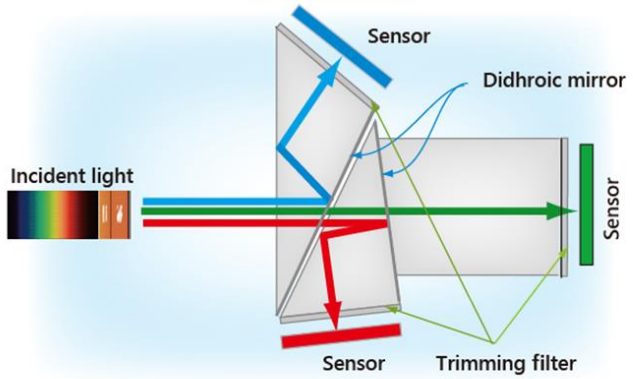
Prism Spectroscopy technology for multi-sensor visible, NIR and SWIR imaging

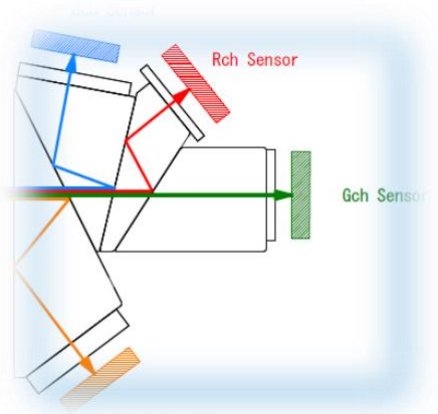
BlueVision

2 Wavelengths ‘Prism’ Spectroscopic camera



3 Wavelengths ‘Prism’ spectroscopic camera





By arranging dichroic mirrors and trimming filters, it is possible to separate the incident light into NUV, visible, NIR or SWIR bandwidths and then mix two of these wavelengths in various combinations. Often the visible spectrum is used for one channel in order to give a visual reference.

Advantage of Multi Sensor Cameras

Higher Color reproduction:

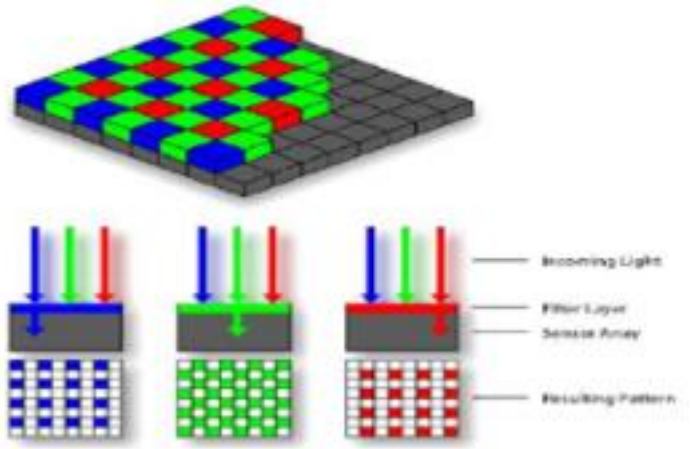
1 Mpixel sensor x 3 Green: 1 mil pixels, Blue: 1 mil pixels, Red: 1 mil pixels

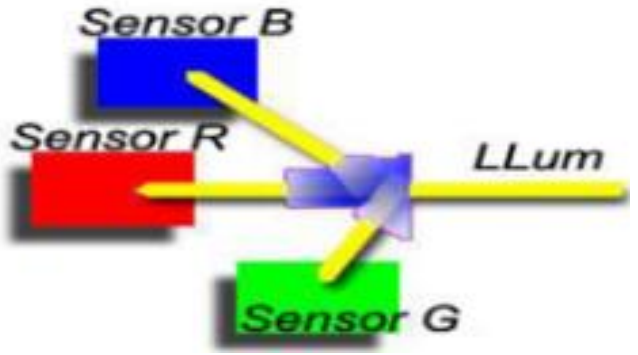
1 Mpixel Bayer single Sensor Green: 50K pixels, Blue/Red: 25K pixels

Flexibity of filter wavelength:

Single(Bayer) – B/W or Color (Fixed)

Multi sensors – Flexible to select the filter wavelength



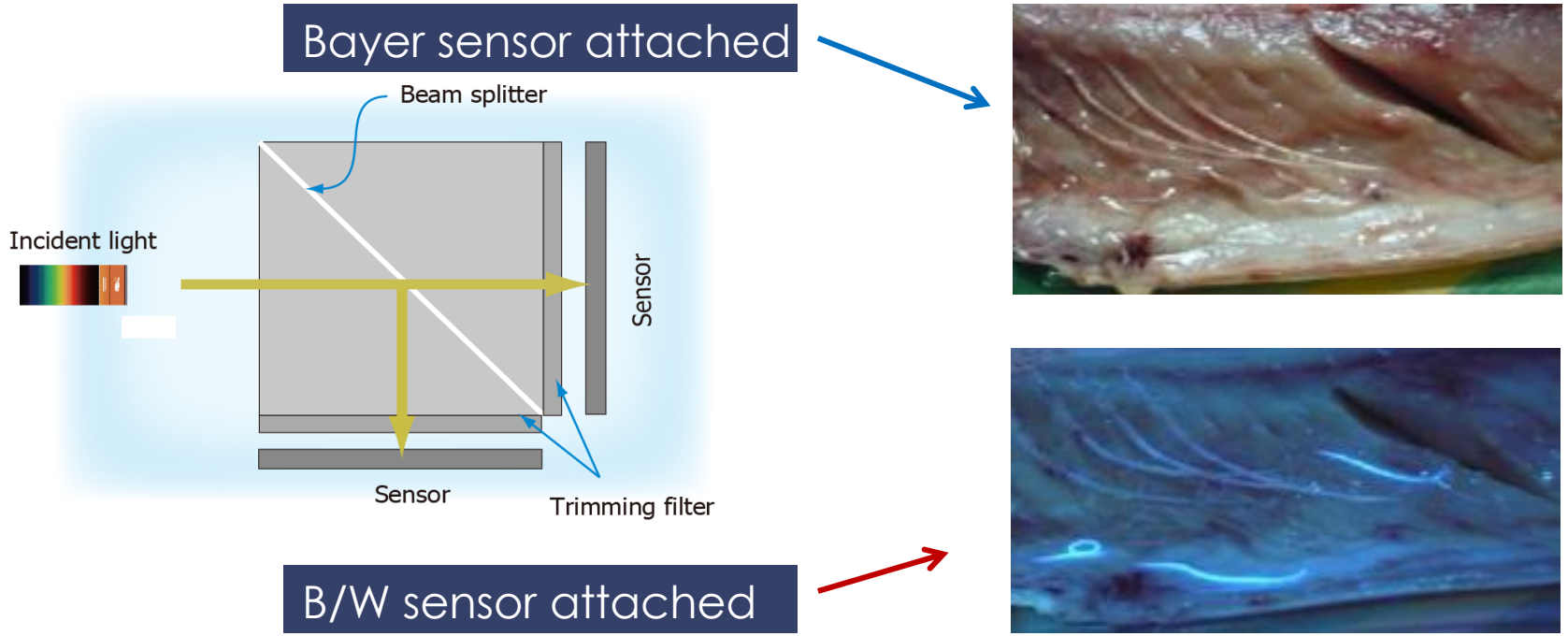


Wavelengths at which to detect materials and their specific characteristics

Material	Absorbing wavelength	Application
Hemoglobin	650nm	Blood
Farm goods	Vary at 700nm	Stress by pest
Mandarin orange	910nm	Sugar content
Grain	1000nm	Sugar content
Methanol molecule	1405nm	
Water H2O	1450nm/1928nm	Grain inspection
Ammonia NH3	1512nm	
Phosphorus	1534nm	
Magnesium	1612-1718nm	
Caffeine	1690nm	Production process
Adipose	1700nm	Quality check
Tea leaves	1870nm	Quality check
Flat grain	1950nm	
Starch	1460nm/2100nm	Food
Protein	1510nm/2300nm	Food 1600nm

Applications: Food inspection, production process surveillance, medical, pharmaceutical, biological

Example of Customized Prism camera (BV-C8320CL base)

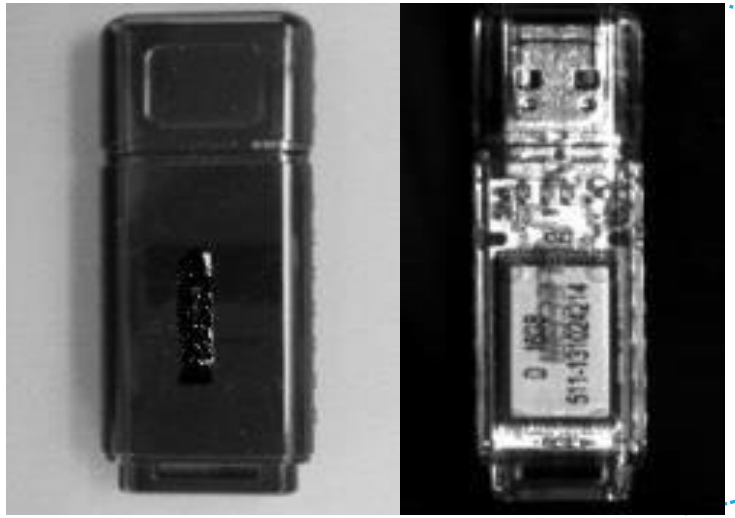


Bayer sensor – RGB signal output (Visible reference)
B/W sensor -- Blue signal output (wavelength selected to pick up fluorescence marker)
For “Anisakis” (parasite) inspection

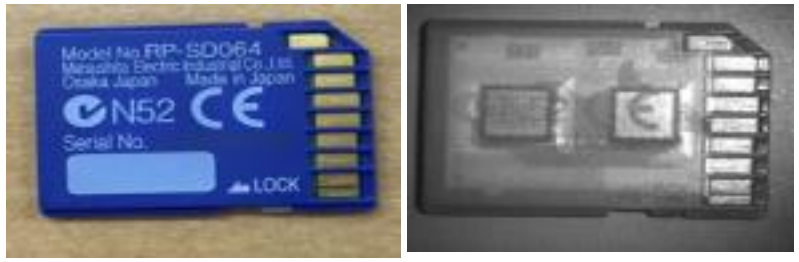
Application note:
Inner inspection covered by Plastic case

Application: Inner object inspection covered by plastic materials
BlueVision Cameras: BV-C3200, C3210, C3500, C3510

USB media



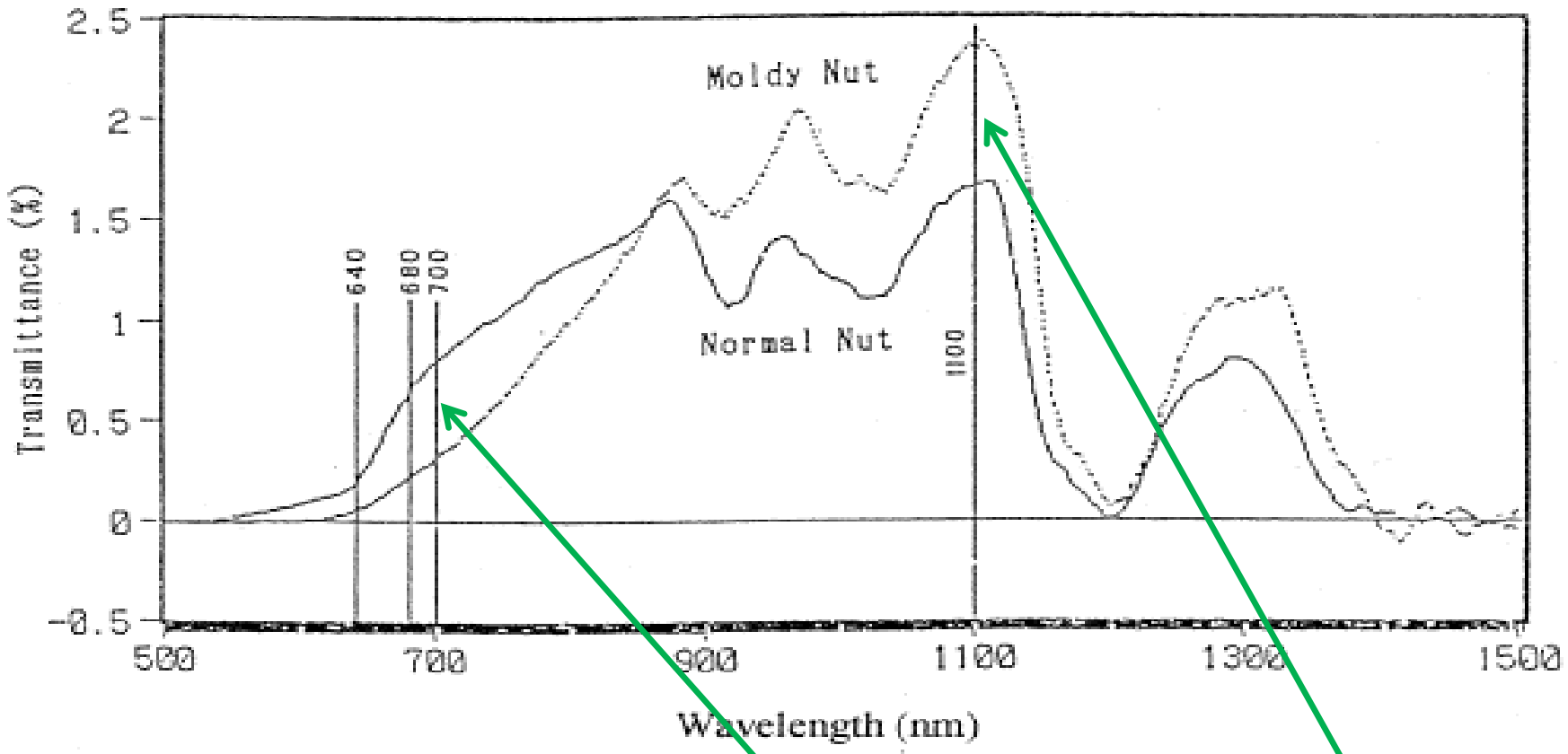
SD Card



Cookie

Application: Spectroscopic curve for Aflatoxin (Nut Mould) Detection

BlueVision



700nm

1100nm

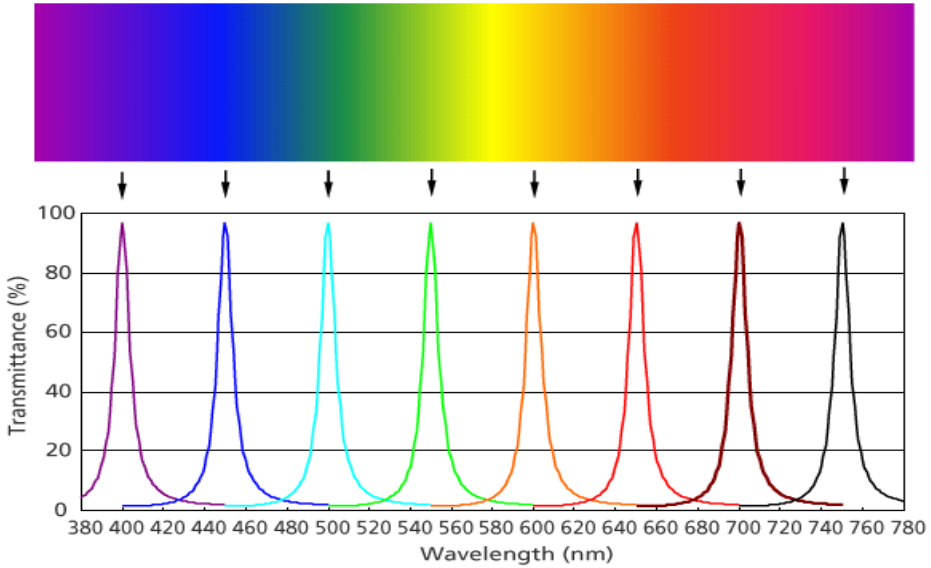
Variable Wavelength light source for Visible, NIR and SWIR wavelengths

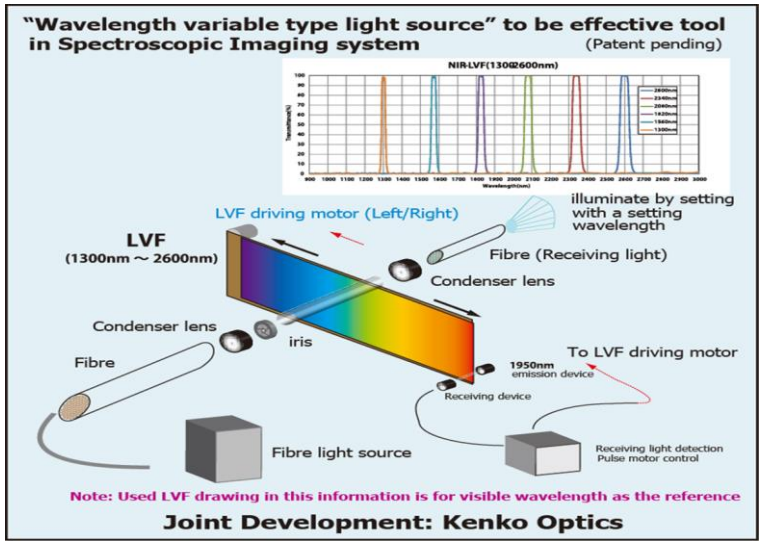
BlueVision

In order to use the spectroscopic imaging in the field, an affordable wavelength variable

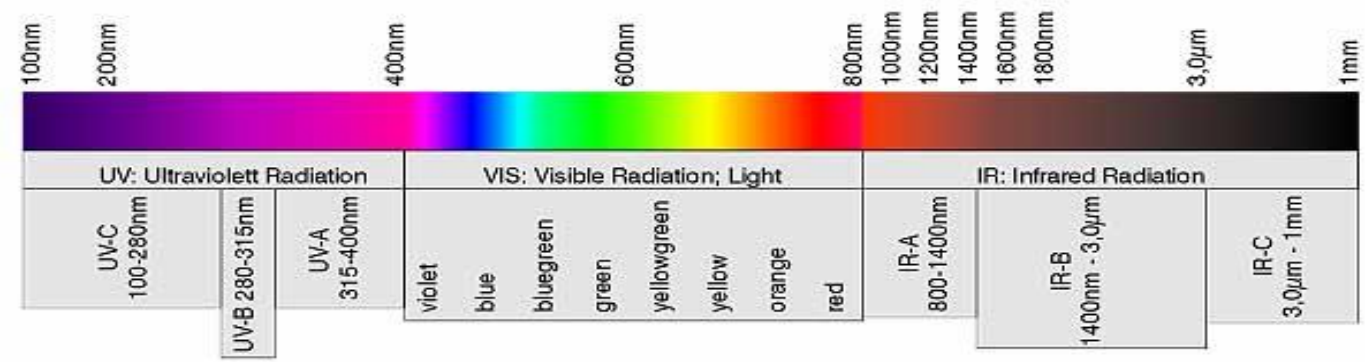
light source handling from visible to SWIR wavelength is required in order for users to find which wavelength is effective to detect material being inspected.

BlueVision realizes cost-effective wavelength variable type light source by using LVF (Linear Variable Filter).





Near-Infrared Imaging
NIR (IR-A) region 800~1400nm



NIR is sometimes called "reflected infrared“ and for this reason requires illumination in the relevant wavelength.

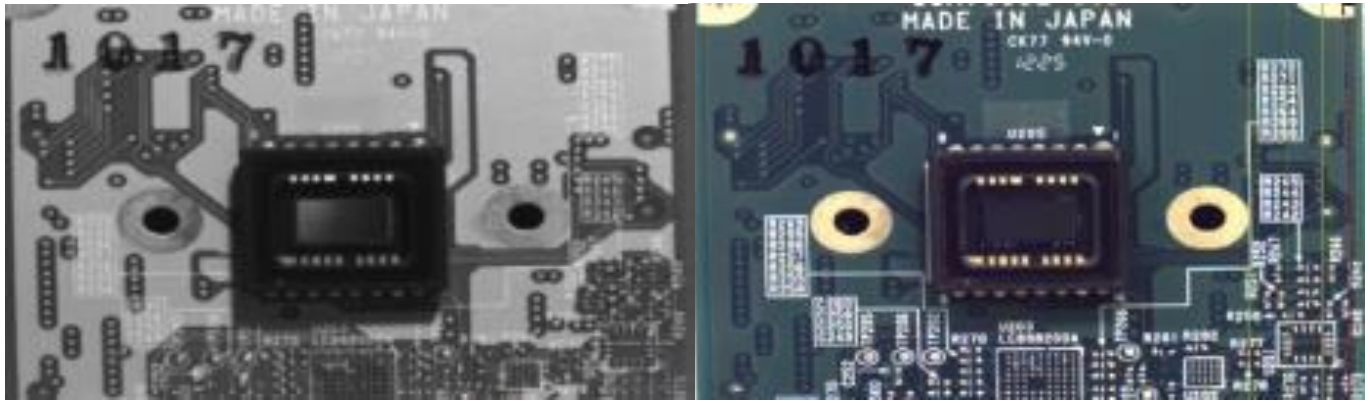
This is generally provided with solid state LED illumination operating in the NIR region both front (or top) and backlighting illuminators are used depending on the application.

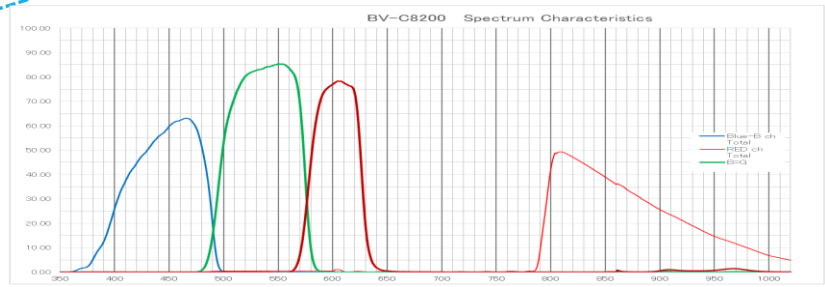
NIR Application: Board (PCB) Inspection

BlueVision

Application: Single camera solution for screen printing checking
by Visible light and PCB wiring check by NIR light

BlueVision Cameras: BV-C8200,C8210,C8220,C8225,C3500





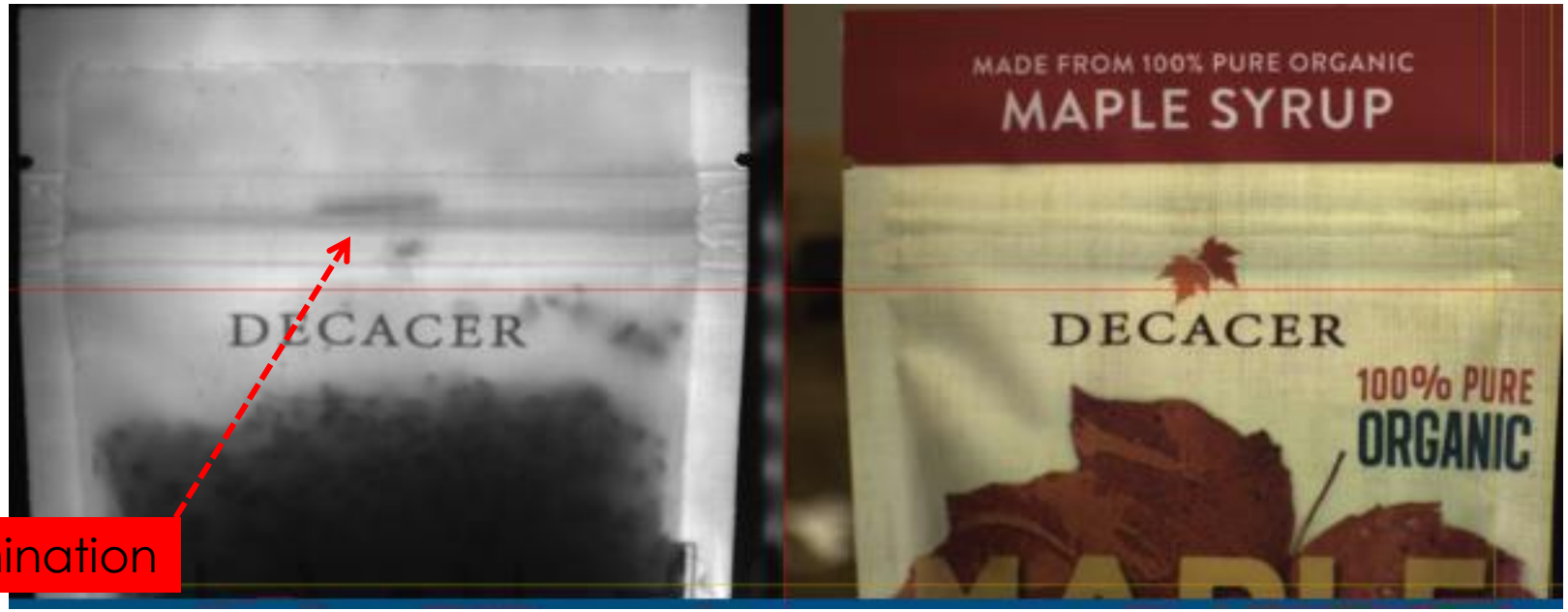
NIR **VISIBLE**

NIR Application:
Surface and sealing inspection

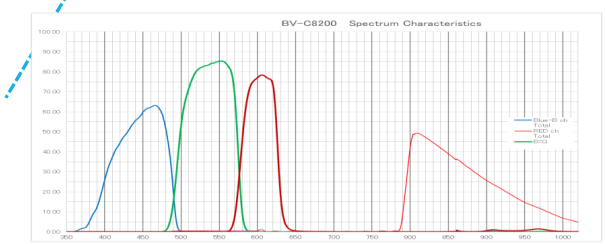
BlueVision

Application: Single camera solution for both surface printing check by Visible light and contamination check in sealing part by NIR

BlueVision Cameras: BV-C8200,C8210,C8220,C8225,C3500



Contamination

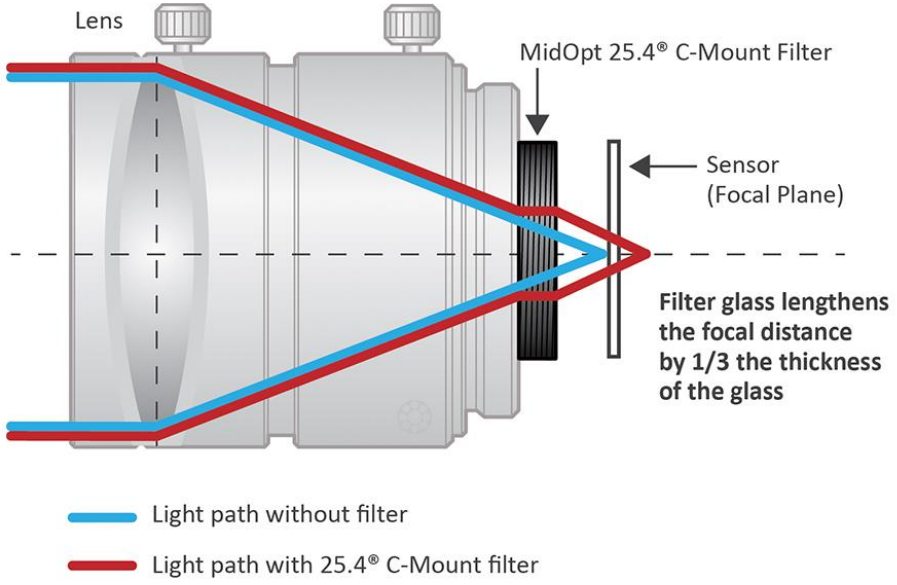


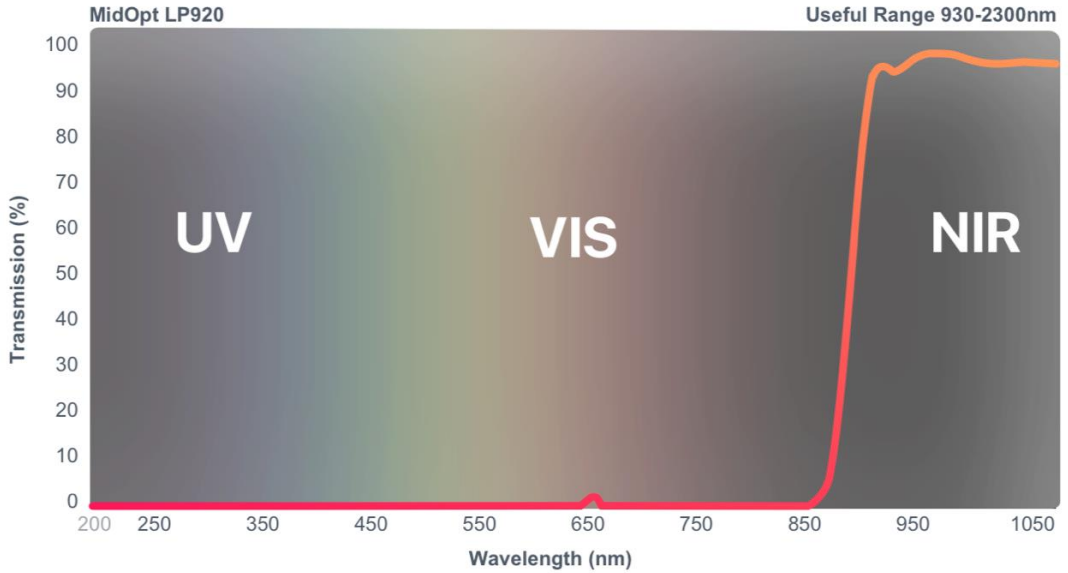
NIR transparent

VISIBLE-reflection

Longpass Filter for NIR

NIR imaging can benefit with the use of longpass filters to reduce the Effects of the visible wavelengths on the sensor and increase contrast. This is an economical solution for isolating wavelength regions.

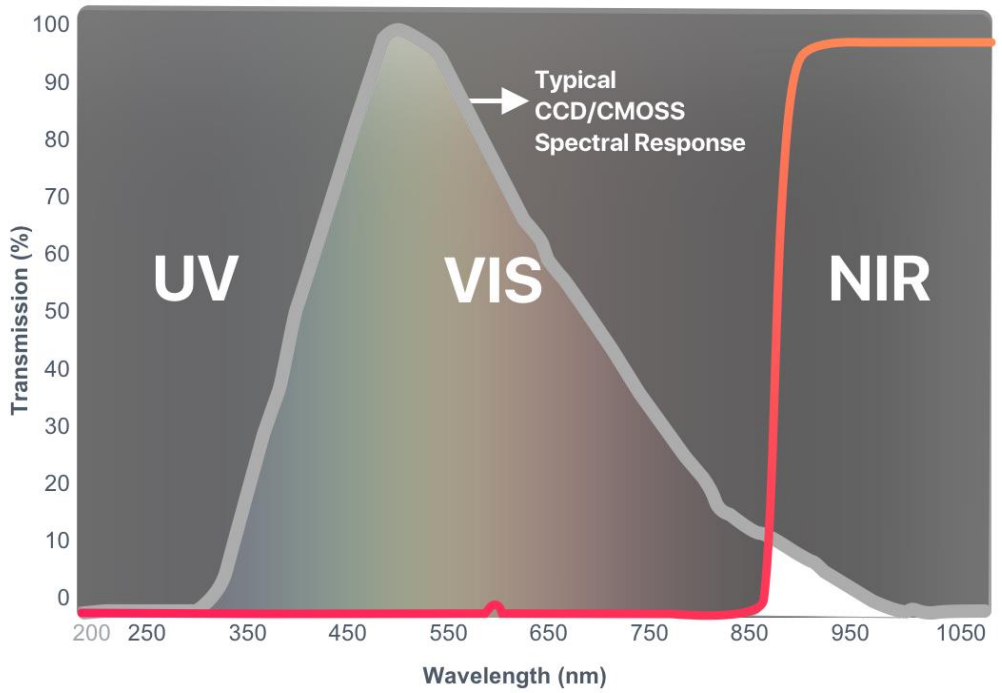




Courtesy of Midwest Optical Systems Inc.

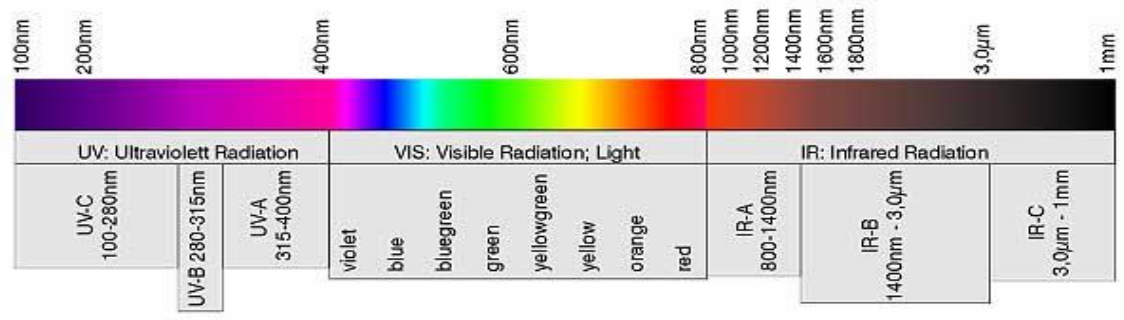
Longpass Filter for NIR

With MidOpt LP920 Filter



Courtesy of Midwest Optical Systems Inc.

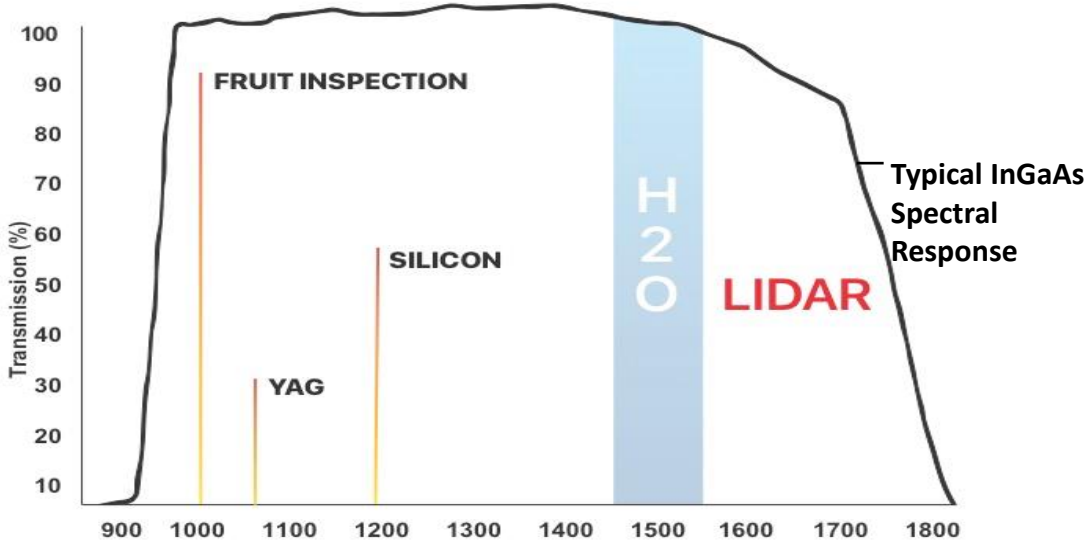
Short Wave Infrared Imaging
SWIR (IR-B) region 1400~3000nm



SWIR is sometimes called "reflected infrared“ and for this reason requires illumination in the relevant wavelength.

SWIR InGaAs camera sensor
spectral response (900nm-1700nm)

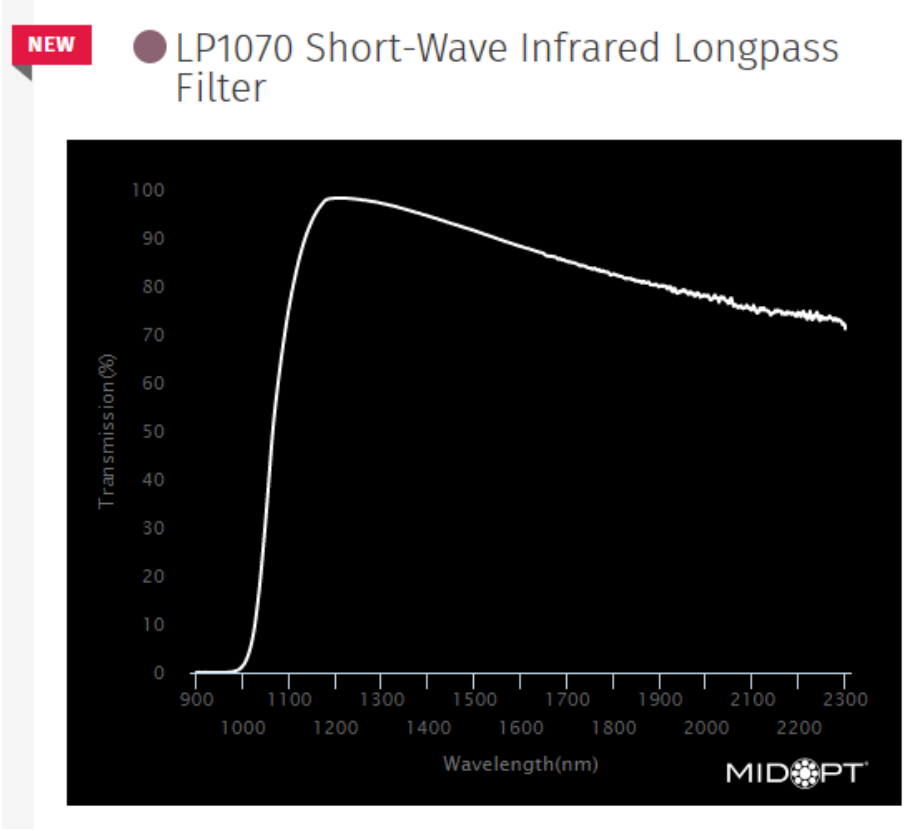
We do offer extended range SWIR cameras
operating out to 2500nm



Courtesy of Midwest Optical Systems Inc.

Longpass Filter for SWIR

As with NIR imaging, SWIR imaging can also benefit with the use of longpass filters to reduce the effects of the NIR region wavelengths on the sensor and increase contrast. This is an economical solution for isolating wavelength regions - Recommended when imaging in the SWIR with an InGaAs sensor



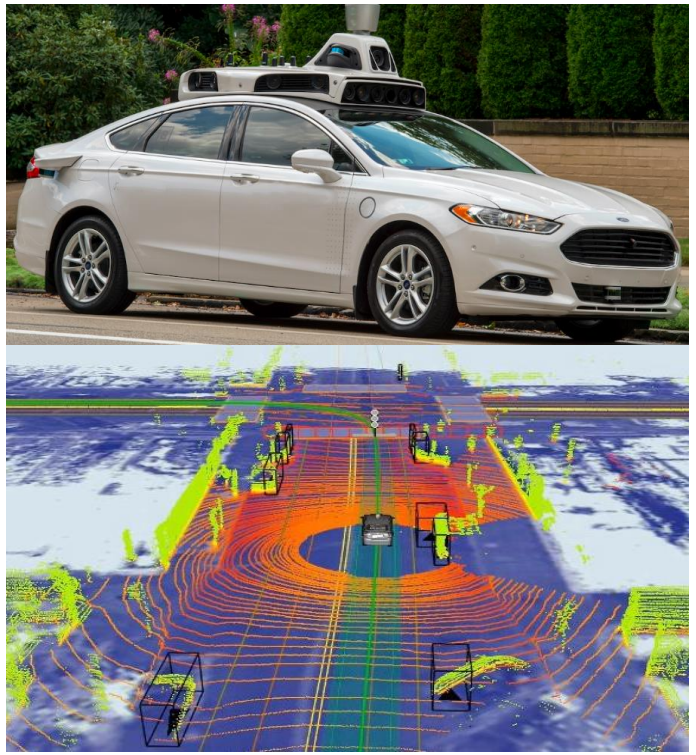
Courtesy of Midwest Optical Systems Inc.

SWIR – Short-Wave Infrared Imaging Examples

- Moisture detection - 1450nm
- LIDAR for autonomous vehicles - 1550nm+

Visible light

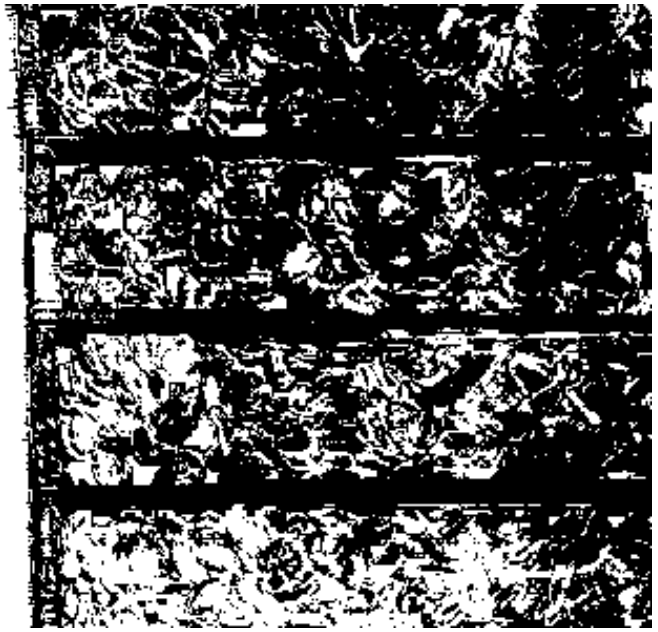
SWIR 1450nm moisture detection



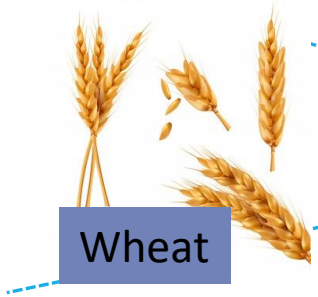
Courtesy of Midwest Optical Systems Inc.

Application note:
Moisture inspection for foods

Purpose: Moisture inspection by 2 different SWIR wavelengths
BlueVision Cameras: BV-C3200, BV-C3201



High (Moisture)



*** By 1200nm and 1450nm**

Low Moisture

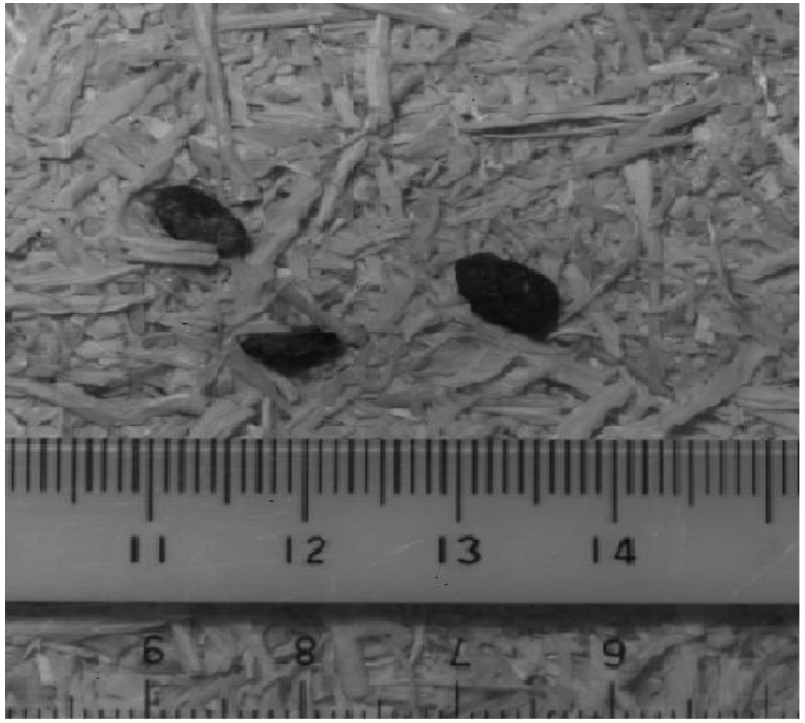
Moisture contents of food can be captured in black gradation (grain, tea leaf, dry food, fruit…etc)

Application note: Contamination inspection for Tea Leaf

Purpose: Tea Leaf inspection by wavelength(Stone contamination in tea leaves) BlueVision Cameras: BV-C3500, BV-C3200, BV-C3201

【Visible camera】

【SWIR camera】

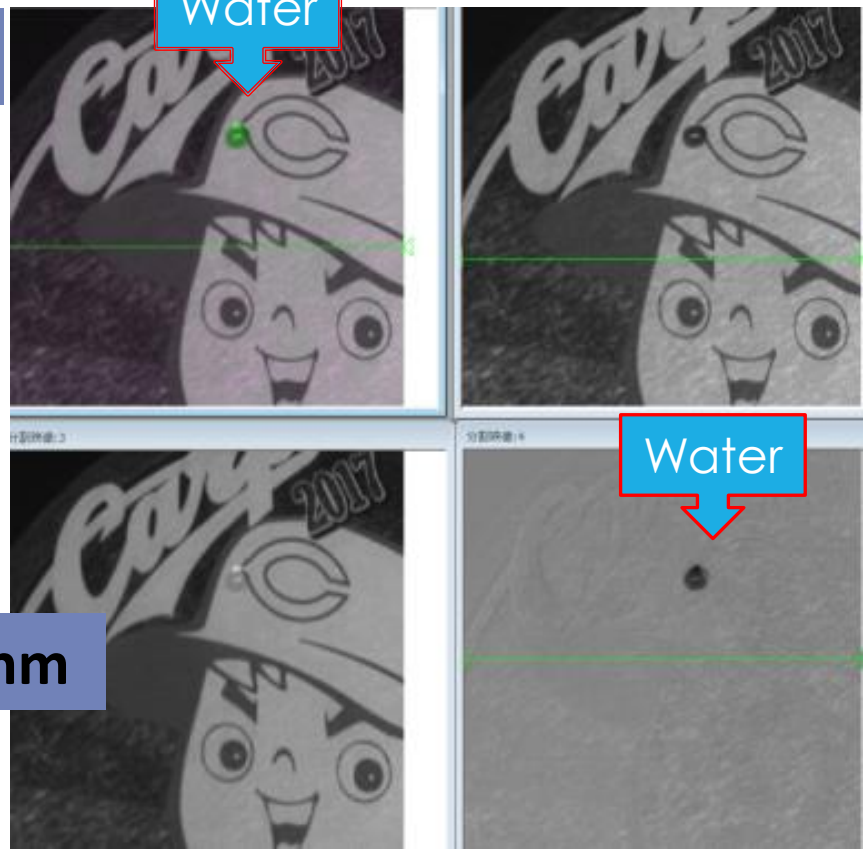


Application note: Beverage pack inspection for water leak

Application: Water leak inspection by 2 different wavelengths (1200nm, 1450nm)

BlueVision Cameras: BV-C3200, C3210, C3500

①+②



②1200nm

①1450nm

①−②

Application note: Meat inspection

In this application SWIR light is being used to inspect the vein structure and hence infer quality level and respective pricing

VISIBLE

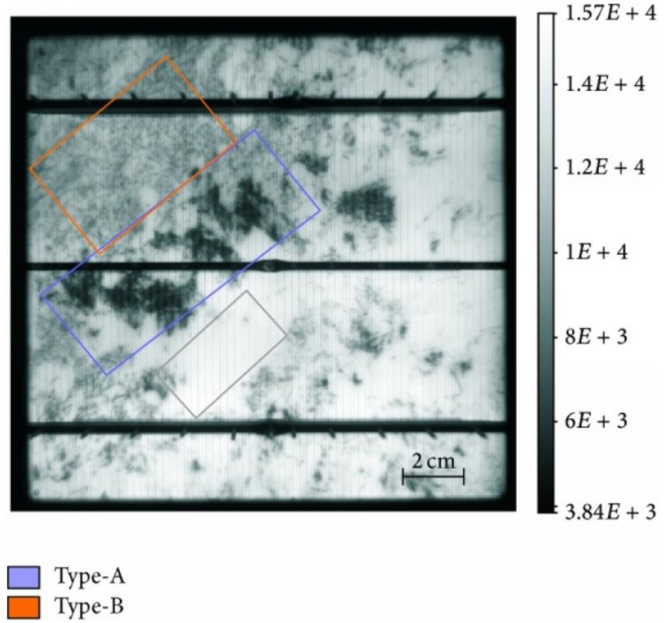
1580nm Reflection

1580nm Backlight

Application note:
Solar Cell Inspection and Characterisation

Solar Cell Inspection

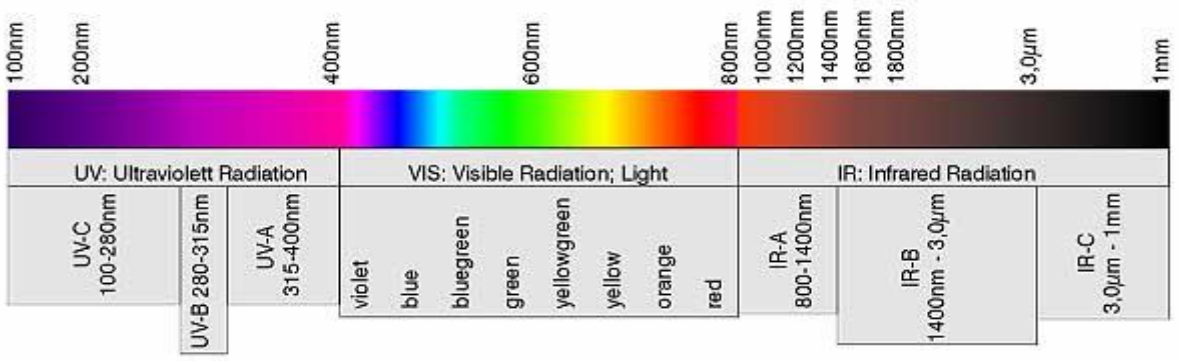
SWIR imaging enables you to look “through” the silicon wafer and therefore allows inspection of defects and failures, which cannot be detected and visualized by other methods. The applications which can be covered include inspection of metallization layers from the back side of the wafer, short and contact/bridge defects, inclusion tracing, flip-chip inspection and inspection of buried structures. For solar cells characterization techniques based on electroluminescence can provide spatially resolved information about the performance of a solar cell.



Silicon material inspection

Due to silicon's transparency beyond 1200 nm, SWIR InGaAs cameras can be used to reveal defects in silicon ingots, before cutting them into wafers. Furthermore, wafers can be inspected to detect cracks defects and saw marks, not only on the surface but also inside the wafer.

Mid and Long Wave Infrared (Thermal) Imaging MWIR LWIR (IR-C) region 3µm~15µm



MWIR and LWIR is sometimes referred to as "thermal or passive infrared". Due to the nature of the blackbody radiation curves, typical "hot" objects, such as exhaust pipes, often appear brighter in the MW compared to the same object viewed in the LW.

MWIR and LWIR imaging does not require illumination as the thermal camera sensors are measuring the emissions from objects within the field of view.

Thermographic cameras can measure the temperature of the object being viewed. This accuracy can be improved by placing a stable blackbody emission unit in the field of view and using this as a calibration standard for the viewing camera.

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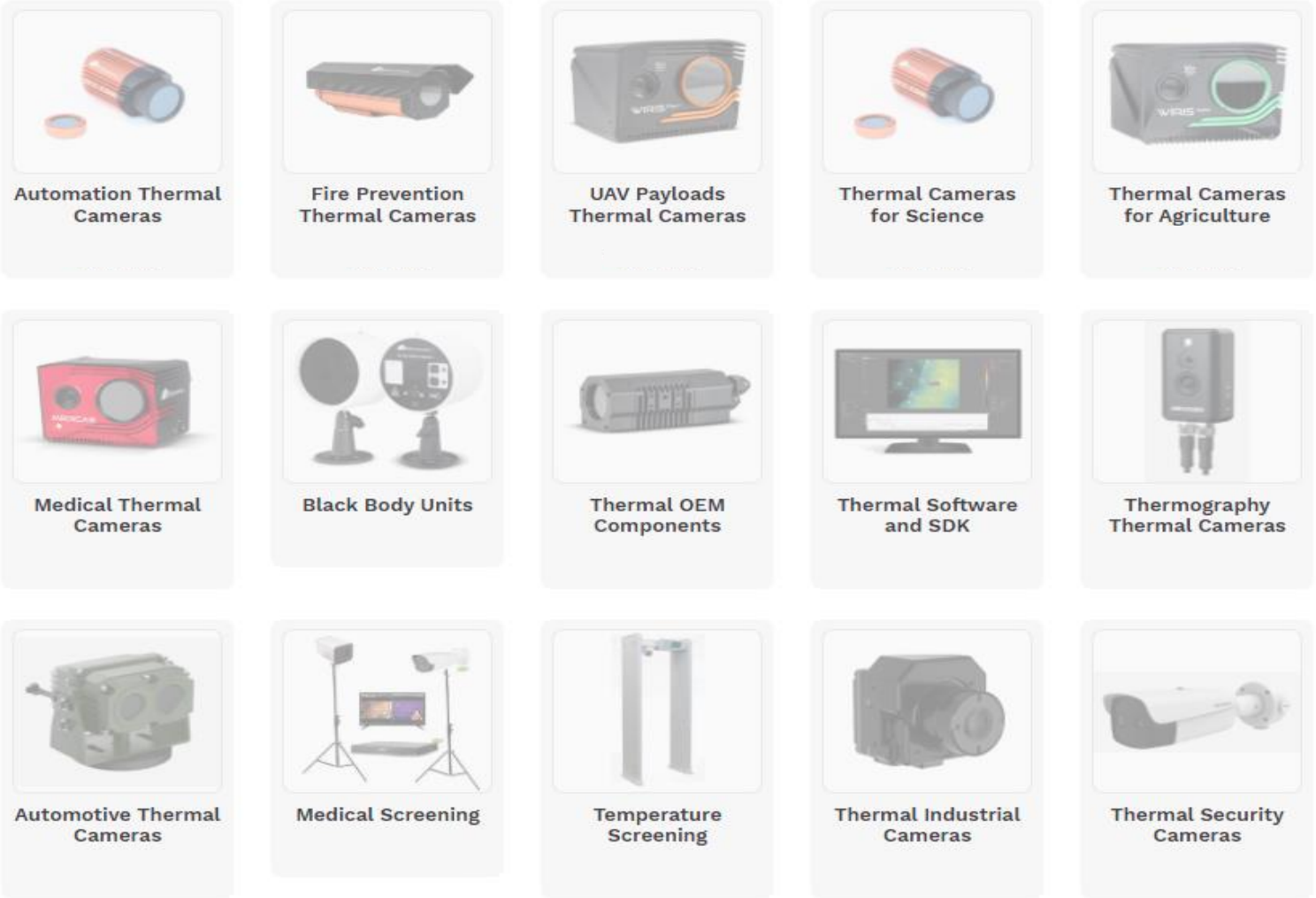
Mid and Long Wave Infrared (Thermal) Imaging MWIR, LWIR (IR-C) region 3µm~15µm

ALRAD THERMAL

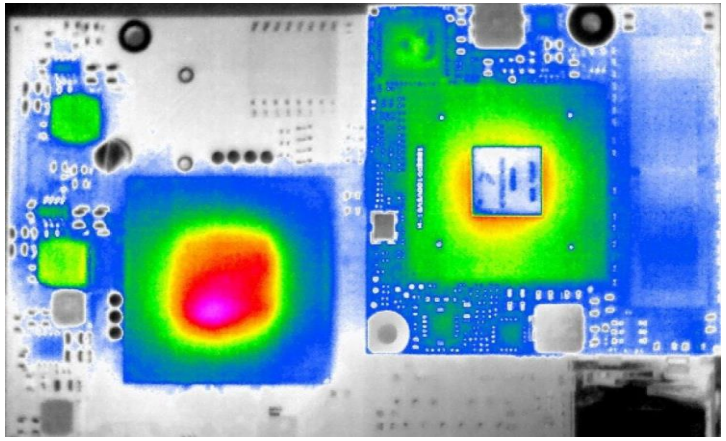


ALRAD provides a wide range of Thermal and Thermographic cameras to Industry and commerce

Weblink: ALRAD Thermal

Mid and Long Wave Infrared (Thermal) Imaging
MWIR LWIR (IR-C) region 3µm~15µm

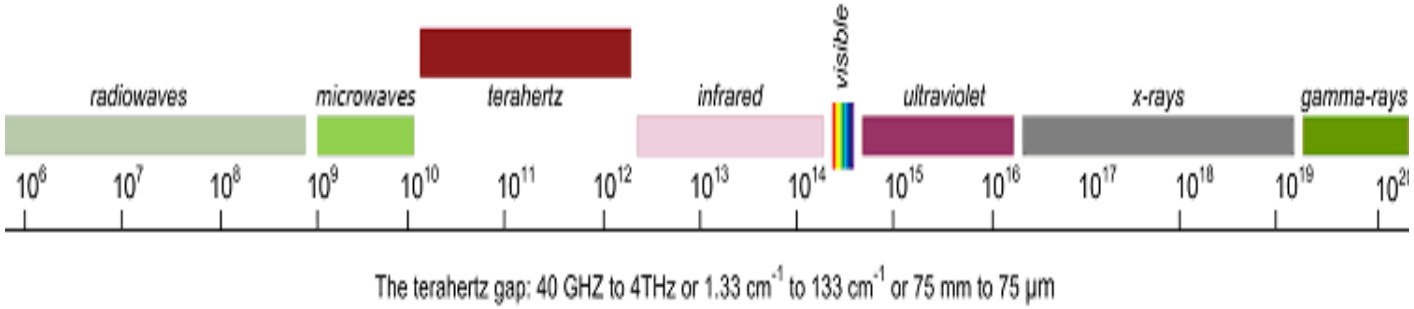
WORKSWELL®
INFRARED CAMERAS AND SYSTEMS



Applications:

- Industrial Inspection – Electrical Installations, Chemical Plants, Oil & Gas Installations
- Thermal surveys of buildings for heat loss and insulation inspection.
- Automation – Packaging inspection, Hot Glue inspection
- Food Processing – Process control
- Security – Fixed / Mobile / Handheld / CCTV
- Automotive – Driver aids
- Medical – Temperature Screening

Terahertz Imaging
THz region (40GHZ to 10THz)



NEW-GENERATION TERAHERTZ IMAGERS

TeraSense has developed and patented a ground-breaking technology for making new-generation semiconductor imaging systems for Terahertz (THz) and sub-THz frequency ranges. TeraSense devices bridge the gap of 0.1 – 1.0 THz since exploiting this particular frequency band has been arousing increasingly more interest as it opens far-reaching possibilities for creating the state-of-the-art visualization solutions to meet the growing demand for sophisticated and cost-effective instrumentation. Owing to its harmless and versatile nature, there is whole host of viable practical applications of THz imaging technology to be realized, from non-destructive industrial product quality control in manufacturing and agriculture to non-invasive medical diagnostics and security screening.

TeraSense - Terahertz Imaging
THz region 50 GHz to 1.0 THz

TeraSense
Terahertz imaging systems

Terahertz imaging cameras

- Frequency range: 50 GHz – 1.0 THz
- High responsivity
- Operating room temperature
- Compact size and low cost
- Video mode (50 fps)
- TeraSense Viewer ® Software
- USB powered (5V)

Terahertz imaging scanner

- Number of pixels: 256 (256 x 1)
- Pixel size: 1.5 x 3 mm^2
- Imaging area: 384 x 3 mm^2
- Responsivity: 8000 V/W
- Compact size and low cost
- Video mode (50 fps)
- TeraSense Viewer ® Software

TeraSense - Terahertz Imaging
THz region 50 GHz to 1.0 THz

TeraSense
Terahertz imaging systems

Terahertz security body scanner

- Hidden remote imaging
- High throughput screening
- Stand-off imaging from 3 m
- Requires no infrastructure and can be set up in minutes
- Compact size and low cost

Terahertz Sources (IMPATT Diodes)

- Available frequencies: 100 GHz, 140 GHz, 180 GHz and 300 GHz
- High output power: up to ~ 400 mW
- Protective isolator for enhanced stability
- Line-width can be narrowed down to 1 MHz
- TTL modulation option
- Stable current source (operating current 150-180 mA)
- High gain horn antenna — or — WR- type flange

Applications of Terahertz Imaging

Terahertz quality control
Non-destructive (NDT) analysis of internal structure of objects, enabling visualisation of contents of sealed packages or food products under various enclosures.

Terahertz imaging security
Systems for people and luggage screening. THz radiation is not detrimental to human body and allows remote detection of metallic, plastic, ceramic and other objects concealed under clothes — at a distance of several meters.

Terahertz wireless communication
High-frequency wireless telecommunication systems (up to 100 Gbit/sec). Building a new generation of high-speed information transmission between electronic devices; building wireless local area networks (WLAN) and wireless personal area networks (WPAN), as well as creating entirely secured dedicated wireless channels of communication.

Terahertz imaging in medicine
THz tomography allows analysis of the upper layers of a human body — skin, vessels, joints and muscles. There are successful applications of THz tomography for detecting skin and breast cancers at early stages. THz imaging has the capability of visualizing conditions of wounds under gypsum (plaster of Paris) bandage layers.

Terahertz science
The scientific applications of THz radiation include spectroscopy of long-wavelength lattice vibrations of crystals, bending vibrations of molecules. Frequencies of soft modes in ferroelectric materials and frequencies matching the energy of apertures in superconductors are also «residing» within the THz range. Terahertz frequency range is convenient for creation and study of meta-materials and plasmonic effects.

Two key THz application fields that are currently used in world practice are:

1) High speed conveyor THz imaging systems for postal office screening (envelopes, packages, parcels, etc.) – this uses a THz Linescan camera.

2) Identification of chemical substances based on the characteristic features of their terahertz spectrum acquired by portable Raman spectrometers.

Applications of Terahertz Imaging

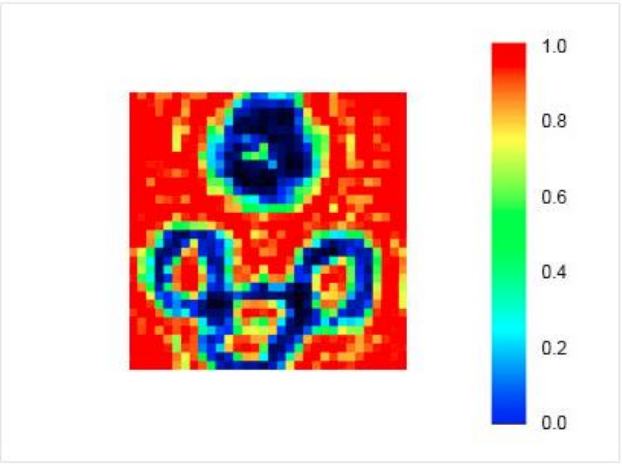
Food and Agriculture

Perhaps more so than anywhere else, in the food and agricultural industries it is highly critical for quality control and inspection testing to avoid the use of ionizing radiation (X-rays) due to their detrimental effect on biological agents. This is where terahertz imaging technology is extremely useful; for instance, checking if a robotic arm has put all candy bars into the carton, or checking for foreign bodies and insects inside of packaged food containers. Seeing through cardboard or PE packaging poses no problem to THz imaging. Checking the quality of various agricultural products like nuts and seeds also opens up huge perspectives for THz technology in this field too.

Terahertz inspection of nuts

Determination of the quantity and quality of nuts contained inside a nutshell is just one of the problems which Terahertz imaging systems can effectively solve. THz cameras allow identification of carcinogenic Mycotoxin fungus contaminating peanuts, corn, other grain-crops and oil-plants. In particular, with the aid of THz imagers one can detect the signs of such nut infections as Aspergillus flavus and Aspergillus parasiticus under the nutshell which exude an extremely dangerous carcinogen, Aflatoxins B1.

Picture of four hazelnuts, the one on top is infected with Mycotoxin fungus.



Terahertz image of the same hazelnuts (100 GHz). It is clearly seen that the upper nut infected with fungus shows much lower transmission in THz light.

Applications of Terahertz Imaging

Pharma

There are a number of materials used in Pharmaceutical and Cosmetics industries which are fairly transparent in terahertz waves. This makes THz imaging technology very attractive as a harmless non-destructive testing (NDT) technique for drugs, pills, medical products on industrial production lines.

Tablet manufacturers can use the high-speed terahertz imaging scanner at a speed up to 15m/sec for quality control (QC) to make sure every pouch in a tablet blister is properly filled with a tablet and that there are no empty blisters.

Paper, carton and plastic are common packing materials and completely transparent in THz light, which enables Terasense technology to ‘see through’ the package and identify all missing items.

Quality control in pill production

In the pharmaceutical and cosmetics industries, composites, paper, polyethylene (PE), and plastics and their derivatives are commonly used as packaging materials. Such materials have been proven to be fully transparent to THz rays, enabling the technology to **identify missing items** inside the packaging.

Pharmacy-related manufacturers need to ensure that every pouch in a tablet blister pack is properly filled, and that there are no empty blisters at the end of the process line. Likewise, it is important to check if quick-dissolving capsules have been properly filled with the active substance (reactant).

Another task is to check plastic pill-containers for fullness. Plastic containers are often intentionally manufactured to be opaque in visible light, while they remain perfectly transparent in the Terahertz spectrum and can be subjected to NDT inspection.

For some applications in the pharmaceutical and cosmetics industries, X-rays are not acceptable and THz inspection is a suitable non-ionising alternative.

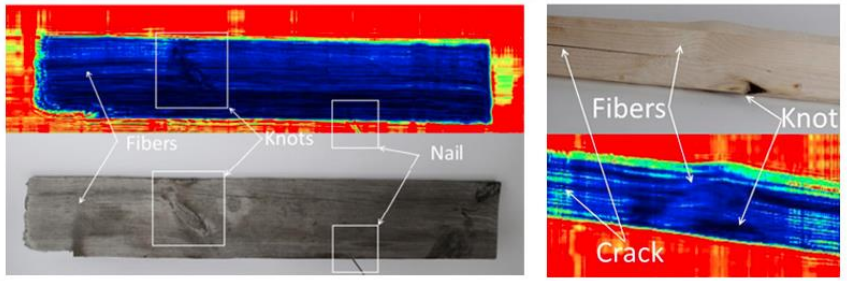
Applications of Terahertz Imaging

Wood

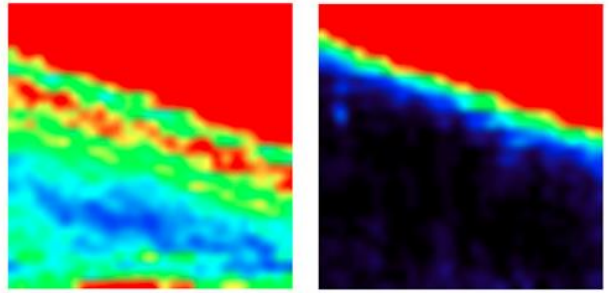
A number of industrial NDT techniques including X-ray density scanning, infrared moisture sensors, visible light optical scanners and microwave kiln drying, employ separate parts of the electromagnetic spectrum to provide imaging of the wood in the wood processing industry.
The high-speed THz imaging scanner solution from TeraSense combines these features and provides the detection of hidden defects in wood (which are difficult to detect using other technologies, e.g. color vision) including but not limited to, knots, hollows, and foreign bodies like nails, screw, wormholes and rotten as well as wet areas.

NDT inspection for wood processing

THz technology offers the capability of transmission imaging that in real time can probe the internal structure of a non-conductive dry material with sub-mm spatial resolution. THz imaging vividly demonstrates the ability to check the internal configuration of the wood and see all hidden grooves, hollows and air pockets.
Other promising applications include detecting termites and other insects inside the wood and analysing the wood for moisture content. The latter is a sure-fire method of determining wet areas inside a wooden log (or depending on the «grey scale», even estimating the volume of water inside the wood).



THz images of wooden boards



Dry wood board (14mm thick) Wet Wood board

THz imaging technology is essentially less invasive than X-ray technology. Terahertz radiation has no ionizing effect and is harmless to people and other living beings. There's no need to use any of the restrictions and precautions that are obligatory for X-ray machines.
Its unique capability of harmlessly penetrating wood and its sensitivity to fiber structure makes terahertz technology ideally suited to applications in many wood processing fields, ranging from sawmills and lumbering to furniture production shops.
For a non-destructive test of wooden products, TeraSense offers a unique Terahertz High Speed Imaging Scanner which fits most conveyors with a belt running speed of up to 15 m/s.

Applications of Terahertz Imaging

Ceramics

One of the important aspects in the ceramic tile industry is to monitor density gradients in ‘green’ tiles right after their formation in a press and examine finished tiles for various defects. Unlike x-ray technology, the TeraSense THz imaging is highly sensitive to density deviations and especially to moisture content of ceramic samples. The TeraSense technology is your instrument to monitor density deviations in a tile right from the forming press and to provide feedback for a powder feeding machine.

Advantages of the THz imaging system

- Extremely high image acquisition rate (up to 5000 fps)
- Non-destructive (no ionizing radiation)
- Powerful tool for inspection of defects in dry tiles
- Powerful tool for measuring density or humidity variations in wet tiles
- Low cost solution

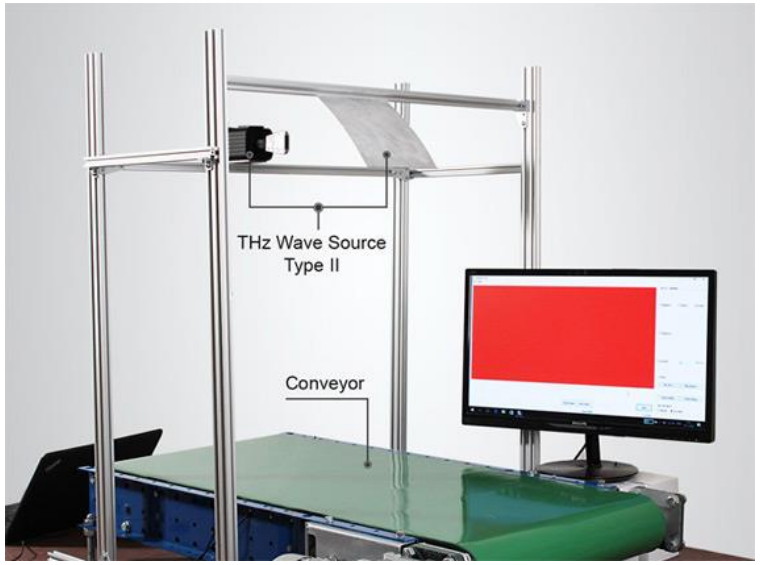
Basic specifications of the system Type II

CAMERA

•Operation frequency: 100 GHz
•Image acquisition rate: up to 5000 lines per second
•Image width and number of pixels: custom (typical 384 x 3 mm2, 256×1 pixel)
•Pixel pitch: 1.5 mm
•Spatial resolution: 3 mm
•Fits conveyor belt running speed up to 15 m/s
•Original software: TeraFast® Viewer
•Interface: mini-USB
•Power supply: 24V / 20W

SOURCE

•Operation frequency: 100 GHz
•Power per camera pixel: 140 µW
•Reflection beamforming optics
•Protective isolator for enhanced stability

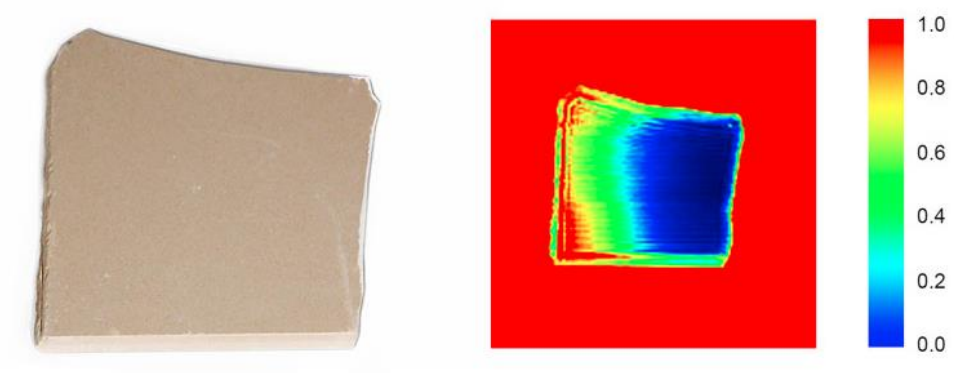


High Speed Linear Terahertz Scanner with Type II sub-THz Source.

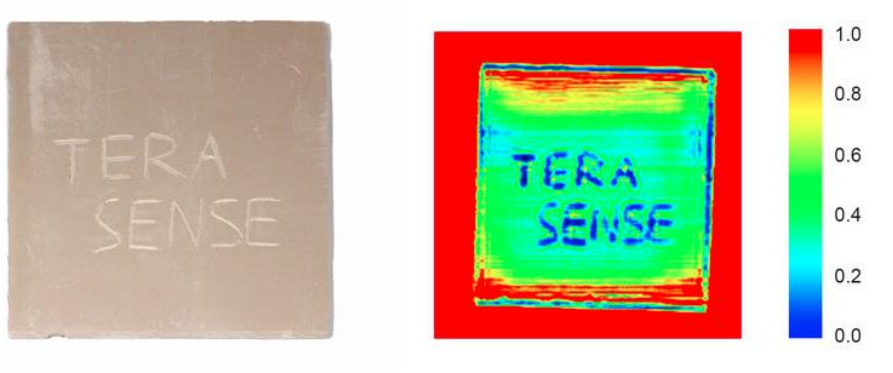
Applications of Terahertz Imaging

Ceramics

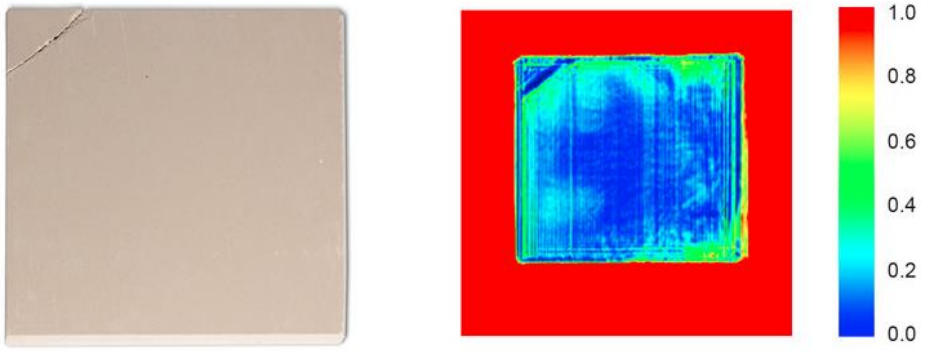
Example Images:



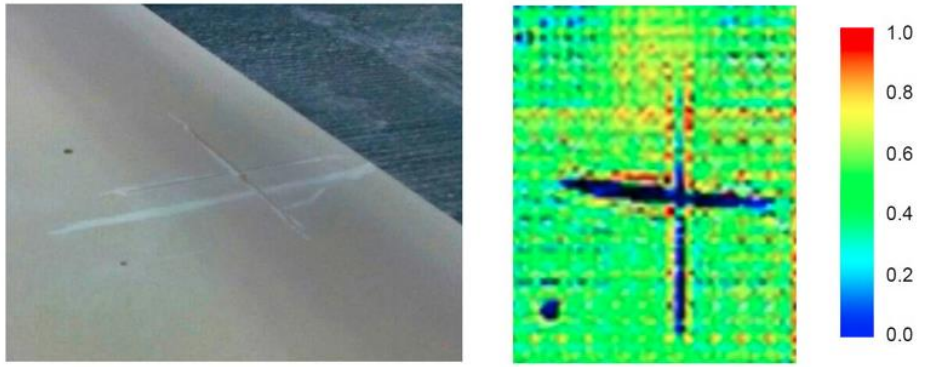
THz transmission image of a 'green' ceramic tile with strong moisture gradient from 0% to 3%.



THz transmission image of a tile with scratched text on it. The scratched text, which in fact is a non-uniform surface, shows a lower transmission in the the scattering properties of the terahertz radiation.



THz transmission image of a cracked 'green' tile with humidity gradient: 1.5 – 2.2%. Cracks, hidden defects and moisture gradient of the tile are clearly detectable.



THz transmission image of a dry ceramic tile. Holes and scratches can be clearly seen.

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- Swivellink
- TeraSense
- The Imaging Source
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- ToupTek
- Trimble
- Tucsen
- V S Technology
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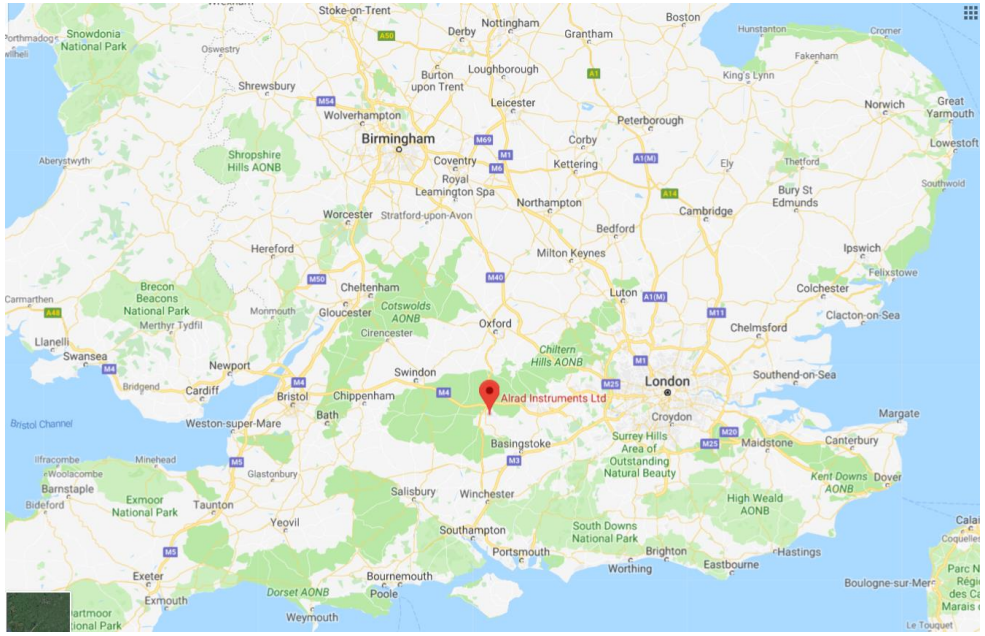

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