Allied Vision

// ALLIED VISION INFRARED CAMERAS

Let's see the invisible

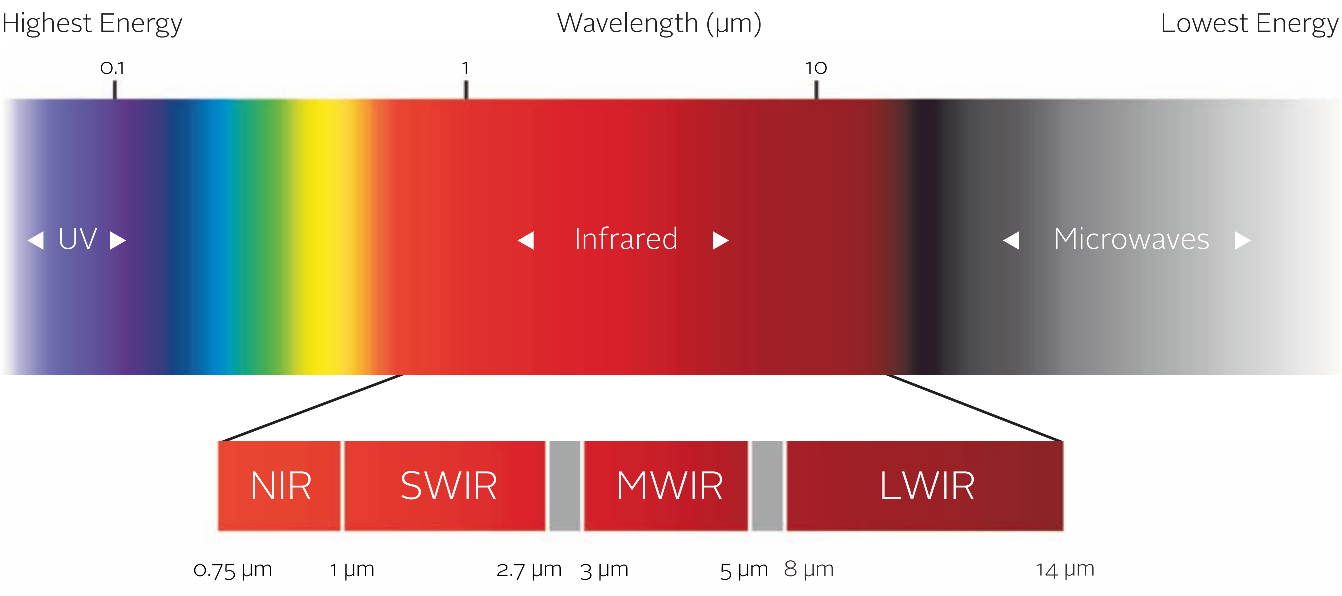
SWIR and LWIR camera technology

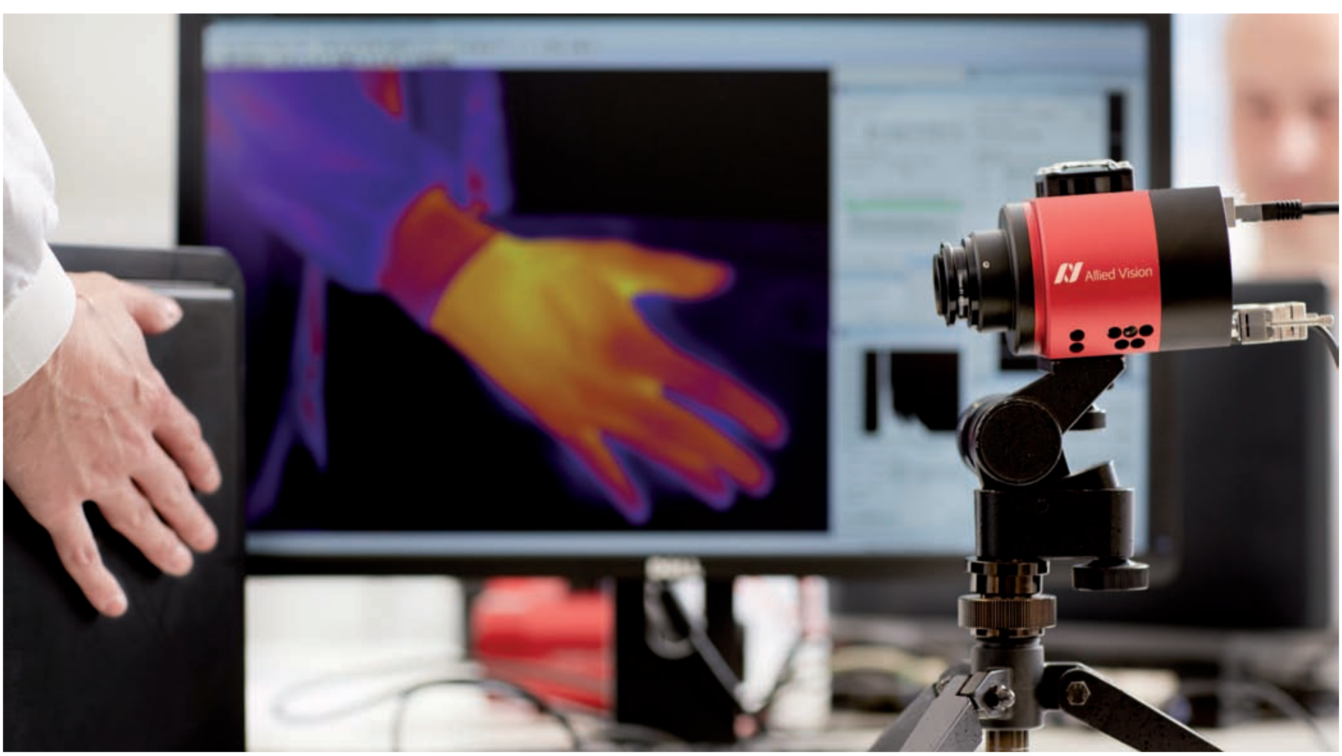
// VISIBLE AND INVISIBLE LIGHT

Infrared radiation

In everyday life, we encounter electromagnetic radiation in many different forms such as visible light, ultraviolet light, radio waves or X-rays, differing only in their wavelengths. Within the electromagnetic spectrum, infrared radiation is located between visible light and microwaves.

Major divisions of the electromagnetic light spectrum





Detecting different types of radiation

All physical objects constantly emit infrared radiation. The hotter an object gets the more radiation is emitted with shorter wavelengths and higher intensity. The radiation intensity at moderate temperatures (above 25 °C) a level that we can detect as heat.

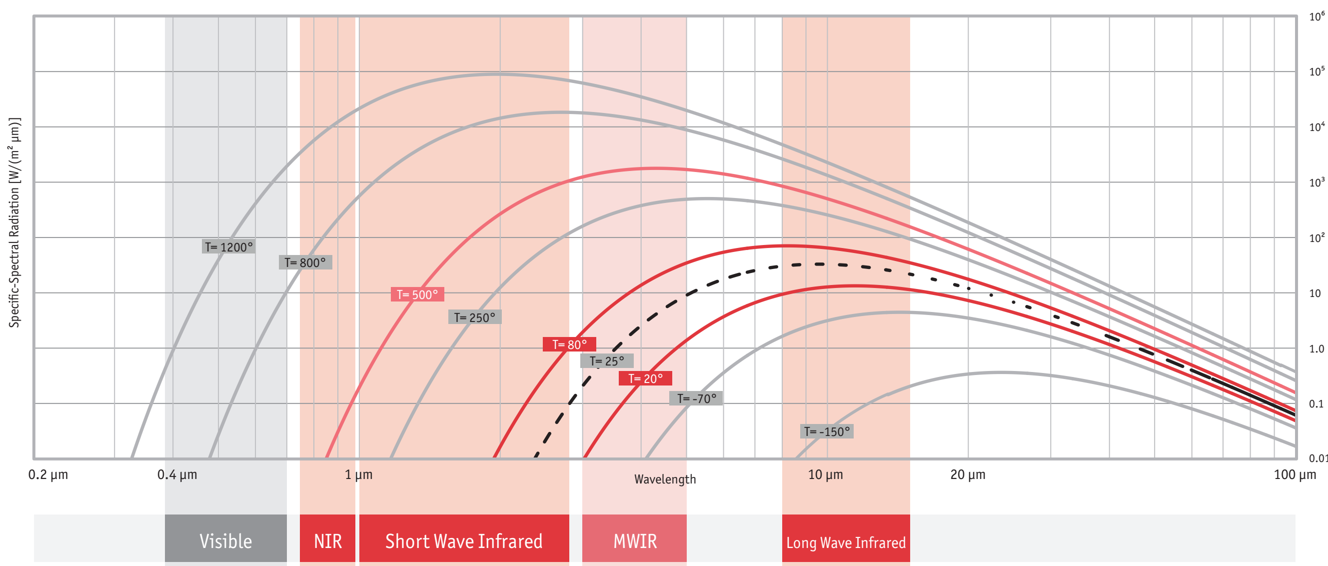
At temperatures above 800 °C, the intensity is high enough and the wavelength short enough for the radiation to pass the threshold at the red end of the visible light spectrum. Hence, steel glows red upon heating and becomes white the hotter it gets.

This means that IR radiation and likewise heat can be detected and measured with cameras calibrated accordingly.

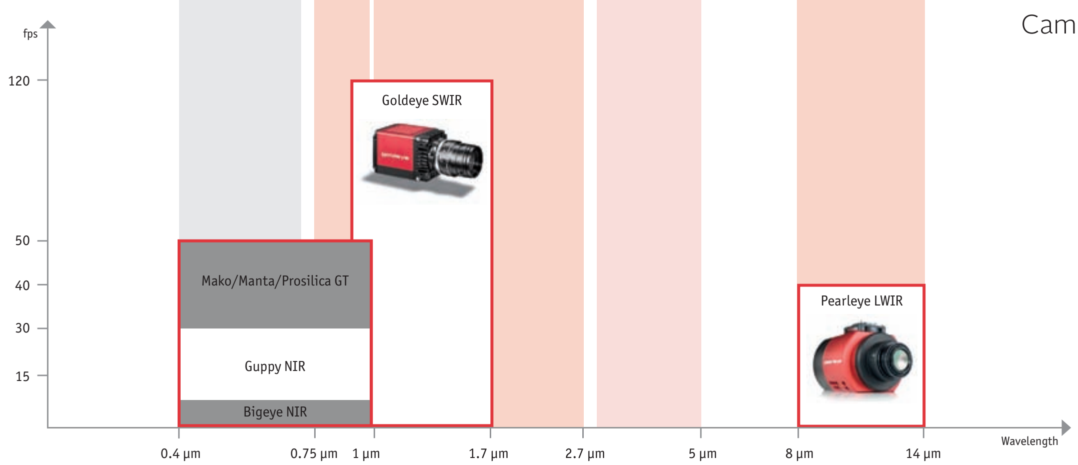
Allied Vision provides cameras for the following spectral bands: Visible light, NIR, SWIR, and LWIR. Thereby, for each spectral band a corresponding sensor technology is used. In general, it can be distinguished between two principles: Quantum and thermal detectors.

Coming back to the temperature measurement capabilities of cameras, the diagram below shows the intensity of radiation in dependency of the wavelength emitted by an object with the given temperature. As you can see, LWIR cameras can ideally detect and measure temperatures between -70 °C and +250 °C, as here the peak of the radiated energy emitted by an object corresponds with the detector's, spectral sensitivity range. In contrast, SWIR cameras are best suited to measure temperatures above 250 °C and up to 800 °C. Above 800 °C, thermal imaging can also be performed with CCD or CMOS cameras normally used for capturing visible images.

Black-body spectrum for temperatures between -150 °C and 1200°C



Cameras from Allied Vision
for IR imaging



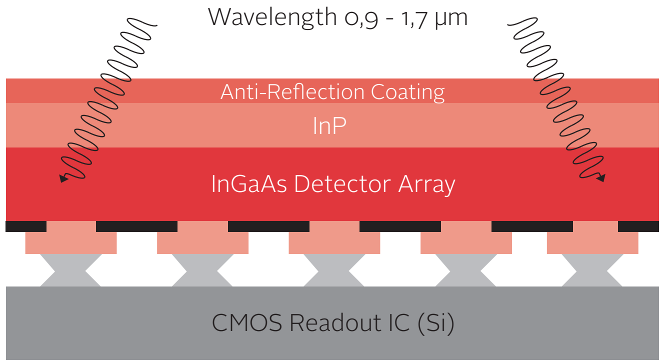
// SWIR CAMERA TECHNOLOGY

The invisible light

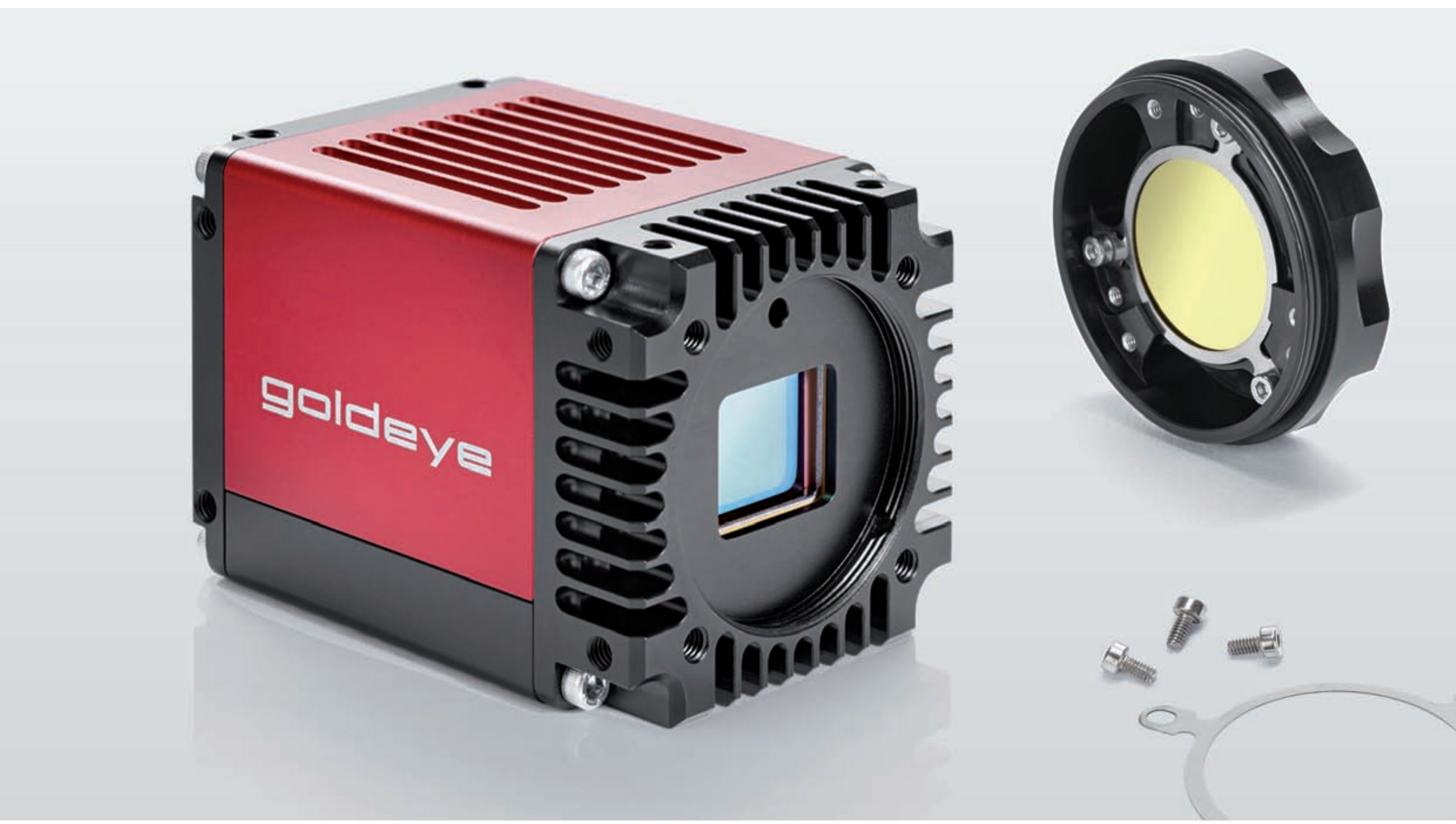
Sensors used in SWIR cameras work similar to silica based CCD or CMOS sensors by converting photons into electrons – so called **quantum detectors**. But to be able to detect light beyond the visible spectrum, their photon sensitive area is made of materials such as Indium Gallium Arsenide (InGaAs) or Mercury Cadmium Telluride (MCT - HgCdTe). Thereby, in dependency of the material composition (chemical structure), these sensors are sensitive in different wavelength ranges and might require a strong cooling to achieve a proper SNR ratio (sometimes down to cryogenic temperatures using liquid nitrogen or a small Stirling cycle refrigerator unit).

In contrast to silicium-only based CCD and CMOS sensors, an InGaAs sensor is made of different materials. Combining these materials is a relative complex and time consuming technology, as many manufacturing steps are needed. Additionally, the production yield is relatively low. This is mainly caused by difficulties that may occur when connecting the CMOS read-out circuit with the photosensitive part of the sensor. All this makes these sensors types quite expensive.

Two other differences between CCD/CMOS and InGaAs sensors are of interest: Currently, it is not possible to combine the ROIC (read-out circuit) with the photosensitive area with 100% accuracy during the hybridization. Therefore, InGaAs sensors have a much higher percentage of defective and non-uniform pixels which makes a proper image correction in the camera inevitable.



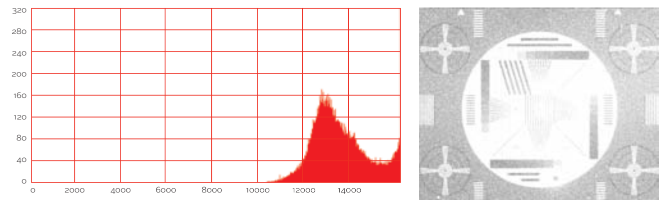
Architecture of an InGaAs photodetector



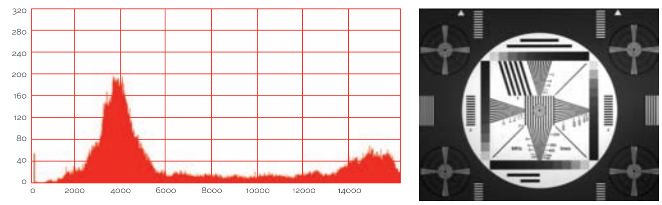
In addition, the band gap between valence and conduction band is smaller for InGaAs semiconductors. This means the thermal excitation of electrons into the conduction band and collection in the ROIC wells is much easier. As a result, the dark current values are higher and a proper and cost-effective cooling is needed to reduce image noise and to enable longer exposure times. That's why most of the InGaAs sensors are equipped by default with thermo-electric cooling (TEC) elements. But sensor cooling does not only reduce the image noise, it also effects the proper correction of non-uniform and defect pixels.

SWIR cameras of Allied Vision are equipped by default with high sensitive, global shutter InGaAs focal plane arrays (FPA). An integrated single- or dual stage TEC cooling ensures extremely low dark current values, which help to achieve an extraordinary image quality.

Although infrared radiation in the short wave infrared region is not visible to the human eye, it interacts with objects in a similar manner as visible wavelengths.



5 seconds exposed image at + 5 °C sensor temperature



5 seconds exposed image at – 30 °C sensor temperature

Therefore, images from an InGaAs sensor are comparable to visible light images in resolution and detail; however, SWIR images are not in color.

Furthermore, InGaAs sensors can "see" even at night and under other challenging conditions like dust or haze.


Finally, one major benefit of SWIR imaging, which is unmatched by other IR imaging technologies, is the ability to image through glass. For SWIR cameras, special and very expensive lenses are mostly unnecessary.

See the unseen

Goldeye short-wave infrared (SWIR) cameras incorporate high-performance InGaAs sensors sensitive in the NIR/SWIR spectral range from 900 nm – 1,700 nm. The cameras are available in two different flavors:
A compact, ruggedized design without fan; and an advanced scientific design with nitrogen gas filled cooling chamber (Cool models).

All Goldeye cameras are equipped with an active thermoelectric cooling (TEC) to reduce noise and to enable extended exposure times as well as constant image quality independent of the ambient temperature. In combination with 14-bit image processing and the numerous on-board image correction features, Goldeye cameras produce an outstanding, low-noise image quality.

The extended feature set, comprehensive I/O control and multiple mounting options facilitate simple system integration. In addition, locking functionality at all connectors enable a secure operation.

All this together make Goldeye cameras the perfect choice for industrial and scientific applications beyond the visible spectrum.

Options

Modular concept:
// C-, F-, or M42-Mount adapters
// Various IR filters
// Silver housing

Further InGaAs cameras with CameraLink interface or QVGA sensors available.

Smart Features & Benefits

// **Built-in image correction** to ensure optimized image quality:
- Non-uniformity correction (NUC)
- Defect pixel correction
- Background correction

// **Comprehensive I/O control options including multiple Trigger modes**
Enable eased system integration

// **Pre- and post-trigger recording (Recorder Mode)**
Prevent missing any detail

// **ROI settings StreamBytesPerSecond, and Stream Hold**
For entire frame rate and bandwidth control

// **High analog gain mode**
Increased sensitivity in low-light applications

// **Look-up tables and Gamma control**
Improve contrast to see what really counts

// **Event Channel and Chunk Data**
Knowing what's going on inside the camera and track it

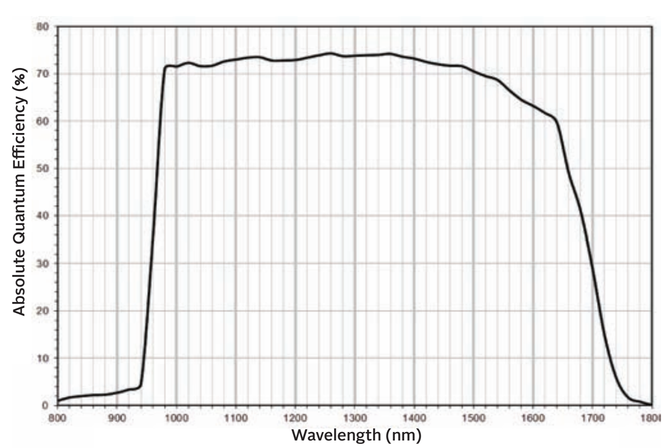
// **Storable user sets**
For simplified camera setup

// **Firmware update in the field**
Enables eased maintenance

Operating Conditions

Power requirements	DC 10.8 ... 30 V or PoE/PoE+
Power consumption	5 W with TEC off
Operating temperature	-20 °C ... +50 °C case temp
Storage temperature	-30 °C ... +70 °C
Regulations	CE incl. RoHS (2011/65/EU)
Shock & Vibration	ISO60068-2-27 and ISO60068

Spectral Sensitivity



Model	Resolution	Frame rate	Pixel size	Sensitive area	Cooling power	Size [WxHxL] mm	Weight
G-032 SWIR TEC1	636 x 508	100 fps	25 µm	15.9 mm x 12.7 mm	max. dT=-30K	55x55x78	< 420 g
G-032 SWIR Cool TEC2	636 x 508	100 fps	25 µm	15.9 mm x 12.7 mm	max. dT=-60K	80x80x90	< 860 g

*without lens

Highlights

- // InGaAs SWIR sensors, with >99.5 % pixel operability
- // Spectral sensitivity ranging from 0.9-1.7 µm
- // Robust industrial or advanced scientigic design
- // 14-bit digital image processing with low noise
- // Simple system Integration
- // Very compact size
- // Multiple camera mounting options
- // GigE Vision interface with Power over Ethernet (PoE/PoE+)
- // Peltier cooling for continuous high-quality SWIR imaging and long exposure times up to 6 s (Cool versions)
- // Comprehensive I/O control options
- // Flexible lens mount selection and filter integration
- // Automated on-board image correction
- // Extended operating temperature range
- // 3 years warranty

// TYPICAL APPLICATIONS

Enhance your vision

Imaging beyond the visible

Short-wave infrared cameras enable various types of new applications or enhance current machine vision systems by imaging beyond the visible spectrum.

As an example, SWIR cameras are often able to “see” through surfaces that are non-transparent to the human eye. This feature helps to visualize underlying features such as fill levels, hidden moisture, or tamper-proof security codes.

Authentification of a bank note

Easy fill level detection

In contrast to MWIR cameras, SWIR cameras do not always require sensor cooling. In addition, no special lenses are needed as wavelengths between 900 nm to 2700 nm can pass through glass. All this helps to keep the overall system costs at a moderate level.

Additionally the usage, the use of filters, wavelength dispersive optics, or monochromatic light sources are convenient to capture a distinct and a measurable contrast of the inspected object.

Moisture Detection

Water absorbs strongly at wavelengths of 1450 nm and 1900 nm. By using a corresponding filter or lighting, this feature can be used for various inspection tasks:

// Verification of coatings or dryness uniformity in bulk material
// Fill level detection through non-transparent containers
// Detection of damaged or bruised fruit
// Gauging relative water content in plants

Items with higher water distribution will appear darker than drier ones.

Bad fruit seen by the human eye (left) and our cameras (right)

The technique described is usable in many industries like:

// Food & beverage, agriculture
// Mining
// Woodworking and lumber
// Textile and clothing
// Automotive

Spectroscopic Analysis

Each inorganic material has a different chemical composition and crystalline structure resulting in an unique spectral response corresponding to its specific light absorption characteristics.

Spectroscopy is non-destructive and requires no sample preparation in general. Therefore, many material attributes can be measured rapidly in-line for qualitative as well as quantitative parameters.

Typical applications are:

// Recycling & Plastic Sorting
// Geology & Mineral Inspection
// Pharmaceutical Quality Control
// Food & Agriculture
// Medical e.g. Disease Diagnosis

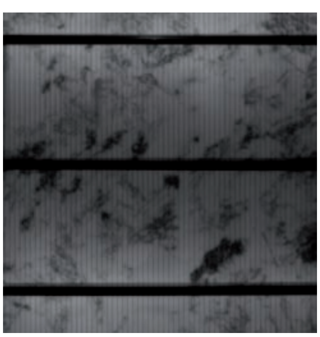
Semiconductor/Solar Cell Inspection

In the wafer and solar cell production, electroluminescence (light emission as a response to electric current) is used especially in the final production step of quality inspection to detect micro-cracks and printing problems. Whereas, photoluminescence (light emission as a response to light) can be applied throughout the entire manufacturing process. SWIR cameras are most qualified for these tasks because the light emitted by silicon has a peak at 1150 nm. Moreover, the quantum efficiency of InGaAs sensors is much higher towards NIR-enhanced cooled or uncooled CCD and CMOS cameras that are sensitive up to ~1000 nm.

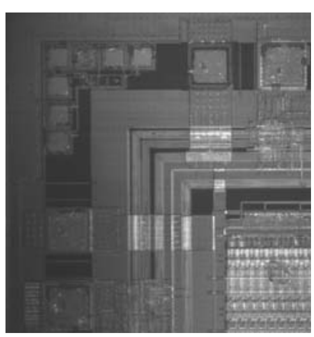
Additionally, at wavelengths below 1100 nm silicon is non-transparent. Thus, SWIR cameras are perfect for analyzing metallization and electrical contact errors on the backside of wafers.

Further Applications

// Metal and glass industry: Thermal imaging of hot objects (ranging from of 250 °C to 800 °C)
// Medical, science, and biology: Laser gauging
// Print industry: Banknotes inspection
// Art inspection
// Vision enhancement



Solar cell inspection



Semiconductor or wafer inspection

Art inspection - See the drawing under the paint
(Image provided by: Musée national d'histoire et d'art Luxembourg)

Detect infrared energy

Thermal detectors are classified by the type of technology used to measure the temperature. The most popular sensor for detecting infrared radiation between 8 and 14 µm is the bolometer or microbolometer.

The Microbolometer

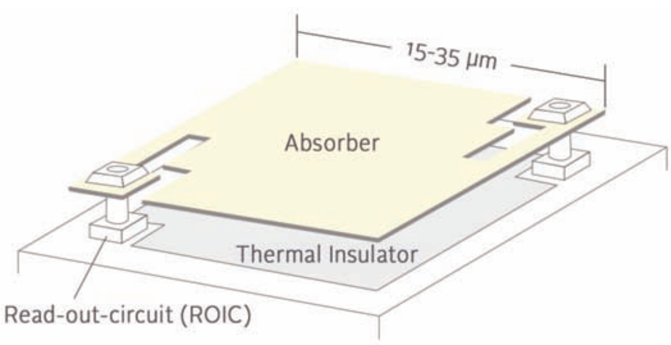
Bolometer sensors consist of resistive vanadium oxide (VOx) or amorphous silicon (a-Si) films. Such films detect electrical resistance changes related to temperature.

Because it is made of a single material rather than a complex mixture of different vanadium oxides, amorphous silicon presents many advantages: The composition of amorphous silicon does not show any variations. At the pixel level, the first benefit is high spatial uniformity. The second benefit is predictable temperature behavior, a factor that contributes to easier sensor operation in changing ambient temperatures.

For these reasons, but also because a-Si based sensors are more sensitive to temperature changes and have in general a higher quality (lower number of defective pixels), LWIR cameras from Allied Vision are only equipped with those sensors.

All microbolometers are equipped with germanium windows to guarantee high transmission in a range between 8-14 µm.

Compared to quantum IR detectors, microbolometers typically have lower costs, a broader infrared spectral response, and require no cooling. On the other hand, they have a lower reaction time to temperature changes and are less sensitive than quantum detectors.



Microbolometer detectors are made up of a multitude of elements . To ensure that the pixels are isolated from each other, the sensor works in a vacuum. Nevertheless, each individual detector (or pixel) has different gain and offset values due to detector-to-detector variability in

the Focal Plane Array (FPA) fabrication process. The difference in gain and offset between each pixel depends also on sensor operating temperature, temperature of the observed scene, electronic readout noise et cetera. All effects together produces a fixed pattern noise (FPN) in the acquired image that needs to be corrected by a non-uniformity correction (NUC) to receive a homogenous image.

Another effect that also necessitates the NUC (non-uniformity correction) is the Narcissus effect: The Narcissus effect occurs when an infrared detector "sees" sources at temperatures other than the background ambient caused by unwanted reflections of internal lens surfaces; these sources are usually reflections of the detector itself. Pixels that are not corrected by the NUC process are defined as defective pixels and need to be identified and replaced by using a nearest neighbor algorithm.

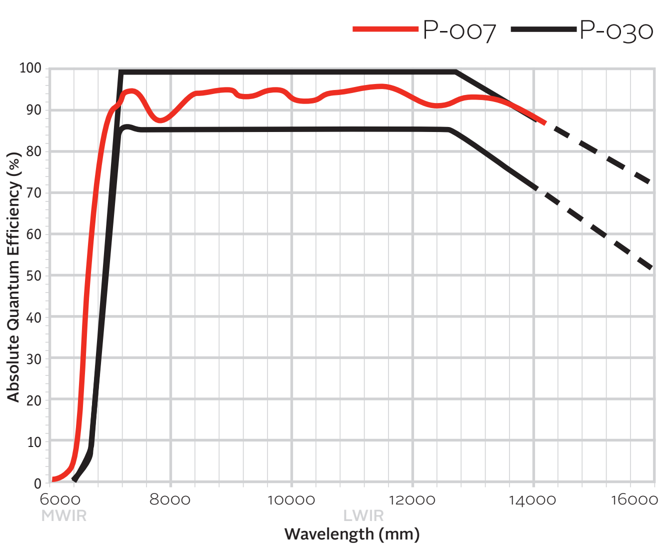
Allmost any microbolometer sensor available today has a rolling shutter. Besides the pixel size, which affects the sensor's sensitivity and dynamic range, the most characterizing parameters of these type of sensors are NETD (Noise Equivalent Temperature Difference) and its time-constant τ. Thereby, NETD represents the amount of temperature needed to distinguish the signal from noise. And the time-constant indicates how fast a sensor can react to temperature changes.

Make the heat visible

Pearleye LWIR cameras are distinguished by their uncooled microbolometer image sensors, which are temperature stabilized to a fixed working temperature. The built-in temperature sensor automatically compensates for temperature-depending output signal drifts. This ensures reproducible absolute measurement results. Thereby, it is possible to detectl temperature distinctions smaller than 80 mK with each pixel.

With their maintenance-free sensors, the comprehensive real-time image correction features, and the standardized vision interface, Pearleye cameras are most qualified for industrial and scientific demands. They can easily be integrated into many GigE Vision compliant software solutions.

Spectral sensitivity



Smart Features

- // On-chip high gain mode
- // Shipped with various built-in correction data sets
  - Defect pixel correction
  - Gain-offset correction (NUC)
  - Drift compensation
  - Temperature linearization via LUT
- // Background correction in the field by using the integrated long-life electro-mechanical shutter

Operating Conditions

Power requirements	DC 12 V via 15-pin D-Sub connector
Power consumption	<18 W
Operating temperature	+15°... +50 °C ambient temp.
Storage temperature	-30°... +70 °C ambient temp.
Regulations	CE, RoHS (2011/65/EU)

Optional Lens Types

	Field of View [HxV]	
Lens Type	P-007	P-030
12 mm, f/0.85, >0,5 m	50° x 38.6°	67,4° x 53,1°
16 mm, f/1.2, >1 m	38,6° x 29,4°	53,1° x 41.1°
18 mm, f/1.0, >1 m*	34,6° x 26,3°	47.9° x 36.9°
22 mm, f/1.2, >1,5 m	28.6° x 21.6°	40° x 30.5°
35 mm, f/1.0, >0,5 m	18.2° x 13.7°	25.8° x 19.5°
75 mm, f/1.0, >5 m	8.5° x 6.4°	12.2° x 9.2°

* Standard lens type

Further Options

Pearleye cameras are available with customized temperature measurement ranges on request. Thereby, it is possible to calibrate the cameras individually between -20 °C and 400 °C.

Besides the default temperature measurement range from -20 °C to + 80 °C, currently the Pearleye P-007 LWIR High Temp model is provided that can detect between 0 °C to +200 °C.

Model	Resolution	Frame rate	Pixel size	Sensitive area	Size* [WxHxL]	Weight
P-007	320 x 240	40	35 µm x 35 µm	11.2 mm x 8.4 mm	90 x 86 x 101 in mm	830 g
P-030	640 x 480	24	25 µm x 25 µm	16 mm x 12 mm		790 g

*without lens

Highlights

// Uncooled microbolometer LWIR sensor
// Spectral sensitivity ranging from 8-14 µm
// NETD < 80 mK, @30 °C with f/1.0 lens
// Very low noise (max. 4 grey levels)
// Customized temperature measurement range between -20 °C to 400 °C
// Robust metal housing for industrial use
// High accuracy by 14-bit digital processing
// Built-in real-time image correction
// Background correction in the field
// 2 years warranty

Measurements without contact

LWIR cameras are mainly used to measure surface temperature profiles of objects with high accuracy (thermography). Futhermore, they make heat radiation visible even at great distances, in total darkness, or through visibility restricted conditions (thermal vision).

Due to their comprehensive image correction features, Allied Vision's Pearleye cameras are most qualified for both thermography and challenging thermal vision applications.

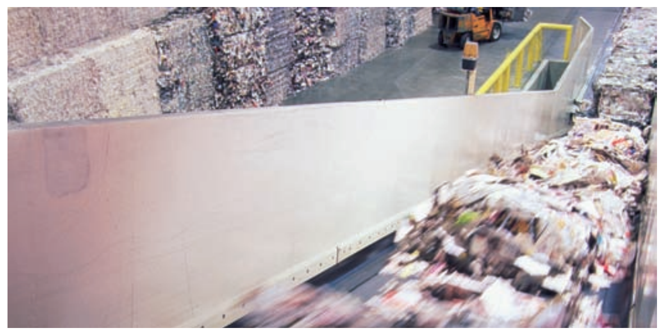
Thermography

A properly calibrated camera is essential to perform accurate non-contact temperature measurements. Although Pearleye cameras apply many built-in image correction mechanisms to create accurate thermographic images, it is impossible to determine the actual temperature of an object. The detected temperature can always only be an approximation, because not only the observed object emits infrared radiation, but there are multiple sources of infrared energy surrounding the object like reflections from other surfaces and differing material emissivity.

There are many thermographic applications in different industries. Here are some examples:

Paper Recycling

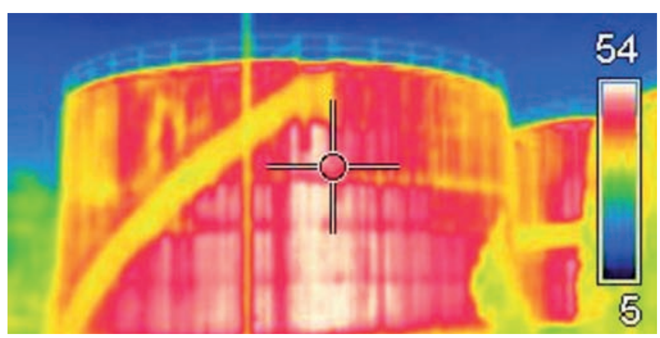
At the beginning of the paper recycling process, the wastepaper is sorted by exposing it to heat (active thermography). A thermal camera monitors the heat absorption to calculate the quality of different paper types like newspapers, magazines, or cardboard. The higher the detected temperature, the higher is the thickness and density of the paper – and the quality. Only paper of high quality is used for the recycling process.



Paper recycling process. Cameras must be fast and precise

Non-contact temperature measurement of chemical reactions

Chemical reactions are endogenous or exogenous proceedings resulting in heat flow. Imaging of temperature distribution by means of thermography does not only allow punctual measuring of heat flows, but also enables analyses of the entire process chains.



Making chemical processes visible

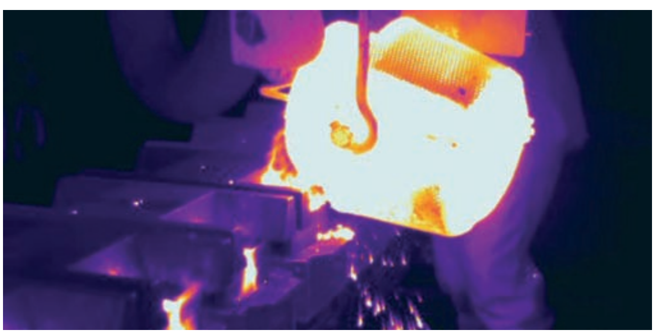
Liquid and foamed chemicals are often kept in tanks. For this purpose, thermography provides an opportunity to monitor the liquid level of tanks.

Industrial Inspection & Process Monitoring

Thermography can be used at all stages of production – from inspecting the quality of raw materials and processing of those raw materials to the inspection of the final product. Continuous temperature monitoring allows an early detection of defects. This saves money as bad raw materials and products can be separated directly and do not stay in the value adding process impurifying the overall product quality.

Exemplary industries are plastic processing, glass processing, and steel processing.

Example applications include monitoring the cooling process after leaving the furnace, inspecting the material thickness (quality indicator) by heating up the material before processing it, and inspecting the temperature of melted glass in order to meet the ideal processing temperature to achieve the best quality for the final product.



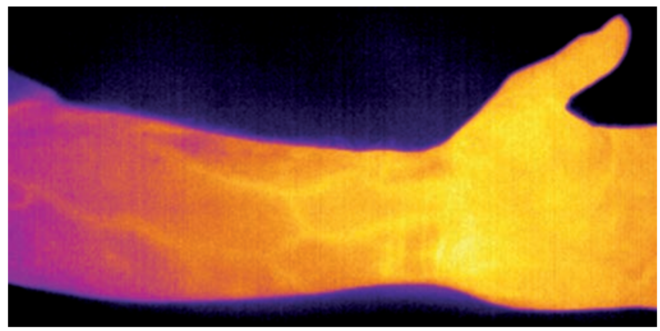
Supervision of critical components

Laser Beam Profiling

For many applications well-calibrated lasers are required, as for laser cutting or extreme ultraviolet (EUV) lithography. For this, especially laser focus and power need to be very accurate. For laser focusing, low noise levels are required to enable a unique detection of the beam's center.

Medical

LWIR cameras can also be applied for noninvasive diagnostics of humans or animals. They are used to visualize and quantify changes in the skin surface temperature that might be caused by viruses, cancer, or inflammation. The range of screenings offered continues to expand, e.g., mammography, evaluation of soft tissue injuries, unexplained pain detection, or fever detection at airports to monitor the potential spread of diseases.



Humane Medicine: Noninvasive medical diagnostics

Thermal Vision

LWIR cameras can detect thermal radiation and do not need a source of illumination. Thus, thermal radiation is "visible" through mist, rain and smoke.

To detect objects at far distances, very low noise levels and a good temperature resolution are required.

In particular, Pearleye LWIR cameras are useful for challenging surveillance and security tasks like night vision or border control.

Further Applications

The applications in the longwave infrared spectrum are multifaceted, and every day new capabilities are found. Especially in these fields of science and research:

// Earth and solar science
// Animal study
// Pollution control
and many others

// OUR SUPPORT

Independence makes you flexible

Allied Vision provides two different software solutions to control Goldeye (SWIR) or Pearleye (LWIR) cameras.

AcquireControl Viewer Application

AcquireControl is a software solution that provides comprehensive camera control and image display options as well as powerful image processing and analyzing functionalities. Histograms and other statistical image data can be displayed for several pre-defined ROIs (Regions of Interest) at any time. The ROIs can be rectangular, circular, line, or ring-shaped. Alternatively, these data can also be logged over a longer period of time.

Furthermore, AcquireControl enables users to display images of infrared cameras in a simple way by utilizing pseudo color LUTs. The current temperature can also be displayed at several points on the image, whereas the temperature indicator range and the desired color profile are user-configurable.

Highlights

- // Simple image acquisition of greyscale, color, and temperature images
- // Comprehensive camera control
- // Statistical image evaluation
- // Pseudo color IR image display inclusive temperature measurement
- // Simultaneous analysis of several user-defined ROIs
- // Support for important image pre-processing functions (lookup-tables, background correction, mirroring, etc.)
- // Many image saving options including video recording

VIMBA Software Development Kit

VIMBA

AVT SOFTWARE DEVELOPMENT KIT

To develop one's own software applications, Allied Vision provides the VIMBA SDK, a free-of-charge comprehensive interface and platform independent SDK that contains the following components:

- // An application programming interface (API) for camera control and image acquisition
- // All required drivers to integrate Allied Vision cameras properly into your system
- // An easy-to-use driver installation tool
- // A viewer application to test AVT cameras and evaluate their features
- // Example collection
- // Operating systems: Windows, Linux, Linux ARMv7
- // APIs: C, C++, .NET
- // Based on GenICam standard

Third-Party Solutions

Like all other cameras from Allied Vision, Goldeye and Pearleye cameras can also be easily integrated into common third-party image processing software solutions that are compliant to the GigE Vision and GenICam standard.

A wide range of third-party software solutions is compatible with our cameras, for example, libraries, SDKs, integrated development environments, vision applications/tools and drivers. Allied Vision work in close cooperation with several certified partners to assure our customers easy installation, tested compatibility, and strong support.

Restrictions on Exports

IR cameras made by Allied Vision Technologies are subject to export restrictions. Therefore, corresponding authorization procedures may cause longer delivery times.

With many years of experience in this field we can help you to speed up proceedings. Please contact us for further information:

sales-office-OSN@alliedvision.com

Just tell us the product of your choice, the country it should be delivered to, and the type of order (purchase or loan). We will then provide you promptly with all the information needed.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// ALLIED VISION

Good is not enough

At Allied Vision, we aim for perfection for our products and services. Therefore, we talk and listen to our customers every day all around the world. Our status as market leader is the result of our relentless pursuit of building not only the best cameras on the market and offering an extremely reliable support – 24 hours a day, 5 days per week.

Our support teams in Germany, Canada, USA, China, and Singapore and our distribution partners in over 30 countries literally speak the language of all our customers. Our engineers and manufacturers in Germany and Canada work closely together and benefit from the ex-change of their innovative ideas and different views originated from various cultures and understanding of the challenges of different markets. Imagine what's possible and we do it for you. We are very proud of the good connection with our customers. Mutual trust is one of ourmain reasons for our success. So that is what we have built our company on.

Our cameras are hightech devices that need to work in any situation. Every camera is built under the best circumstances possible, e.g., cleanroom conditions. And we take care of all the details no matter how big or small. Just like our cameras do.

Get an idea of how we implement all of this in our line of infrared cameras and how efficient, safe and reliably they work. High quality and perfect usability are just a few of the features we equipped them with.

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