UNDERSTANDING AND USING INFRARED TECHNOLOGY

WHITE PAPER 2020

SUMMARY

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INTRODUCTION

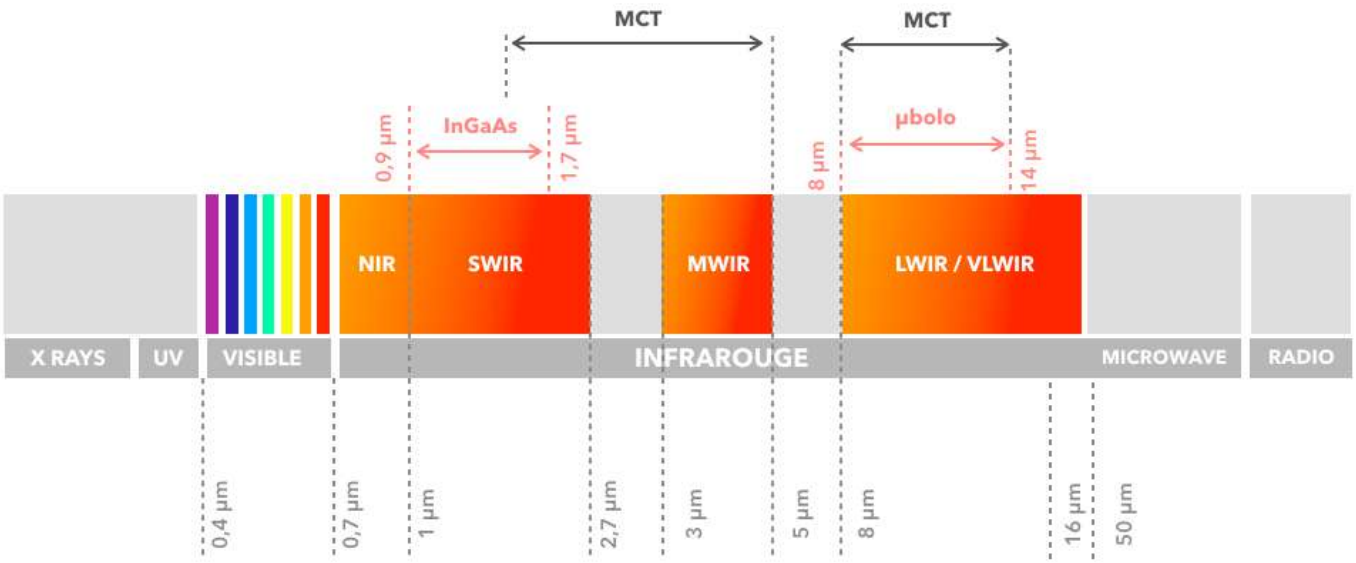
Infrared technology is a broad topic. Infrared detectors are high-tech devices that come in several varieties, each with its own unique specifications. And the potential uses for the different types of detectors are vast. So, let's get back to basics with the fundamentals of infrared detection technologies and their applications.

The science is simple. Infrared vision systems detect electromagnetic waves emitted in a spectral band that is outside of what we call the visible spectrum. What we see with the naked eye (in the visible spectrum) is essentially light reflected off of objects. However, all objects give off energy that cannot be seen with the naked eye. This energy (electromagnetic waves outside the visible spectrum) can be captured and used to generate images—if you have the right imaging system. This is where infrared detection comes in.

Why do you need to know what infrared detection is and how it is used? First of all, for the opportunities it can bring. Infrared is used in a wide range of applications in virtually all sectors of the economy, from defense and aeronautics to manufacturing and other industries. Today infrared technology has the capacity to bring value to a dizzying array of products and processes.

I- NOT ALL SPECTRAL BANDS ARE CREATED EQUAL

The electromagnetic spectrum is made up of different spectral bands. And infrared detectors that operate in the different bands lend themselves to different applications with well-defined specifications.



MCT: Mercury Cadmium Telluride / ***InGaAs***: Indium Gallium Arsenide / ***µbolo***: Microbolometer

NIR: Near Infrared / ***SWIR-MWIR***: Short or Medium Wave Infrared / ***LWIR-VLWIR***: Long or Very Long Wave Infrared

•**NIR (Near infrared)** : these wavelengths are the closest to the visible spectrum at between 0.78 µm and 2.5 µm.

One near-infrared technique, NIR spectroscopy, can enhance quality control and process control in industries like food manufacturing, animal nutrition, farming, dairy, pharmaceuticals, and chemical manufacturing—all of which are under pressure to carry out increasingly stringent controls on high-throughput production lines.

Because it is non-intrusive and delivers rapid results, NIR spectroscopy is particularly well-suited to these applications.

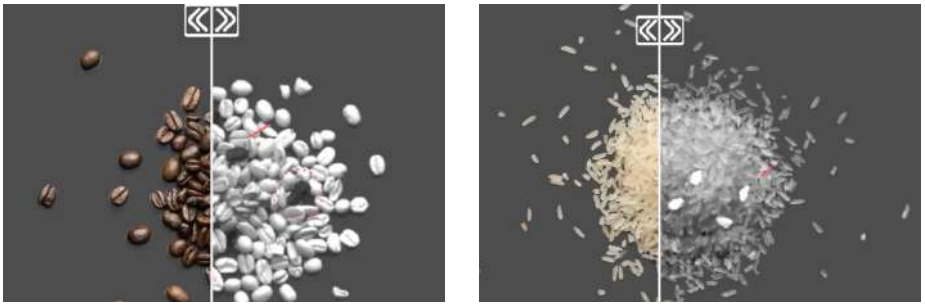
Here are a few specific examples of how NIR detectors are being used in these industries:

In the pharmaceutical industry :

NIR imaging can be used to measure the fill levels of capsules and containers (even made from opaque materials), determine product moisture content, and check the blending of pharmaceutical powders (for quality control) or the chemical composition of tablets (an anti-counterfeiting measure).

In the food industry:

The technique can be used to measure important information like the moisture, protein, fat, starch, free fatty acid, organic acid, or ethanol content of food products, as well as the density, total solids, and carbohydrate profile. And, because NIR is a non-destructive testing (NDT) technique, it is ideal for inspecting produce in the farming industry.



In the chemical industry :

It can be used to analyze the hydrocarbons present in oil, petroleum, and process wastewater, for example. It is also useful in the analysis of polymer structures.

In addition to applications in industrial quality control and process control, NIR detectors also help make industrial facilities safer and more secure by enabling effective surveillance. Active infrared sensors, made from NIR detectors and LEDs, can be used for nighttime surveillance to detect the presence of humans or nuisance animals. NIR detectors can also monitor industrial facilities for hotspots or gas leaks.

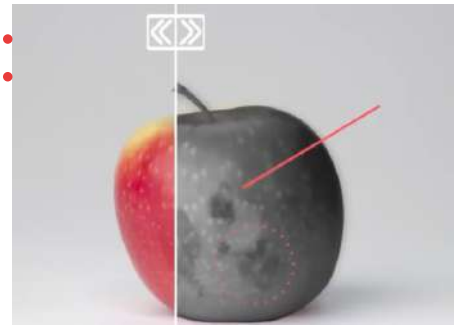
•**SWIR (short wave infrared):** The spectrum from 1 µm to 2.7 µm:

SWIR is mainly reflected light, similar to what is seen in the visible spectrum.
In fact, SWIR-based vision is at the frontier between visible imaging and thermal imaging. Imaging in this spectral band, very close to thermal imaging, offers greater contrast (i.e. resolution) than visible imaging and can "see" things that are not visible to the naked eye.

SWIR lenses can be designed to ensure excellent imaging outdoors and at night, even in rain or fog.
Another advantage of SWIR imaging over visible imaging is that it can more clearly distinguish between colors that appear virtually identical in the visible spectrum. Finally, SWIR detectors are effective even in smoke, fog, and dust, making them ideal for a variety of industrial environments.

Therefore, SWIR is the spectral band of choice for imaging systems for machine vision, industrial automation, scientific research, and chemical analysis, with applications such as:

In the farming industry, SWIR can be used to monitor crops and improve yields; it can also "see" bruising on produce before it is visible to the naked eye, making it a useful addition to food sorting lines.



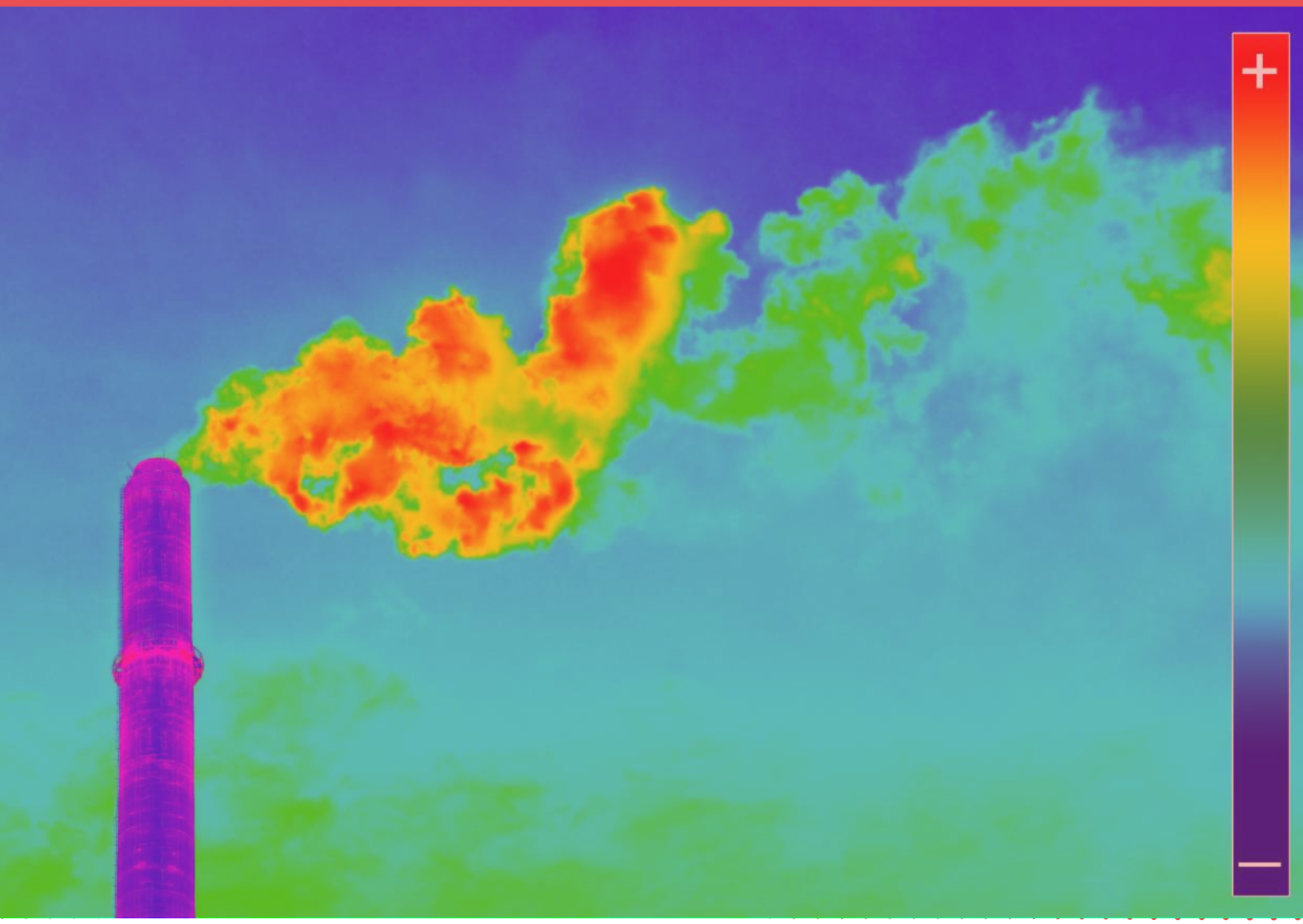
In the pharmaceutical industry, it can detect fill levels

In recycling plants, SWIR detectors can enable advanced quality controls.

•**MWIR (medium wave infrared):** The spectrum from 3 µm to 5 µm. Thermal imaging begins in this part of the spectrum, where temperature gradients present in the scene being observed start to form.

MWIR is ideal for hot environments. It is often used to detect hotspots (fire, hot equipment) that give off temperatures higher than the ambient temperature.
And, because it is not affected by humidity and can “see” through fog, MWIR can be used for coast guard or marine surveillance. However, it is not effective in rain.

MWIR detection requires cryogenically-cooled technologies like HgCdTe (MCT, or MerCad), a II-V semiconductor material.V



Here are a few applications for MWIR detectors:

Industry : Gas detection: methane, propane, ethanol, and sulfur hexafluoride and other gases invisible to the naked eye. When used on board drones, MWIR detectors can monitor facilities that contain gases (pollutants, toxic gases) for maintenance purposes.

Scientific research: Gas-leak detection in labs; MWIR technology is also found in research equipment like spectroscopes and microscopes.

Environmental and air quality monitoring: MWIR detectors can track volcanic sulfur dioxide plumes, measure pollutant concentrations in the air (urban, industrial, tropospheric, household and agricultural biomass burning). It can also be used to monitor greenhouse gases like carbon dioxide and methane.

Defense: Detection of chemical weapons and explosives (gases), chemical agents, and neurotoxins in combat or to protect civilians from attacks on public places.

- **LWIR (long wave infrared):** The spectrum from 7 µm to 14 µm.
This is the most widely used infrared band due to its excellent detection of most terrestrial objects. The maximum spectral luminance of bodies at ambient temperature is within the LWIR band.

LWIR is mainly reserved for applications that demand high sensitivity and performance. This is because it responds very well in the presence of smoke and aerosols. These qualities also make LWIR particularly effective for fire safety equipment. And, because LWIR detectors are not sensitive to the sun's rays, they generate very similar images during the day and at night.

Fire safety: Fire detection, forest-fire analysis.

Manufacturing:
Temperature monitoring on glass, metal, automotive, and plastic molding lines.

Home inspections and home energy audits:
Water damage, damaged electrical wiring or electronic components, heat loss due to poor insulation.

II- WHICH DETECTOR IS RIGHT FOR YOUR APPLICATION?

There are two main types of infrared detectors: cooled and uncooled. Each type has specific features that make it suitable for certain applications.

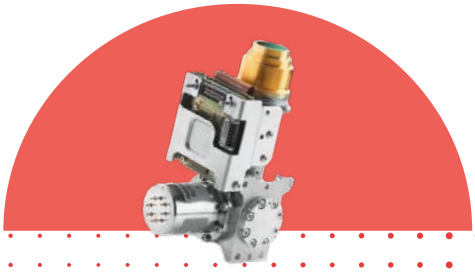
Coolde detectors :
These detectors are kept at an extremely low temperature using a cryogenic cooling system. This system lowers the sensor temperature to cryogenic temperatures and reduces the heat-induced noise to a level lower than that of the signal emitted by the scene.

The primary advantages of this type of detector are incredibly high resolution and sensitivity and the resulting high image quality.
These detectors operate in the MWIR (medium-wave infrared) and LWIR (long-wave infrared) bands. And, the higher the thermal contrast, the easier it will be to detect objects against a background that is close to the same temperature as the objects.

However, these detectors do cost more than uncooled detectors.
They also require regular maintenance and are larger.

Cooled detectors offer very high frame rates, making them ideal for industrial R&D. For example, cooled detectors are more powerful and effective at capturing fast movements and obtaining precise measurements than uncooled detectors.

These detectors also have a greater capacity to zoom in on images than uncooled detectors. This is because they capture shorter infrared waves.



Cooled detector

Uncooled detectors or microbolometers:
These detectors do not require a cooling system. They leverage devices called microbolometers. With microbolometer technology, temperature differences in a scene trigger changes in the microbolometer's temperature. These changes are then converted into electrical signals and then into images. Uncooled detectors operate in the LWIR (long-wave infrared) band, which covers the vast majority of temperatures found on Earth.

Systems equipped with uncooled detectors are more cost effective and require less maintenance than systems with cooled detectors. They also have longer lifespans and are more compact.

They are particularly well-suited for equipment used in military ground operations, such as thermal goggles to detect presence and sources of heat, weapon sights, and binoculars. Drones equipped with uncooled detectors can be used for the surveillance of industrial infrastructures.

The outdoor and leisure market, which includes activities like hunting and nature observation, is another area where uncooled detectors are used.

They are found in vision systems like thermal weapon sights and binoculars. These thermal vision systems let nature lovers observe wildlife and enjoy the landscape safely, even at night or when visibility is low due to poor weather.

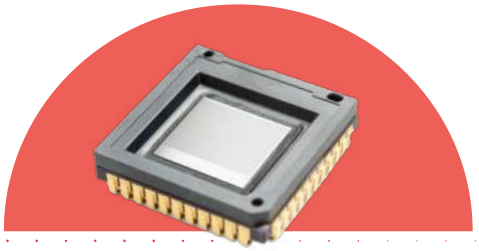
Smart buildings are another area where uncooled detectors are becoming increasingly common.
These detectors can count people, help manage building energy systems, and improve employees' working conditions. Uncooled infrared sensors can generate data on building occupancy rates, which can in turn be used to improve space management. Occupancy data can be analyzed in real time and used to constantly adjust energy consumption for lower energy spending. Building safety also benefits from uncooled infrared technology, which can be used to pinpoint hotspots to prevent fires as well as to detect intruders.

Finally, in the automotive industry, uncooled infrared detectors are playing a central role in the development of advanced driver assistance systems (ADAS) and the perception systems that will enable tomorrow's autonomous vehicles to drive safely by detecting obstacles during the day and at night in all weather.

They also enhance passenger comfort by automatically regulating in-cabin systems like heating, ventilation, and air conditioning. Uncooled infrared sensors are also used in driver vigilance devices and can improve supervision of all vehicle systems.

Infrared technology, in its many forms, is used in a wide range of applications The first step to choosing the right technology and using it optimally is understanding how it works and how it can enhance your products or processes. And with markets like machine vision, smart buildings, and new space just getting off the ground, infrared technology has a bright future ahead of it.

Visit the LYNRED blog [https://www.lynred.com/we-share] for regular updates on the latest applications for infrared technology and to learn how infrared can bring innovation and new opportunities for growth to your business.



Uncooled detector

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