Technological Advances Lead to a Greater Variety of Infrared Detectors

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Infrared radiation is widely used in diverse technical and scientific fields including spectroscopy, optical communications, and other measurement applications. Through advances in photonics technology, a wide variety of infrared detectors are now available in order to meet a large range of application needs.

Infrared detectors are classified into two categories – thermal models and quantum models. A thermal detector uses the energy of the infrared beam as heat, while the quantum detector offers a higher detection. Advances in research to better detect this part of the higher spectrum have lead to the development of more advanced detectors, including InGaAs photodiodes, PbS & PbSe photoconductive detectors, pyroelectric detectors, and hybrid detectors. While all of these devices are excellent at light detection, each is better suited for certain applications than others.

InGaAs PIN Photodiodes

Designed to have small terminal capacitance and large shunt resistance, InGaAS PIN photodiodes are categorized as having high-speed response and low noise. InGaAs PIN photodiodes have many types of active areas and can be divided into six categories:

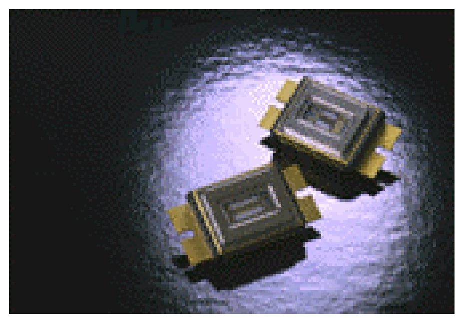
***High-performance NIR Detectors with Low Noise* —** These standard type InGaAs-PIN Photodiodes have a spectral response of 0.9 to 1.7um, and are available in 7 active areas ranging in diameter from 0.04mm up to 5mm.

***Long-wavelength Enhanced Type InGaAs PIN Photodiodes* —** These devices ensure spectral response extending to the long wavelength range. Compared to standard type detectors with a cutoff wavelength of 1.7 um, these devices offer longer cutoff wavelengths of 1.9 um, 2.1 um and 2.6 um, allowing for optimal selection. Thermoelectrically cooled devices are also available.

***Short-wavelength Enhanced Type InGaAs PIN Photodiodes* —** Compared to standard type devices, this type of device provides enhanced sensitivity in the short wavelength range from 0.7 to 0.9 um. (0.25A/W at =0.78 um).

***InGaAs PIN Photodiode with Pre-amp* —** These modules incorporate an InGaAs PIN photodiode and transimpedance amplifier into a TO-18 package. They are applicable for large-capacity, long-distance optical communications and other near-infrared detection.

***InGaAs Linear Image Sensors* —** Incorporating an InGaAs photodiode array chip, a thermoelectric-cooler and C-MOS multiplexers with charge integration amplifiers, the InGaAs linear image sensors (Photo 1) are self-scanning photodiode



arrays designed specifically for detectors in near-infrared multichannel spectroscopy. Some spectrophotometers feature InGaAs detection for simultaneous, rapid and precise spectral acquisition over the 0.9 micrometers to 1.7-micrometer or 1.2 to 2.6 micrometer wavelength range with a 1-nm bandwidth. Sampling is available for transmission, absorption and reflection measurements.

Complete models feature LabView®-based software for instrument control, quantitative analysis, and timed acquisition. Advanced systems even have an intelligent electronic design that allows unconventional readout modes. This technology has low noise, precision analog design, and a readout frequency of 1MHz Max.

Self-scanning photodiode arrays for detectors in near infrared multichannel spectroscopy are also available. Such an array incorporates an InGaAs photodiode array chip, shift resister with C-MOS transistor, charge amplifier array, clamp circuit, and hold circuit. The design permits it to have stable operation in wide photometry range. Low dark current enables long time exposure, so the sensor's output has a high S/N signal for low-level light. Two-stage TE cooled types enable lower dark current and are used in near infrared multichannel spectroscopy, radiant thermometry, non-destructive inspection system, and optical fiber transmittance measurement.

***InGaAs Multichannel Detector Head* —** These devices incorporate a low-noise driver/amplifier circuit that provides reliable operation from simple external signals. Some modules also include a highly stable temperature controller that cools the sensor to a preset temperature level as soon as the power is turned on.

PbS and PbSe

PbS, PbSe cells make use of the photoconductive effect by which the electrical resistance decreases with application of infrared radiation. PbS and PbSe photoconductive detectors have a higher detection performance, faster response and operate at room temperature. Some Pyrodetectors can also be used to minimize noise fluctuation caused by changes in the ambient temperature.

These products can be used in thermometers, HMD (Hot Metal Detectors), flame monitors, spectrophotometers, fire detectors, gas analyzers and moisture analyzers.

InAs & InSb Photovoltaic Detectors

The InAs and InSb detectors are photovoltaic-type detectors that have p-n junctions. Their wavelength regions for responsivity correspond to those of the PbS and PbSe detectors. Since the InAs and InSb detectors have faster response speeds and better S/N ratios, they can be designed into different applications than PbS and PbSe detectors.

Major applications for InAs and InSb photovoltaic detectors are gas analyzers, spectrophotometers, thermal imaging, and remote sensing.

MCT (HgCdTe) Detectors

The MCT is a photoconductive detector that makes use of the photoconductive effect, which decreases the element's resistance value as infrared light enters the device. Controlling the composition ratio of HgTe and CdTe can modify the band gap of HgCdTe. Utilizing this fact, various types are available in different spectral response.
Radiant thermometers, moisture analyzers, gas analyzers, spectrophotometers, film thickness gauges, FTIR, thermal imaging, and remote sensing instruments are some of the applications in which the MCT detectors can be used.

Two-color Detectors

Two-color detectors have a sandwich structure in which an infrared-transmitting silicon photodiode is mounted on top of an infrared detector. This structure makes it possible to design instruments using the same optical path from UV through infrared.

Major applications include flame monitors, spectrophotometers, laser monitors, and film thickness gauges.

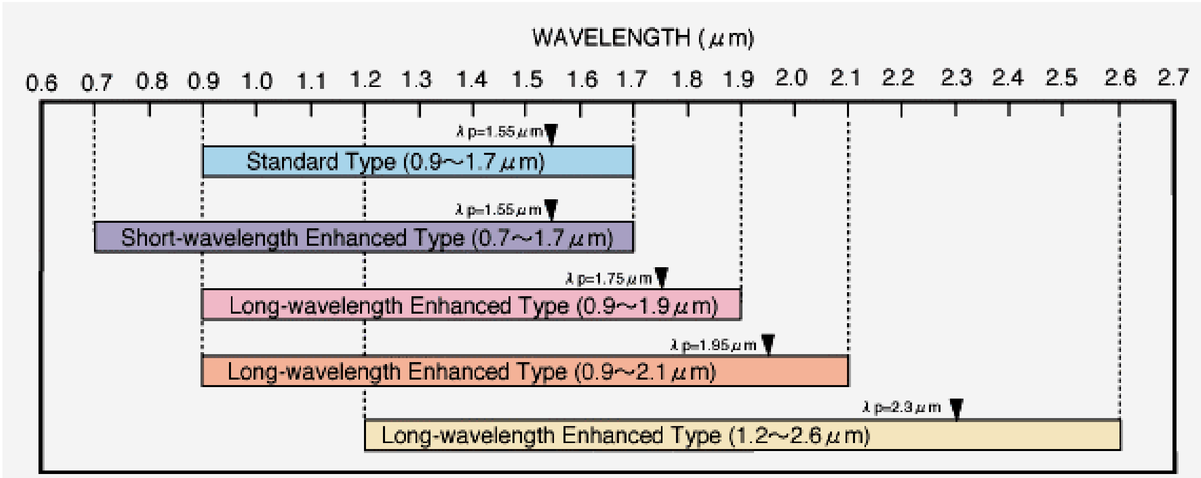
Pyroelectric Detectors

The pyroelectric infrared detectors consist of a pyroelectric element ($LiTaO_3$), high resistor, and low-noise FET built into a TO-5 package. A pyroelectric crystal such as $LiTaO_3$ is spontaneously polarized. As window material, they often use a silicon filter, which has a flat spectral transmittance. Other window materials are available, depending on the application.

Pyroelectric infrared detectors are best used in radiant thermometers, fire detectors, gas analyzers, and human body detection products.

Selection of the proper infrared detector has become quite a challenge, with so many now available. In order to select the best one for a design, the following parameters should be taken into consideration – spectral response, response speed, active area and number of elements, cooling, and object temperature.

As can be seen by Figure 2, (next page) infrared detectors can have many different spectral response characteristics. It should be noted that cooling a detector element may affect its spectral response. For InGaAs, InAs, and InSb detectors, the spectral response shifts to the shorter wavelength side. In contrast, spectral response shifts to the longer wavelength side for PbS, PbSe, and MCT (HgCdTe) detectors.



Just like spectral response, different response speeds are available depending upon the detector selected. It should also be noted that the response speeds of the PbS and PbSe cells become slower with cooling.

Two types of cooled detectors can be selected: thermoelectrically-cooled types and dewar types. Thermoelectrically-cooled detectors assure low-noise measurement over extended time periods. Dewar types are cooled with either liquid nitrogen or dry ice and are capable of performing measurements with exceptionally low noise.

When selecting an infrared detector in accordance with the temperature of an object, it is necessary to consider the distribution of the energy (the wavelength dependency of the energy) radiated from the object. When the object's temperature is known, the distribution of the radiating energy is given by the law of black body radiation, known as Planck's Law.

Selection of an infrared detector must be done carefully. Technological advances have allowed for these devices to be specialized for certain applications. Consideration of the application and reviewing all the parameters of the many types of detectors will result in the best performance.