Marktech Optoelectronics

Customization of Optoelectronic Detectors

Part Two in a Six-Part Series

Utilizing our 30 years of experience in optoelectronics, Marktech's customization process focuses on customer needs and applications. Instead of using standardized–but perhaps non-optimized–parts, Marktech allows advantageous custom product variations to enhance your product design.

Custom packaging and electrical sorting of products offer further differentiation. Marktech provides the designer with insights concerning custom variations–variations that optimize electrical, optical, and thermal characteristics–without the need for large volume commitments. With manufacturing facilities in California, Germany, and Japan, Marktech is a vertically-integrated company, allowing us to produce detector components quickly, thus decreasing your time to market. We can even produce your entire package in the United States, if need be.

To solve your needs, Marktech engineers will discuss with you:

- Application needs specific to your project
- Optimization recommendations for component and assembly packaging, technology, and thermal and electrical parameters
- Manufacturing of dedicated end-products in support of your specifications and needs

In this **second installment** in our six-part series on Marktech's customization capabilities, we focus on optoelectronic detector materials, to allow options to customize detector components for optimal mating with compatible emitters.

Overview

Photodetectors are sensors, detecting light and converting the photons into measurable currents, and are therefore useful for applications ranging from water faucets to nuclear transient events. With varied technologies and packaging, specific measurements can be made that are ideal for your applications.

Marktech devices are solely solid-state devices (there are no photomultiplier tubes in our product line, although our products may supply similar functionality). Response rates can be as fast as 300 picoseconds. Light levels that can be measured range from tens of photons to massive levels. Wavelengths can range from 150nm to greater than 3000nm.

Each photodetector uses p-n or n-p junctions as part of either a photodiode or phototransistor construction, effectively working as an inverse function from the typical operation of a light emitting diode. Depending on the technology used, the detectors provide current response to specific ranges of light wavelength.

Detector Materials and Characteristics

The materials used may be silicon, GaP, or InGaAs. The P and N epitaxial layers of the wafer materials can be optimized for specific customer specifications and desired characteristics, including minimum reflection, Optimized Responsivity low dark current, minimum series resistance, low capacitance, fast response, low cross talk, and more. The detectors can be packaged in a variety of packages from metal can and standard 3mm and 5mm plastic packages, to surface-mount...or virtually any custom package assembly. Detector applications range from simple door opening to the latest cancer PET scan system.

Detector Wavelengths

Available products have wavelengths varying from 150nm (UV) through the visible range (440 to 700nm), through SWIR (short wavelength infrared) (up to 2600nm), and beyond to MWIR (medium wavelength IR) (>3000nm). This link to our online Product Selector Guide helps in the selection of the emitter wavelengths, while also indicating compatible detectors. Tight binning by Marktech can provide uniform wavelength characteristics to optimize the application and mating detectors' sensitivities, providing process-controlled, uniform product solutions.

Marktech Photodetector Variations:

- Silicon photodetectors (400nm to 1100nm): photovoltaic, photoconductive photodiodes, and phototransistors
- Silicon avalanche photodiodes (400nm to 1100nm, with 800nm, 905nm optimization)
- UV detectors (150nm to 450nm)
- InGaAs PIN photodetectors (800nm to 2600nm) and SWIR (short wavelength IR) detectors (1050nm to 1720nm)

Products are also available in epitaxial wafer form, and can be packaged as photoreflectors, arrays, and hybrid parts. For part listing and additional information, visit our detectors catalog.

Silicon Photodetectors (400nm to 1100nm):

Marktech's silicon phototransistors can be utilized in applications requiring very high sensitivity, uniform

response, and increased reliability such as card readers and optical sensors.

The photovoltaic silicon photodetectors have a spectral sensitivity from near-ultraviolet, through the visible range, to short wavelength infrared (SWIR) (400nm to 1100nm). These are used in applications such as medical, analytical, communications, spectroscopy equipment, and sensing requiring broadband sensitivity with enhancements in the blue/green region. These devices can exhibit moderate-speed response, high sensitivity, and low noise. Devices are available as either phototransistors or photodiodes.

The photoconductive silicon photodetectors are suitable for high-speed and high-sensitivity applications. The spectral range extends from 400nm to 1100nm, making these photodiodes ideal for visible and near-IR applications, including such AC applications as detection of pulsed LASER sources and LEDs.

Marktech's broad line of silicon photodetectors are provided in a variety of package types including through-hole plastic, ceramic, metal-can, surface mount, and full custom. These devices are available with standard silicon die having a spectral sensitivity of approximately 400nm to 1100nm, or with special UV-enhanced silicon chips with sensitivity in the lower UV-A range. Custom active areas and multi-element chips can also be manufactured to suit your application. Many of our wafers/chips are manufactured in the USA and optimized to insure uniform and consistent performance with high reliability. These devices are well-suited for visible and near-IR applications requiring high speed and high sensitivity as well as low noise such as optical switches and optical communications.

Marktech silicon detectors can be obtained with integrated filters for reduced visible light interference or optimized for your required spectral output. In addition to our various package styles available off-the-shelf, Marktech can integrate multiple detectors and/or emitter detector combinations in a single package type.

Silicon photodetector variations:

- Silicon phototransistors
- Avalanche Photodiodes
- Silicon photodiodes in SMT, through-hole DIL, and metal can packaging
- Photodiode arrays
- Dual/quadrant photodiodes
- X-ray detectors
- Multichip photodiodes for expanded wavelength or sensitivity
- Silicon photovoltaic PIN photodiodes
- Silicon photoconductive PIN photodiodes
- Silicon PIN photodiodes with enhanced blue sensitivity
- Silicon photodiode arrays
- Differential photodiodes

Customized optimizations:

- UV blue-green NIR (near-IR)
- 1064nm, 2200nm, and 2600nm
- Minimum reflection
- Low dark current
- Minimum series resistance
- Low capacitance
- Low carrier lift time
- Fast response
- Low cross-talk

Customized packaging:

- Tested wafers
- Chips
- Hermetic packaged devices
- Hybrids (detector/amplifier in one package)
- Detector/filter combinations (bandpass or color glass)
- Hybrid/modules (ceramic or COB [chip on board])

Typical industries served

Medical, optical communications, industrial, scientific, and analytical

Common applications

Remote controls, optical encoders, position sensors, fiber optics, barcode readers, and chemical analysis.

Silicon Avalanche Photodiodes (400nm to 1100nm, optimized for 800nm and 905nm)

Avalanche photodiodes are ideal for high-speed and low-light level detection in the near-infrared range. These detectors have become the semiconductor equivalent of photomultipliers in many applications including data communication, LIDAR, instrumentation, and photon counting. In addition, cost-effective customization of these APDs is offered to meet exacting design specifications. Operation voltage selection and voltage breakdown (Vbr) binning, wavelength-specific band-pass filtering, and hybridization options are among many of the application-specific solutions available at Marktech.

Marktech APDs have an internal gain mechanism, fast time response, low dark current, and high sensitivity in the near-infrared region. These APDs are recommended for applications that require high bandwidth or where internal gain is needed to overcome high pre-amp noise. In addition, Marktech APDs provide higher sensitivity than a standard photodiode and are ideal for extreme low-light level detection and short pulse

detection. APDs are essentially photodetectors that provide an amplification gain stage through avalanche multiplication. They are similar to photomultipliers but are solid state semiconductor devices.

Silicon Avalanche photodiodes (Si APDs) are the preferred optical detectors for applications where the wavelength lies between 400nm and 1100nm (with 800nm and 905nm optimized sensitivities), and exhibit high speed and low noise for visible to near-IR applications. Standard versions are available in three active area diameter sizes: 200, 500, and 800um and are offered in hermetic TO cans and can also be supplied in cost-effective LCC packages.

UV Detectors (150nm to 570nm)

UV LEDs are becoming more prevalent in the industry, replacing old technology such as mercury lamps. As a result, the need for UV detection is also increasing. Marktech UV detectors are offered in a variety of TO metal can-type packages from TO-18 to TO-39 with a special UV glass lens to ensure optimum lifetime and the least amount of material degradation. Marktech offers both standard and custom packaging including components, assemblies, and bare chip options to match your application requirements.

Our UV detectors use materials including GaP Schottky, GaN, and SiC. A die can be packaged individually in a variety of hermetically sealed packages or multiple die can be integrated in a custom package to suit your specific application. Marktech UV detectors offer superior stability over time and high device sensitivity with low dark current.

UV-A: Marktech also offers, on a custom basis, silicon-based UV detectors, which are designed for operation in the UV-A range. These devices are available in plastic and surface mount packages in addition to the standard TO metal can-type.

Typical industries served: Medical, industrial, scientific and analytical, environmental/ecological, and commercial

Common applications: Biomedical/chemical analysis, UV emitter output monitoring, outdoor UV sensors, gas/flame detection, spectrometers and wearable devices, emitter calibration, UV dosimetry and imaging including solar UV measurements and astronomical studies, flame sensors (fire alarm systems, missile plume detection, combustion engine control), spatial optical communications (intra- and inter-satellite secured communications), and biological and chemical sensors (ozone detection, determination of pollution levels in air, and biological agents detection).

InGaAs PIN Photodetectors (800nm to2600nm)

This high-sensitivity and high-reliability product series is ideally suited for applications in the SWIR (short wavelength infrared) wavelength range. This high-sensitivity and high-reliability product is ideally suited for optical communication devices.

Photodiode chip active area sizes from 0.1mm to 3.0mm are available to provide the optimum balance between low dark current, high speed, and light sensitivity. This allows for increased flexibility and options in a variety of applications ranging from fiber optics and high-speed optical communications to medical and chemical analysis.

Integrated TE (thermal electric) cooling is currently not utilized on our standard PIN photodiodes, thereby reducing costs and improving overall efficiency.

In addition to PIN photodiodes, Marktech offers foundry services for epitaxial growth of SWIR wafers in the 1.0um to 2.6um range, using InP material as the base substrate. Marktech is currently producing these high-reliability wafers in 2″, 3″, and 4″ diameters. Among the applications for these wafers are photodetectors, linear arrays, and image sensors. Photodetectors processed using our epitaxial wafers provide significant advantages, including lower dark current, better shunt resistance, and overall improved performance at lower operating temperatures.

Marktech manufactures InP PIN photodiodes using InGaAs/InP technology, which have a spectral sensitivity in the 800nm to 2600nm range for applications requiring low dark current, high speed, and sensitivity such as fiber optics and optical communications. Marktech's detector die can be placed in a variety of packages from metal can TO-5, TO-18, and TO-46 to surface mount and standard 3mm and 5mm plastic packages. We can also incorporate the detector die in custom-designed assemblies.

SWIR (Short Wavelength IR) Emitters (1050nm to 1720nm)

Marktech Optoelectronics is one of only a handful of manufacturers that supply emitters in the extended wavelength or SWIR range. Marktech's standard product offering includes both through-hole and surface mount packages with wavelengths from 1050nm to 1720nm and operating currents ranging from 20mA to 350mA for high-power applications. Higher wavelength ranges up to 3000nm are available in specific package types.

The SWIR wavelength range requires specialized optical detectors since standard silicon detectors have a maximum sensitivity limit of up to only approximately 1100nm. Marktech produces a line of InGaAs detectors that are optimized for sensing light in this SWIR wavelength range. These detectors can be obtained as an individual, discrete component, or they can be combined with a silicon sensor to cover the complete

spectrum of light from the visible to the SWIR range. Marktech also offers the option to custom-produce multi-element devices with emitter and detector chips in the same package.

The Marktech extended wavelength standard SWIR package offerings include:

- TO-46 flat
- TO-46 lens
- TOPLED PLCC4
- SMD 1206
- SMD 1206 lens
- SMD high-power black

Marktech's optoelectronic manufacturing and assembly capabilities include:

- SMD, through-hole, and chip on board assembly
- High-density pick and place
- Prototyping
- Small- to high-volume production runs
- PCB design and fabrication
- Single or multi-layer
- Flexible or rigid
- Aluminum, FR4, ceramic, and polyimide
- Schematic capture
- PCB design
- Simulation
- CAD/CAM
- Consigned or purchased materials
- In-circuit testing
- Reliability testing
- Potting
- Conformal coating
- IPC standard assembly
- Use of your part numbering system
- Shipped to your packaging requirements

Additional outsourced capabilities include:

- Plastic injection molding
- Metal work fabrication
- Optical analysis
- Thermal analysis

Photodetector Applications:

- **Astronomy:** Space-based telescopes with far-IR wavelengths
- **Automotive:** Driver vision in low light, collision detectors, twilight detection
- **Banking:** Counterfeit detection in currency
- **Communication:** Fiber optic communication (typically operates in the infrared wavelength) with very high rise time (response rate) to allow high data rates of up to 100 gigabits/second, silicon photodiodes used for short wavelength links (650 for POF and 850 for glass MM fiber), long wavelength systems used in InGaAs (indium gallium arsenide) detectors as they have lower noise than germanium (which allows for more sensitive receivers), very high speed systems using avalanche photodiodes (APDs) that are biased at high voltage to create gain in the photodiode
- **Chemical/biological:** High-speed detection
- **Consumer:** Household electronics (radios, DVD players, TVs, computer sensors), cameras
- **Environmental:** Detection via spectroscopy for pollutants and particulates, global temperature monitoring via space-based sensors, thermal imaging for home and business heat loss/efficiency, recycling (material identification from fluorescence of plastics/glass)
- **Industrial:** Robotic imaging/sensing, video camera imaging, process control through temperature monitoring, arc light detection (ultraviolet wavelength detectors are offered in applications where mercury lamps and UV LEDs are used), bar coding
- **Medical:** Pulse oximeters, CAT, and PET scans
- **Military:** Night vision applications, intake/exhaust temperatures for aerospace
- **Municipal:** Monitoring of water purification for municipal water supply, pools
- **Safety/Security:** Smoke/flame detection, TSA security

SWIR for Night Vision Applications

Arrays of SWIR detectors have been utilized in SWIR night vision systems, which rely on the intense night glow that can illuminate the scenery even when there is complete darkness in the visible spectrum.

The Visible Imagery of a Parking Lot at Night

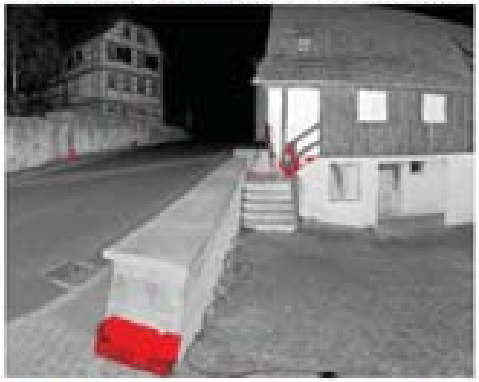
SWIR Imagery of left Parking Lot at Night under the Same Conditions

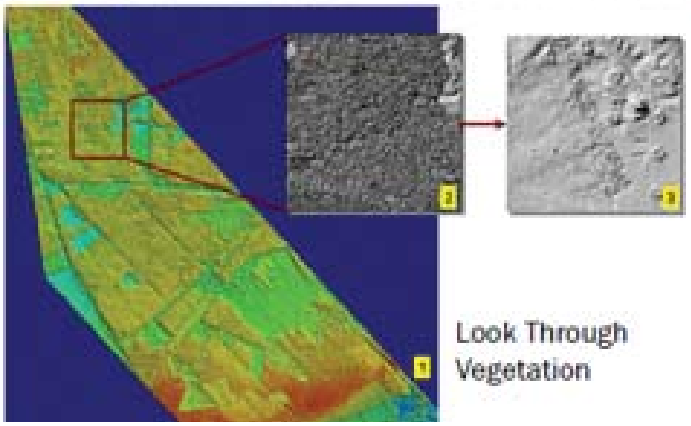
SWIR Detector for Homeland Security Applications

Visible Image – View with the naked eye

SWIR Image

IED - Improvised Explosive Device) Detection

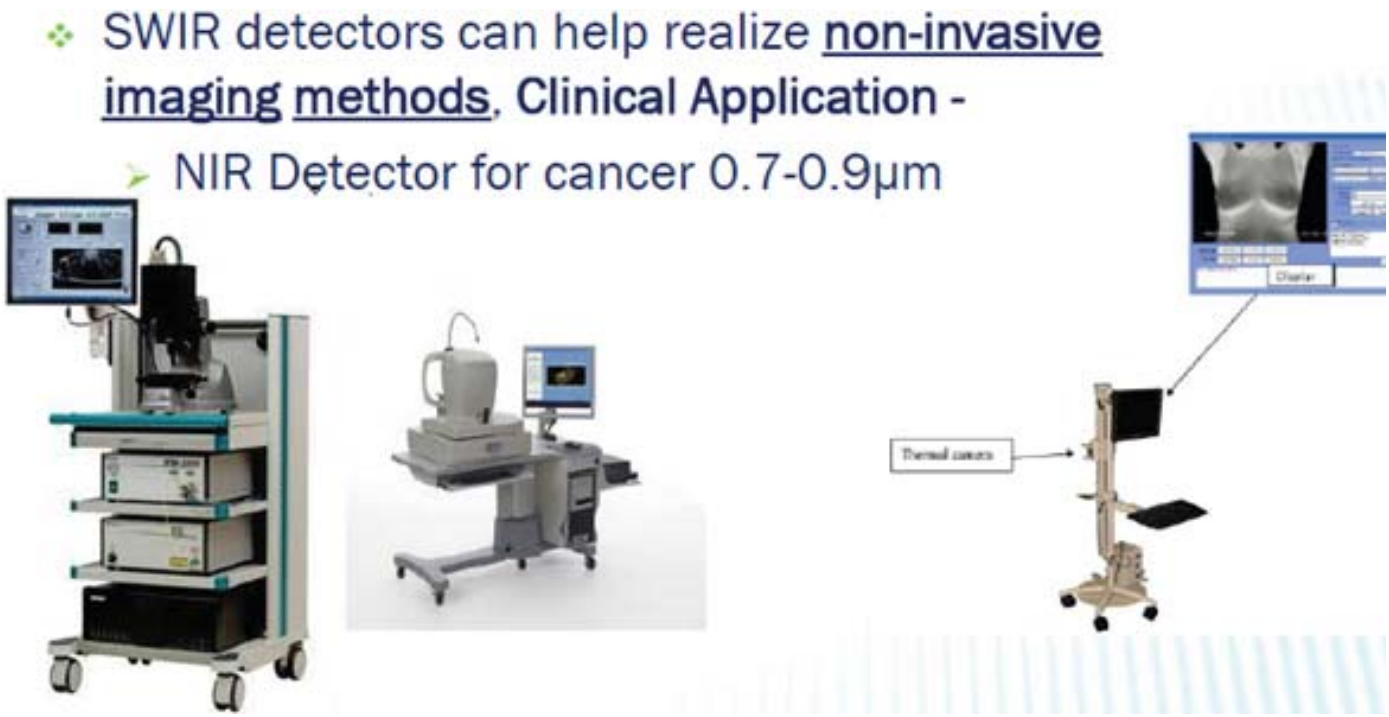




Look Through Vegetation

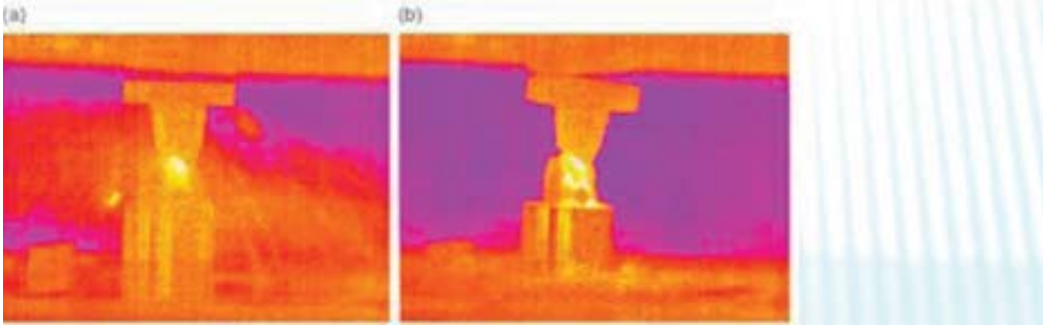
Applications in Medical & Biophotonics

SWIR detectors can help realize the non-invasive imaging methods, for example, optical coherence tomography (OCT) systems, utilizing SWIR to exploit the low scattering properties of >1μm light to see the previously unreachable, thick parts of the eye's cornea.



SWIR Industrial Applications

Inspection for High-Temperature Manufacturing Processes: Web inspection of continuous processes such as high-temperature manufacturing processes and quality controls.

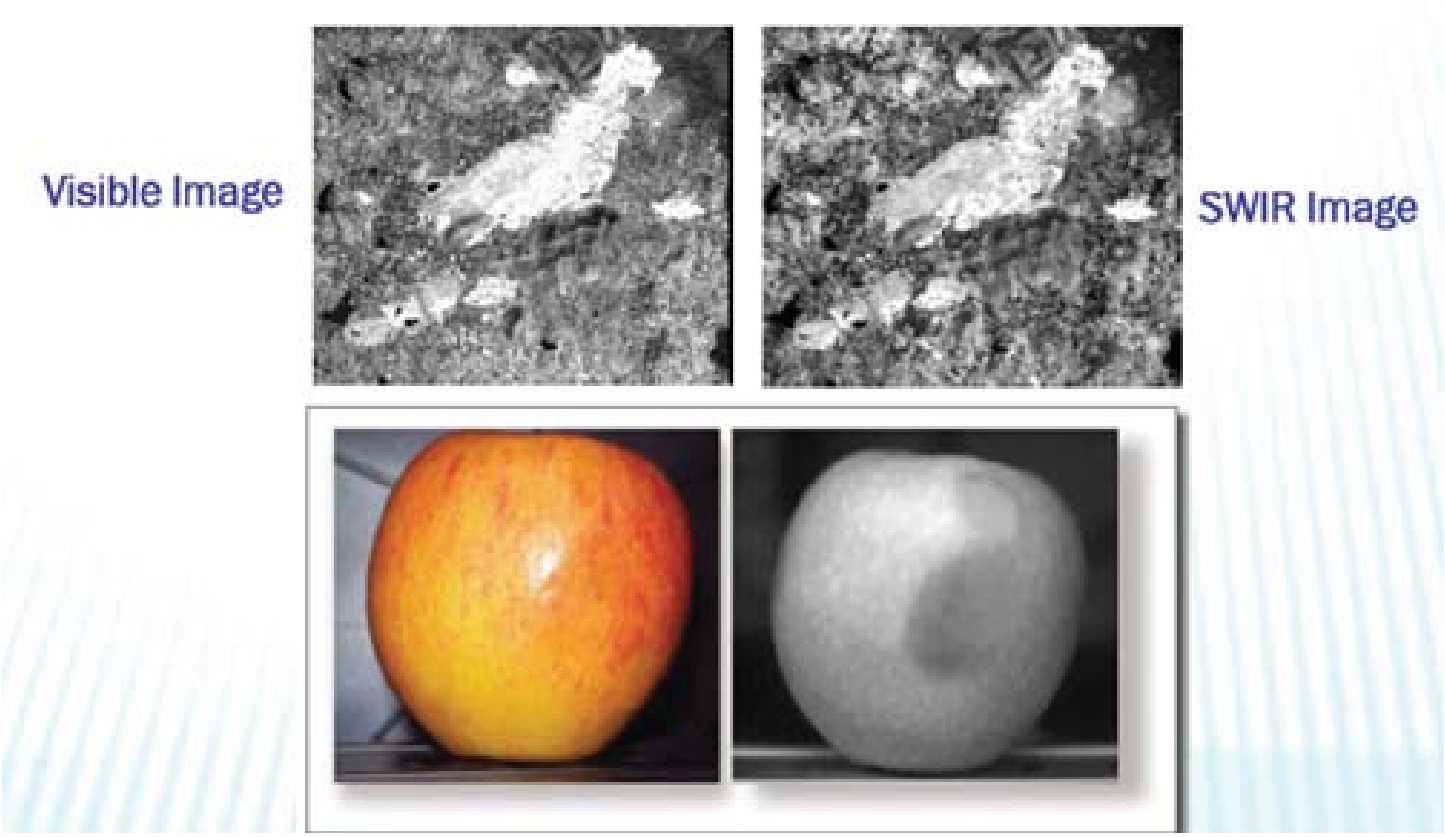


Recycled Plastics Resorting Application: SWIR can be used in the recycled plastics industry due to C-H, O-H, and N-H found in plastics, and uses wavelength around 1.0-2.2μm.

SWIR Applications in Agriculture

SWIR detectors, such as 1240nm, 1640nm, and 2130nm, combined with visible detectors, can be applied in some remote sensors for soil moisture and agricultural drought monitoring.

SWIR imaging can provide more information about rock and soil features better than visible images due to the reflection characteristics of rock and soil in the 1.8um to 2.5um range.



LIDAR Applications

LIDAR (light detection and ranging) is a surveying method that measures distance to a target by illuminating that target with a laser light. LIDAR uses laser light pulses, while radar uses radio waves. Avalanche photodiodes enable the LIDAR application as a remote sensing technology that optically measures properties of scattered light to find range and/or other information about a distant target.

To learn more about Marktech, optoelectronic emitters, or our start-to-finish customization capabilities, visit our website at www.marktechopto.com.