EDITION

AN-07

APPLICATION NOTE · MEDICAL IMAGING · BIOPHOTONICS

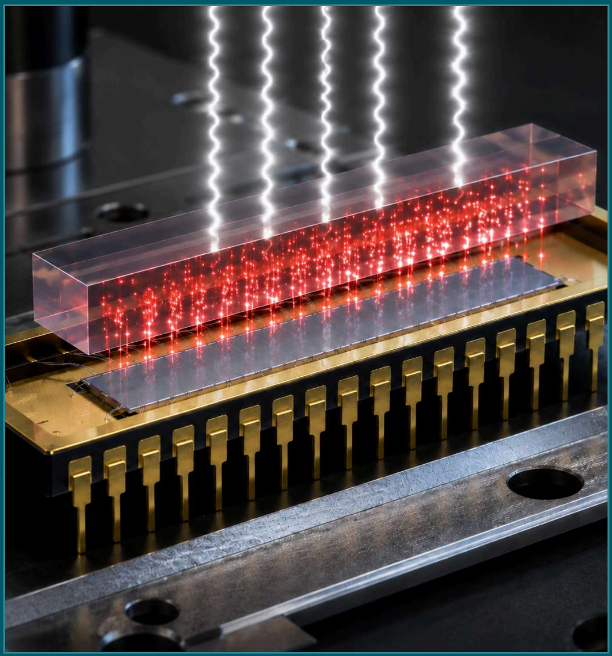
Photodiodes and Emitters for Medical Imaging and Biophotonic Instruments

How Opto Diode's silicon and InGaAs photodiodes, avalanche detectors, scintillator-coupled assemblies, and infrared LED emitters fit the everyday jobs in medical imaging and biophotonics: CT and digital radiography, fluorescence detection, pulse oximetry, OCT, and blood and tissue analysis, from 400 nm to 1700 nm.

FEATURED COMPONENT

Scintillator-Coupled Detector

Silicon photodiode coupled to a scintillator for CT and digital radiography, low dark current, tight channel matching · ceramic package



λ	400 nm – 1700 nm
FEATURED	Scintillator Detector
IMAGING	CT · Radiography
EMITTERS	Red / IR LED

WHAT YOU'LL LEARN

- L.01 Why scintillator-coupled silicon photodiodes carry modern CT and radiography
- L.02 How red and infrared emitter and detector pairs make pulse oximetry work
- L.03 Where avalanche photodiodes win over PIN silicon in photon-starved fluorescence
- L.04 Which detector fits OCT and near-infrared tissue analysis in the SWIR band

WHO IT'S FOR

- A.01 CT, digital radiography, and X-ray imaging designers
- A.02 Patient-monitoring and pulse-oximetry engineers
- A.03 Fluorescence, flow-cytometry, and assay instrument designers
- A.04 OCT and near-infrared spectroscopy developers

OVERVIEW

Medical instruments live or die on two things: signal you can trust and parts that keep working for years. A CT detector has to turn a faint scintillation flash into a clean number millions of times a scan. A pulse oximeter has to read a tiny change in transmitted light through a finger that never stops moving. A fluorescence reader has to pull a handful of emission photons out of a bright excitation background. This note walks through how Opto Diode's catalog fits those jobs, with low-noise silicon and InGaAs photodiodes for detection, avalanche photodiodes when the light runs out, scintillator-coupled assemblies for imaging, and reliable infrared emitters for the light source side. In a clinical instrument, the detector is not a component you revisit. It has to be right the first time.

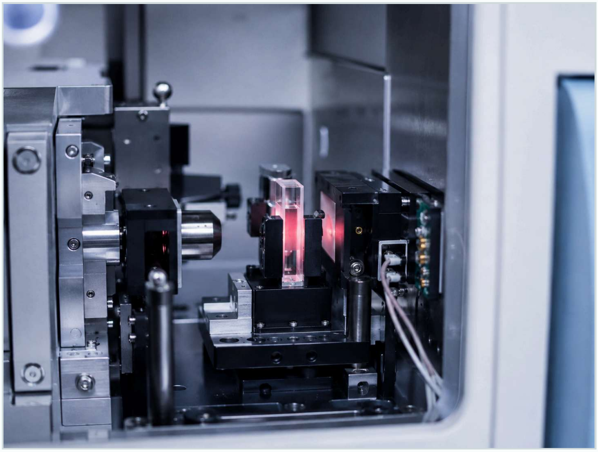
01

01 · APPLICATION CHALLENGE

The signal is small, and the part can never fail.

Medical detection sits at an awkward intersection. The optical signal is usually weak: a faint scintillation flash, a few percent change in transmitted light, a thin trickle of fluorescence riding on a bright background. At the same time, the part is going into an instrument that has to pass clinical qualification and then run for years without drifting. A detector that looks fine on a benchtop can still fail a medical program on channel-to-channel mismatch, dark-current drift with temperature, or a package that does not survive the screening and sterilization a device demands. The detector family, the way it is matched and packaged, and the screening behind it usually matter more than peak responsivity on a datasheet.

FIG.01 — Bench-Top Application Example



02

02 · DESIGN PRINCIPLE

Pick the detector for the photon budget, then prove the part.

Start with how much light you actually have. When photons are plentiful, as in a well-lit CT scintillator channel or a transmitted pulse-oximetry signal, a low-dark-current silicon PIN photodiode is the workhorse, and the job becomes matching, linearity, and stability. When photons are scarce, as in fluorescence, flow cytometry, or OCT, an avalanche photodiode buys real internal gain that lifts a weak signal above the readout noise. When the light moves into the near-infrared for tissue work, InGaAs takes over past 1000 nm. Once the family is right, the medical part of the job begins: matched channels, hermetic packaging, and the screening and documentation a clinical device needs.

DESIGN PRINCIPLE · 02

Geometry and stability beat raw responsivity.

A quad-cell whose four quadrants are matched to a few tenths of a percent will null-seek more reliably than a higher-responsivity discrete array that drifts apart over a working day. For position work, specify quadrant matching, position linearity, and dimensional stability of the package first. For low-light detection, specify NEP and dark-current drift. Treat peak responsivity as tertiary.

TBL.00 — GENERIC vs. FIELD-ENGINEERED DETECTORS

PARAMETER	GENERIC DETECTOR	OPTO DIODE FAMILY	WHY IT MATTERS
IMAGING CHANNELS	Loose discrete diodes	Scintillator-coupled silicon arrays	Matched channels give uniform CT and radiography images
LOW-LIGHT GAIN	PIN silicon only	APD (silicon avalanche)	Internal gain lifts fluorescence and OCT above noise
NEAR-INFRARED	Silicon cutoff near 1100 nm	InGaAs photodiodes (to 1700 nm)	Reaches the OCT and tissue-analysis SWIR band
LIGHT SOURCE	Third-party emitter	AlGaAs infrared LED emitters	Stable red and IR source matched to the detector

03

03 · ENGINEERING SELECTION

A practical framework for choosing the right detector.

Start with the photon budget. If light is plentiful, as in a CT scintillator channel or a transmitted pulse-oximetry signal, a low-dark-current silicon PIN photodiode is the workhorse, and the work shifts to channel matching, linearity, and stability. If light is scarce, as in fluorescence, flow cytometry, or OCT, an avalanche photodiode buys the internal gain that lifts the signal above readout noise. If the band runs past 1000 nm for tissue work, move to InGaAs. Once the family is set, the medical part begins: matched channels, hermetic packaging, and the screening and documentation a clinical device has to carry.

In practice, let the imaging modality set the starting point. CT and digital radiography lean on matched, scintillator-coupled silicon arrays, where channel-to-channel uniformity drives image quality. Pulse oximetry pairs red and infrared emitters with a single silicon detector, so emitter stability matters as much as the photodiode. Fluorescence and OCT push toward avalanche gain or InGaAs. When two families both fit, choose the one that simplifies the front-end electronics and the calibration you will maintain over the life of the instrument. Specify wavelength, signal level, and the qualification standard first; package details follow.

WAVELENGTH	RESPONSE	NOISE	FORM	PACKAGE	CUSTOM
400 nm – 1700 nm	DC – high-speed	Low dark current	Array / single / emitter	Hermetic, screened	Channel / array layout

TBL.01 — OPTO DIODE FAMILIES FOR MEDICAL IMAGING & BIOPHOTONICS

TECHNOLOGY	FAMILY	SPECTRAL RANGE	FORM	TYPICAL USE
Scintillator-Coupled Si	Silicon photodiode	Visible (via scintillator)	Array / module	CT, digital radiography
Standard Silicon	Silicon PIN photodiode	400 – 1100 nm	Single / multi	Pulse oximetry, general detection
Blue Enhanced Si	Silicon photodiode	400 – 1100 nm	Single element	Blue / UV fluorescence
Red Enhanced Si	Silicon photodiode	600 – 1100 nm	Single element	Red / NIR fluorescence, oximetry
APD (Si)	Silicon avalanche	400 – 1100 nm	Single element	Fluorescence, flow cytometry, OCT
InGaAs Photodiode	InGaAs PIN	900 – 1700 nm	Single element	OCT, tissue NIR analysis
AlGaAs IR Emitter	Infrared LED	Red / 800 – 940 nm	Emitter	Pulse oximetry, patient monitoring

TBL.02 — DOMINANT FAILURE MODES IN MEDICAL DETECTION

MODE	ROOT CAUSE	DESIGN RESPONSE
Channel mismatch	Unmatched discrete detectors	Matched scintillator-coupled silicon array
Dark-current drift	Temperature swing, moisture ingress	Low-dark-current silicon, hermetic package
Emitter aging	Output drift over device life	Screened AlGaAs emitters, stable output
Qualification failure	Unscreened commercial part	Hermetic packaging with medical screening

04

04 · PRODUCT FIT

Recommended Opto Diode building blocks.

TBL.03 — RECOMMENDED OPTO DIODE FAMILIES BY APPLICATION

PART / FAMILY	APPLICATION	FORM / PACKAGE	WHY THIS PART
Scintillator-Coupled Si	CT and digital radiography	Matched array, ceramic	Uniform channels give clean, artifact-free images
Red / IR Emitter + Si	Pulse oximetry, patient monitoring	Emitter and photodiode pair	Matched source and detector for stable readings
APD (Si)	Fluorescence, flow cytometry, OCT	Single element, hermetic	Internal gain raises weak signal above readout noise
InGaAs Photodiode	OCT and near-infrared tissue analysis	Single element, hermetic	Extends detection into the 900 to 1700 nm band
Blue Enhanced Si	Blue and UV fluorescence assays	Single element, low dark current	Responsivity matched to short-wavelength emission
Standard Silicon	General clinical detection	Single or multi-element	Proven, low-noise workhorse for visible light

KEY FEATURES

- Matched scintillator-coupled silicon for imaging
- Low dark current, low noise silicon and InGaAs
- APD internal gain for photon-starved signals
- Matched red and infrared LED emitters
- Custom channel counts and array geometry

APPLICATIONS

- CT and digital radiography
- Pulse oximetry and patient monitoring
- Fluorescence and flow cytometry
- Optical coherence tomography
- Near-infrared tissue and blood analysis

BUILT FOR PRECISION

- Hermetic TO and ceramic packages
- Glass-to-metal seals, no epoxy near die
- Medical screening and documentation
- Matched detector and emitter pairs
- ISO 9001:2015 certified

CUSTOM PROGRAMS

Engineered to your application.

Opto Diode designs custom channel counts and array layouts for imaging, matched detector and emitter pairs for monitoring, integrated amplifier hybrids, and hermetic or filter-integrated packages for medical instruments that have to hold calibration for years and pass clinical qualification. Everything is designed and built in-house under ISO 9001:2015, with the screening and documentation a medical program needs. Custom programs typically ship qualification samples in 8 to 12 weeks.

NEXT STEPS

Talk to Applications Engineering.

Bring your wavelength band, signal level, channel count, packaging needs, and the qualification standard you have to meet, and we'll come back with a recommended standard family, or a custom path, within one engineering review cycle.

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