

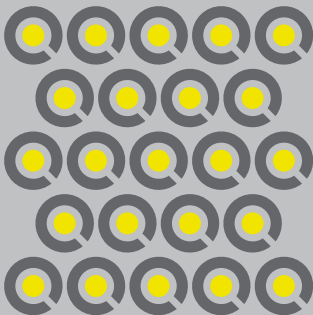
## SPAD23

### Description

SPAD23 is a detector array with 23 hexagonally packed single-photon avalanche diodes (SPADs) with best-in-class performance.

- ✓ Optimized for a wide detection spectra and low noise
- ✓ Credit card-sized system with time tagging

SPAD array



A schematic representation of the 23 SPADs placed on a hexagonal grid.



SPAD23 system

## Applications

### *Confocal microscopy*

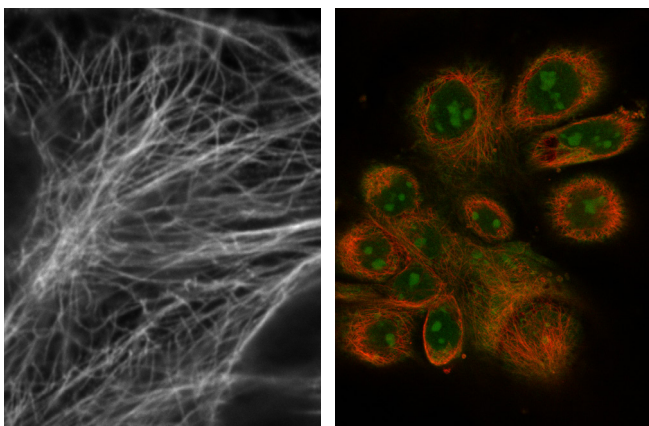
SPAD arrays increase light collection and enable innovation in the field of confocal scanning microscopy. This innovation finally leads to a sharper and brighter image with functional information about the underlying molecular function, interactions and environment.

#### **Applications:**

Image scanning microscopy (ISM), quantum ISM (Q-ISM), fluorescence lifetime imaging (FLIM), fluorescence correlation spectroscopy (FCS), stimulated emission depletion microscopy (STED)

#### **Why SPAD arrays?**

- Achieve super-resolution with a standard confocal microscope
- Increase light collection
- Increase imaging speed
- Reduce background noise



A confocal microscopy image. A multi-channel confocal microscopy image.

### *Quantum information*

Temporal photon correlations and photon number resolving (PNR) enable probing of quantum properties of light. Our detector has an extremely low crosstalk and thus enables reliable measurements of second and third order photon correlations, as well as quantum random number generation for unbreakable encryption.

#### **Applications:**

Antibunching and coincidence correlation, quantum random number generation

#### **Why SPAD arrays?**

- Simplify setup with single-chip multi-channel detector
- Increase data rate with detector parallelization
- Photon number resolving (PNR) detection

## Operating conditions & technical specifications

### Recommended operating conditions

SYMBOL	PARAMETER	MIN	MAX	UNIT
<b>Operating voltages</b>				
$V_{OP}$	SPAD high-voltage	26	32	V
<b>Environment</b>				
T		-55	35	°C

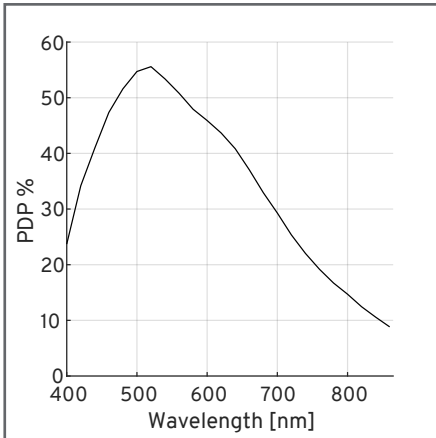


### Typical technical specifications

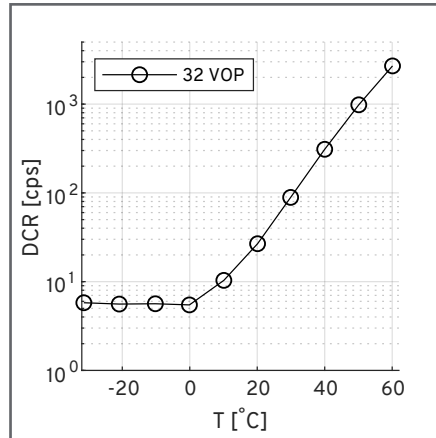
PARAMETER	CONDITIONS	TYP
Peak detection probability	$V_{OP} = 32\text{ V}$	55% @ 520 nm
Wavelength window with PDP >35%	$V_{OP} = 32\text{ V}$	440-660 nm
Fill factor	Collimated light	> 80%
Dark count rate	$V_{OP} = 32\text{ V}$ $T = 20^\circ\text{C}$	< 100 cps
Number of noisy pixels with DCR > 1 kcps	$V_{OP} = 32\text{ V}$	1
Dead time	$V_{OP} = 32\text{ V}$ $V_q = 0.8\text{ V}$	50 ns
Timing jitter	$V_{OP} = 32\text{ V}$	120 ps
Afterpulsing	$V_{OP} = 32\text{ V}$ $V_q = 0.8\text{ V}$	0.1%
Crosstalk	$V_{OP} = 32\text{ V}$	0.14%
Maximum count rate per pixel		7.8 Mcps
Time-tagging resolution		20 ps



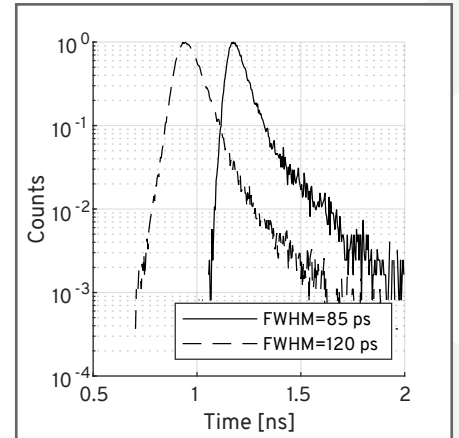
## Typical performance characteristics



Photon detection probability.



Dark count rate over temperature.



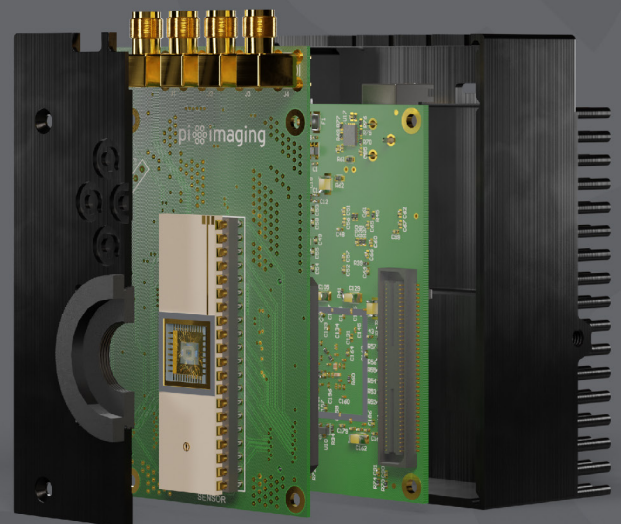
Excellent timing jitter with a FWHM of <120 ps for wavelengths between 510 and 785 nm.

## System integration

A system overview is shown on the right. For operation, only two plugs are required, a 5 V power supply and a USB3 connection.

The software provides functionalities for photon-counting and time-tagging modes. It can be accessed through TCP/IP for easy integration into LabVIEW, MATLAB or Python.

Credit card-sized system, housing an FPGA and the SPAD23 sensor.



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