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AdvanSiD
Advanced Silicon Detectors

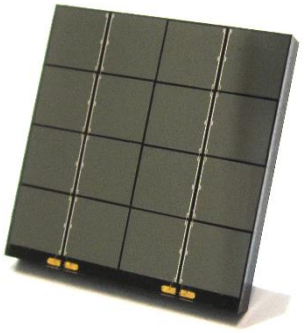
Hybrid TD Arrays
RGB-SiPMs

General Description

High fill-factor, 16 channels hybrid array with 3x3 mm^2 or 4x4 mm^2 active area silicon photo-multipliers (SiPMs) with common anode bias connection and independent cathodes readout.

RGB AdvanSiD hybrid arrays are based on the AdvanSiD “N-on-P” silicon technology for detection of Red, Green, and Blue light. RGB-SiPMs have peak efficiency at 550 nm, with detection spectrum extending from 350 nm to 900 nm.

The SiPM is an innovative solid state silicon detector with single photon sensitivity. SiPMs are a valid alternative to photomultiplier tubes (PMT detectors). The main benefits of this detector are high gain, extremely good timing performance, low operative voltage, insensitivity to magnetic field, and high integration level.



Features

- **Red, Green, Blue light detection**
- **Superior breakdown voltage uniformity**
- **Low noise**
- **Excellent temperature stability**
- **Detection of extremely faint light**
- **Very high gain (10^6)**
- **Extremely good timing performance**
- **Insensitive to magnetic fields**
- **Not damaged by ambient light**
- **Small and compact**
- **Nickel free, MR compatible package**

Application

- High Energy Physics
- Medical Imaging
- Nuclear Medicine
- DNA Sequencing
- Homeland Security
- Flow Cytometry
- Biological Sensors
- Analytical Instruments
- SEM Microscopy
- Confocal Microscopy

Ordering Information

Product Code	Description
ASD-RGB3S-P-4x4TD	4x4 array of 3×3 mm^2 active area SiPMs
ASD-RGB4S-P-4x4TD	4x4 array of 4×4 mm^2 active area SiPMs

S indicates square SiPM; P indicates plastic chip scale package (CSP); TD indicates tile with die-to-die wire bonding.

Hybrid TD Arrays RGB-SiPMs

Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
T_A	Operating Temperature Range	-25	+40	°C
T_s	Storage temperature	-40	+60	°C
T_{sol}	Lead temperature (solder) 5s		+250	°C
M_{VW}	Max voltage working range	Breakdown Voltage + 4		V

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

Geometrical, Electrical, and Optical Typical Characteristics (T_a=20°C)

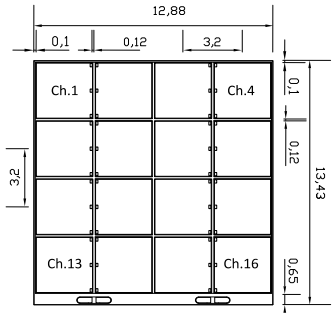
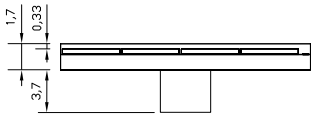
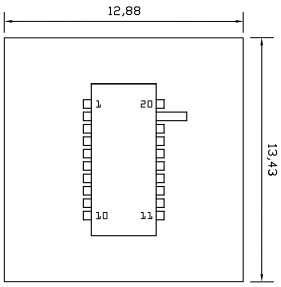
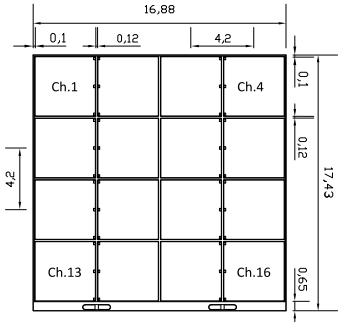
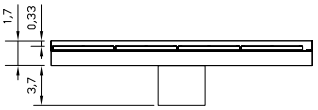
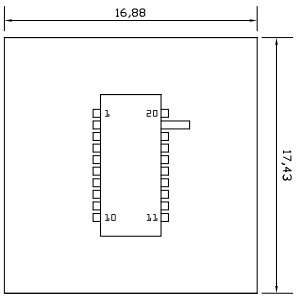
Symbol	Parameter	Product	
		ASD-RGB3S-P-4x4TD	ASD-RGB4S-P-4x4TD
AA	Effective active area	3×3×16 mm^2	4×4×16 mm^2
Ch	Channels (SiPMs)	16	16
S	SiPM size	3×3 mm^2	4×4 mm^2
P	SiPM pitch	3.2 mm	4.2 mm
N	Cell number	5520 /channel	9340 /channel
FF^A	Array fill-factor	83.5 %	87.3 %
CS	Cell size (pitch)	40 µm × 40 µm	
FF	Cell fill-factor	60 %	
RQ	Quenching resistance	550 kΩ	
C	Cell capacitance	90 fF	
τ_{RC}	Recharge time constant	50 ns	
S_R	Spectral response range	350 to 900 nm	
λ_p	Peak sensitivity wavelength	550 nm	
PDE	Photon Detection Efficiency (1)	32.5 %	
BV	Breakdown voltage(2)	Typical: 27 V Min: 25 V Max: 29 V	
σBV	BV standard deviation(3)	50 mV	
ΔBV	BV uniformity(4)	< 0.4 V	
OV	Recommended Overvoltage range(5)	Min: 2 V Max: 4 V	
DCR	Dark Count Rate(6)	< 100 kHz/mm^2 @ 2 V OV	< 200 kHz/mm^2 @ 4 V OV
G	Gain(7)	2.7×10^6	
BVTC	Breakdown Voltage Temperature Coefficient	27 mV/°C	
n_{epoxy}	Refractive index of epoxy resin(8)	1.5115 (@ 589 nm, 23°C, uncured)	
T_{epoxy}	Spectral transmission of epoxy resin(8)	> 97% @ 1000 – 1600 nm ; > 99% @ 400 – 1000 nm	

(1) Measured at peak sensitivity wavelength ($\lambda = \lambda_p$) at +4 V overvoltage (not including afterpulse and crosstalk).
(2) Refer to the data provided with each product. Special selection of devices based on BV available upon request.
(3) BV of SiPMs belonging to a same production lot is within 200 mV (±2σ) from mean BV value.
(4) Maximum difference in the BV of the SiPMs in each array.
(5) Overvoltage: excess bias beyond BV.
(6) 0.5 p.e. threshold level at 20 °C and +4 V overvoltage (primary dark count rate not including afterpulse).
(7) Measured at 20 °C at +4 V overvoltage.
(8) *To be used as a guide only, not as a specification. Reported data is not guaranteed.*

Hybrid TD Arrays RGB-SiPMs

Dimensional Outlines and Channels Numbering

Units = mm, Mechanical tolerance = ±0.15 mm unless otherwise noted.

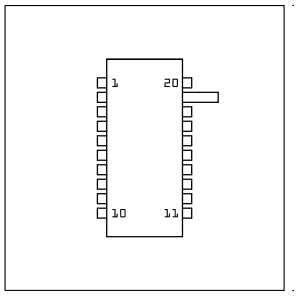
Product	Top View	Side View	Bottom View
ASD-RGB3S-P-4x4TD 4×4 SiPMs array 3x3 mm² active area SiPMs 3.2 mm SiPM pitch 120 um gap between SiPM dies Material: FR4 + transparent epoxy layer			
ASD-RGB4S-P-4x4TD 4×4 SiPMs array 4x4 mm² active area SiPMs 4.2 mm SiPM pitch 120 um gap between SiPM dies Material: FR4 + transparent epoxy layer			

SiPMs Bias and Read-out

TD type arrays feature font side die-to-die wire bonding. The SiPM dies are grouped in columns and interconnected through the front bond pads. Common bias terminals are available for each column of the array. Each SiPM of the array (channel) is independently read-out from the back side of the dies.

- ➔ **SiPMs in RGB "TD" type arrays feature common cathode bias**
- ➔ **Independent anode read-out - Positive output signals**

Pin-out



Array bottom view

Pin number	Name	Channel	Pin number	Name	Channel
1	A4	Ch.4	11	K1	Ch.1,5,9,13
2	A3	Ch.3	12	K2	Ch.2,6,10,14
3	A8	Ch.8	13	A14	Ch.14
4	A7	Ch.7	14	A13	Ch.13
5	A12	Ch.12	15	A10	Ch.10
6	A11	Ch.11	16	A9	Ch.9
7	A16	Ch.16	17	A6	Ch.6
8	A15	Ch.15	18	A5	Ch.5
9	K3	Ch.3,7,11,15	19	A2	Ch.2
10	K4	Ch.4,8,12,16	20	A1	Ch.1

A = Anode
K = Cathode

Connector

JAE 0.8 mm pitch IL-WX series.

One pin header connector mounted on the back of the module (part number JAE IL-WX-20P-VF-BE).

One receptacle (socket) provided with each shipped SiPM array (part number JAE IL-WX-20S-VF-BE).

SMT mounting of sockets should follow constructor's indications.

Datasheet and mechanical information available at this link (JAE website).

General Specifications (JAE IL-WX-20P-VF-BE)

Parameter	Value	Unit
Number of contacts	20	-
Rated current	0.5	A
Dielectric withstanding voltage	500 (1 minute)	V (AC rms)
Insulation resistance	100 (min)	MΩ
Contact resistance	20 (max)	mΩ
Operating temperature range	-40 to +85	°C

Device Characteristics

This section reports the dependences on overvoltage, temperature, and wavelength of most relevant device parameters. Refer to the data accompanying each shipped product for more detailed information.

All measurements are performed in a tight-light climatic chamber at T=20°C, unless otherwise noted.

SiPM output signals are amplified with ASD-EP-EB-N or ASD-EP-EB-PZ evaluation boards and acquired with fast oscilloscopes; the digitized data is then processed with dedicated PC programs.

Explanation of SiPM working principle and details on SiPM properties parameters can be found on the *Introduction to SiPMs* available at http://advansid.com/resources/the-silicon-photmultiplier.

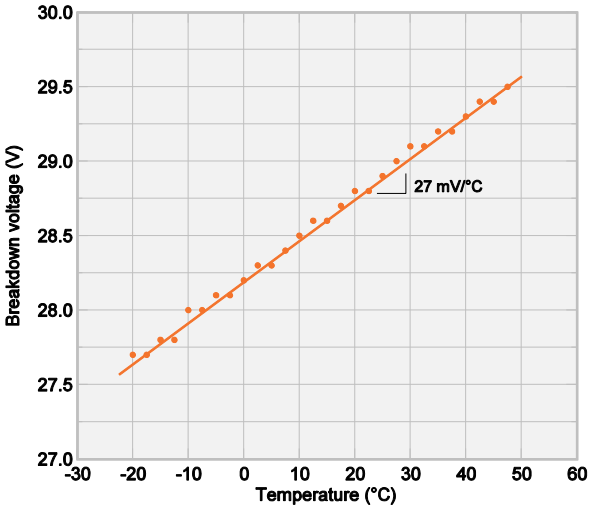


Fig.1 RGB-SiPMs breakdown voltage temperature dependence.

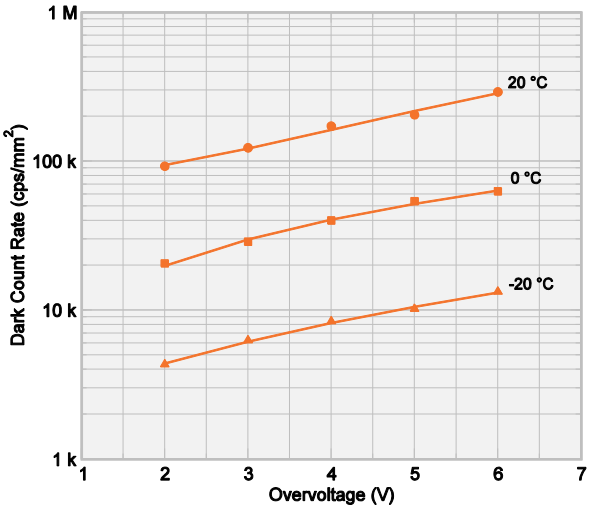


Fig.2 Dark count rate per square mm in RGB-SiPMs as a function of overvoltage and temperature. 0.5 p.e. threshold level. Primary dark count rate, not including afterpulse.

Hybrid TD Arrays RGB-SiPMs

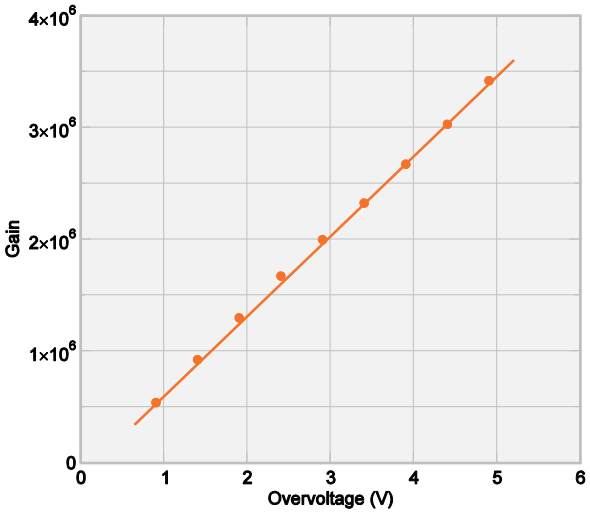


Fig.3 Gain of RGB-SiPMs as a function of overvoltage.

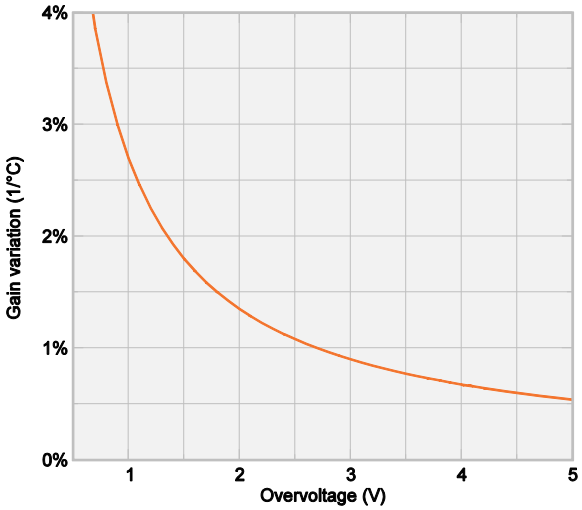


Fig.4 Relative variation of gain with temperature in RGB-SiPMs as a function of overvoltage.

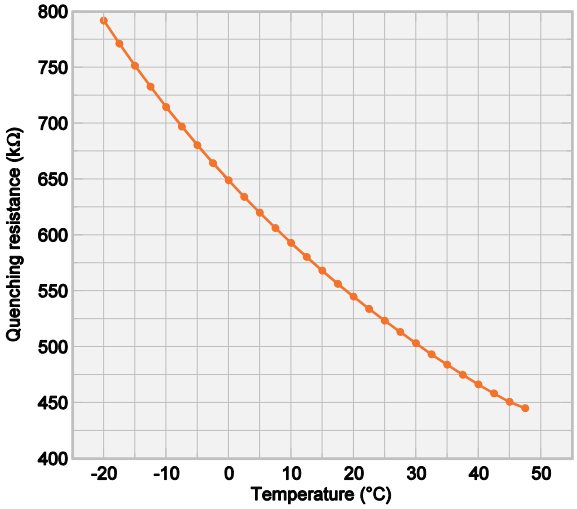


Fig.5 Temperature dependence of poly-silicon quenching resistance in RGB-SiPMs.

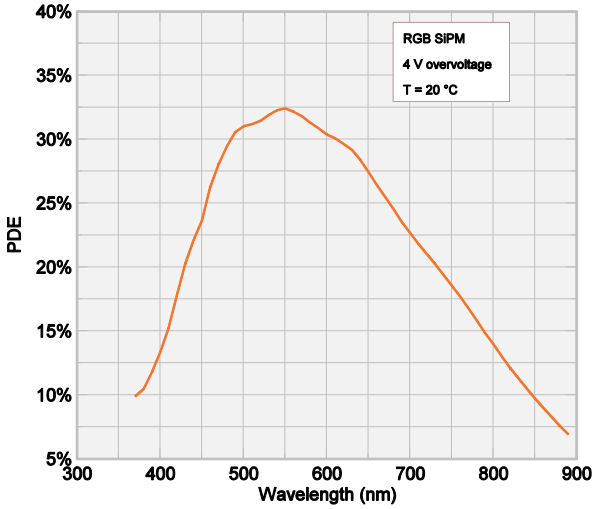


Fig.6 Photo detection efficiency (PDE) in RGB-SiPMs as a function of wavelength (crosstalk and afterpulse not included).

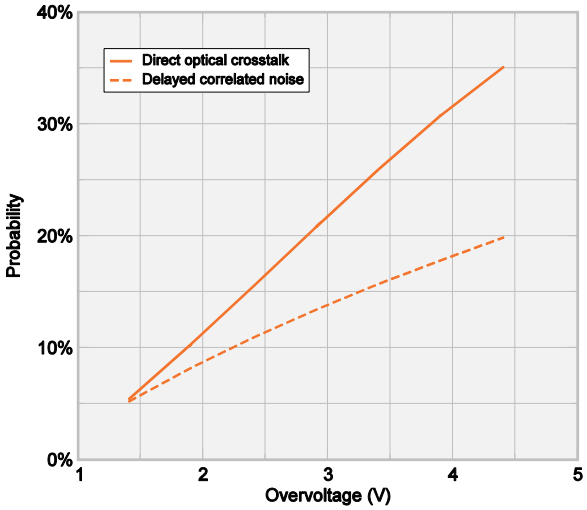


Fig.9 Delayed correlated noise probability (delayed crosstalk and afterpulse) in RGB-SiPMs.

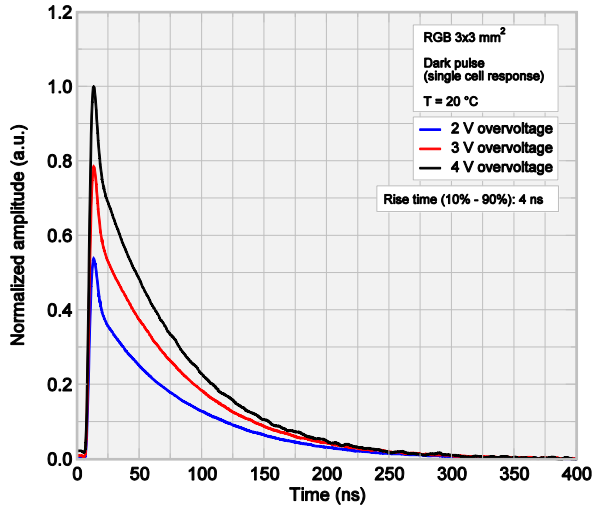


Fig.10 RGB-SiPM pulse shape (dark pulses, single cell response) at different overvoltage. Signals acquired with ASD-EP-EB-N.