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AdvanSiD
Advanced Silicon Detectors

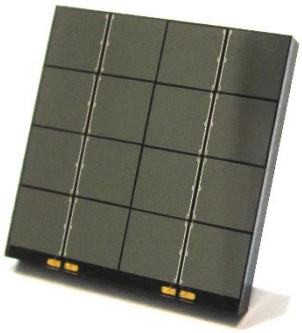
# Hybrid TD Arrays
# NUV-SiPMs

## 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.

AdvanSiD hybrid arrays feature the new low-afterpulse NUV-SiPMs that are based on the "P-on-N" silicon junction technology for the detection of Near Ultraviolet Light. NUV-SiPMs have peak efficiency at 420 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

- **Near Ultra Violet light detection**
- **Afterpulsing probability < 4 %**
- **Dark Count Rate < 100 kHz/$mm^2$**

- **Superior breakdown voltage uniformity**
- **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-NUV3S-P-4x4TD | 4x4 array of 3×3 $mm^2$ active area SiPMs |
| ASD-NUV4S-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 NUV-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 + 6 | | 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-NUV3S-P-4x4TD | ASD-NUV4S-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 | 800 kΩ | |
| C | Cell capacitance | 90 fF | |
| $\tau_{RC}$ | Recharge time constant | 70 ns | |
| $S_R$ | Spectral response range | 350 to 900 nm | |
| $\lambda_p$ | Peak sensitivity wavelength | 420 nm | |
| PDE | Photon Detection Efficiency (1) | 43 % | |
| BV | Breakdown voltage(2) | Typical: 26 V Min: 24 V Max: 28 V | |
| σBV | BV standard deviation(3) | 50 mV | |
| ΔBV | BV uniformity(4) | < 0.4 V | |
| OV | Recommended Overvoltage range(5) | Min: 2 V Max: 6 V | |
| DCR | Dark Count Rate(6) | < 50 kHz/mm$^2$ @ 2 V OV | < 100 kHz/mm$^2$ @ 6 V OV |
| G | Gain(7) | 3.6×10$^6$ | |
| BVTC | Breakdown Voltage Temperature Coefficient | 26 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 | |

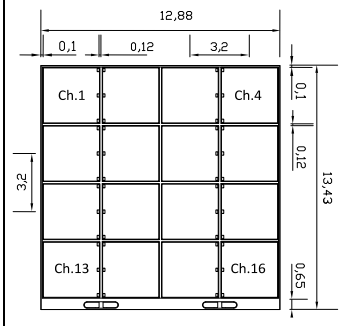
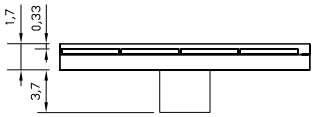
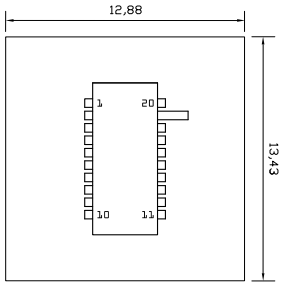
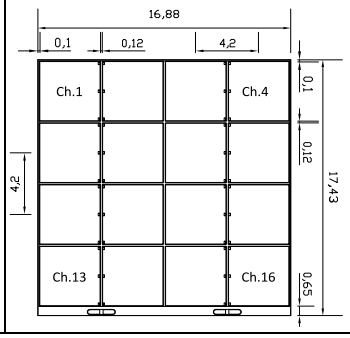
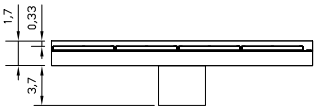
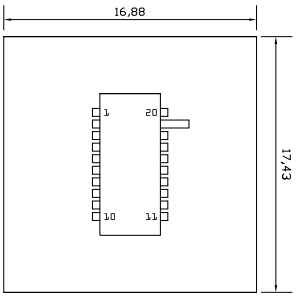
*(1) Measured at peak sensitivity wavelength ($\lambda = \lambda_p$) at +6 V overvoltage (not including afterpulse and crosstalk).*
*(2) Refer to the data provided with each product. Special selection of devices based on BV available upon request.*
*(3) BV of SiPMs belonging to a same production lot 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 +6 V overvoltage (primary dark count rate not including afterpulse).*
*(7) Measured at 20 °C at +6 V overvoltage.*
*(8) To be used as a guide only, not as a specification. Reported data is not guaranteed.*

*Information in this datasheet is believed to be reliable. However, no responsibility is assumed for possible inaccuracies or omissions. Specification are subject to change without notice.*

# Hybrid TD Arrays NUV-SiPMs

## Dimensional Outlines and Channels Numbering

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

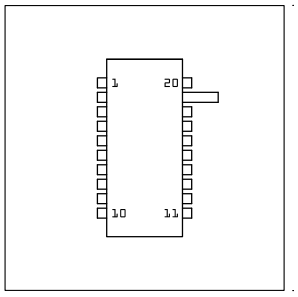
| Product | Top View | Side View | Bottom View |
|---|---|---|---|
| **ASD-NUV3S-P-4x4TD**<br>4×4 SiPMs array<br>3x3 mm² active area SiPMs<br>3.2 mm SiPM pitch<br>120 um gap between SiPM dies<br>Material: FR4 + transparent epoxy layer |  |  |  |
| **ASD-NUV4S-P-4x4TD**<br>4×4 SiPMs array<br>4x4 mm² active area SiPMs<br>4.2 mm SiPM pitch<br>120 um gap between SiPM dies<br>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 NUV "TD" type arrays feature common anode bias**
- ➔ **Independent cathode read-out - Negative output signals**

## Pin-out




Array bottom view

| Pin number | Name | Channel | Pin number | Name | Channel |
|---|---|---|---|---|---|
| 1 | K4 | Ch.4 | 11 | A1 | Ch.1,5,9,13 |
| 2 | K3 | Ch.3 | 12 | A2 | Ch.2,6,10,14 |
| 3 | K8 | Ch.8 | 13 | K14 | Ch.14 |
| 4 | K7 | Ch.7 | 14 | K13 | Ch.13 |
| 5 | K12 | Ch.12 | 15 | K10 | Ch.10 |
| 6 | K11 | Ch.11 | 16 | K9 | Ch.9 |
| 7 | K16 | Ch.16 | 17 | K6 | Ch.6 |
| 8 | K15 | Ch.15 | 18 | K5 | Ch.5 |
| 9 | A3 | Ch.3,7,11,15 | 19 | K2 | Ch.2 |
| 10 | A4 | Ch.4,8,12,16 | 20 | K1 | 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.

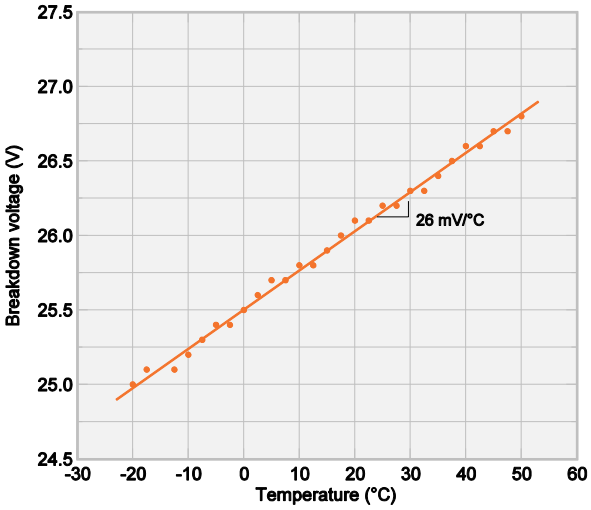



**Fig.1** NUV-SiPMs breakdown voltage temperature dependence.

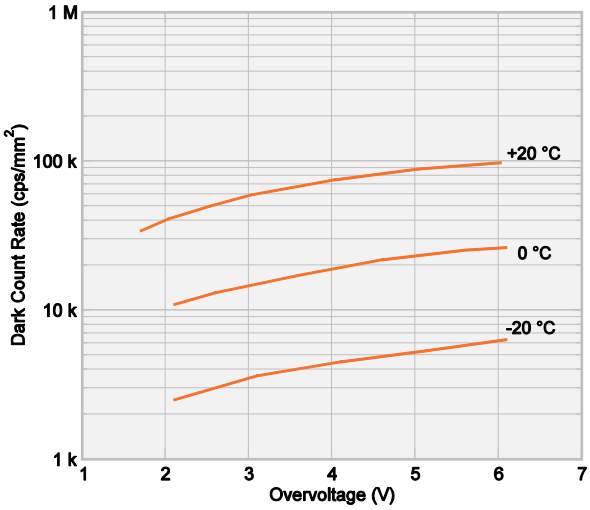



**Fig.2** Dark count rate (per mm$^2$) in low-afterpulse NUV-SiPMs as a function of overvoltage and temperature.

## Hybrid TD Arrays NUV-SiPMs

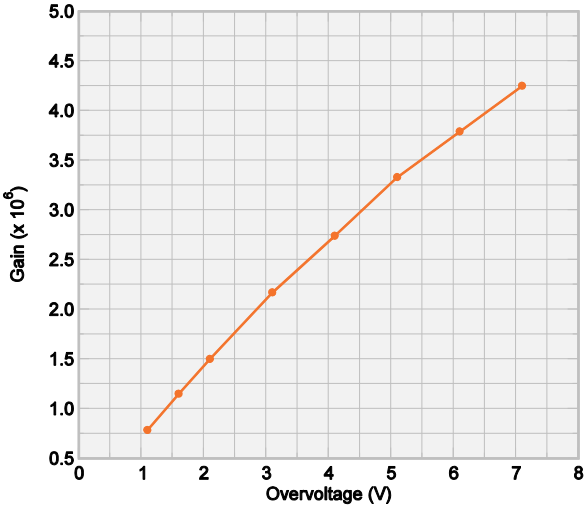



**Fig.3** Gain of NUV-SiPMs as a function of overvoltage.

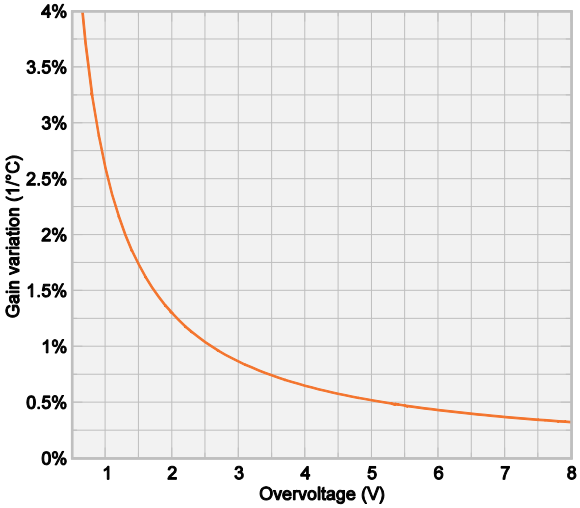



**Fig.4** Relative variation of gain with temperature in NUV-SiPMs as a function of overvoltage.

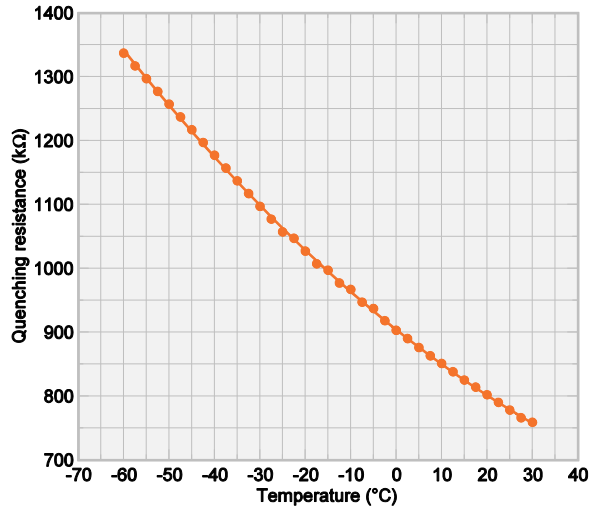



**Fig.5** Temperature dependence of poly-silicon quenching resistance in NUV-SiPMs.

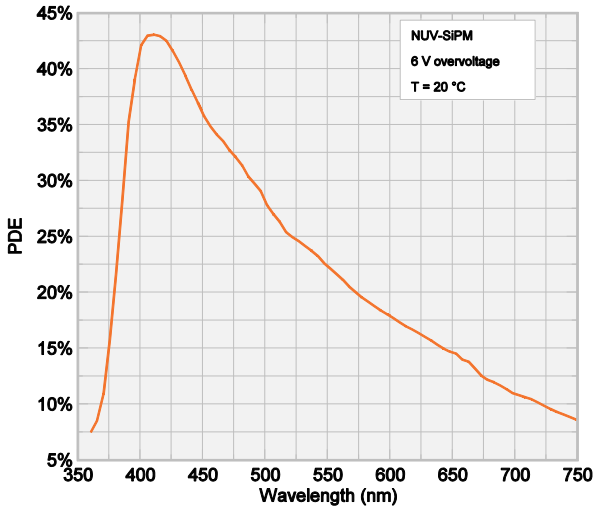



**Fig.6** Photo detection efficiency (PDE) in NUV-SiPMs as a function of wavelength (crosstalk and afterpulse not included).

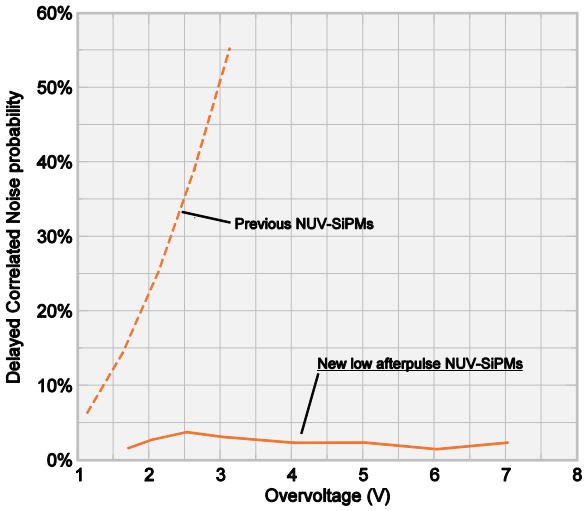



**Fig.9** Delayed correlated noise probability (delayed crosstalk and afterpulse) in NUV-SiPMs.

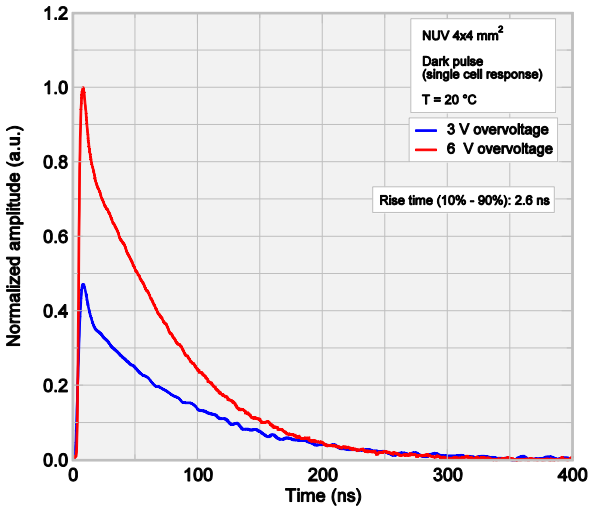



**Fig.10** NUV-SiPM pulse shape (dark pulses, single cell response) at different overvoltage. Signals acquired with ASD-EP-EB-N.