

# NIR-Enhanced, Single Pixel Silicon Photomultiplier (SiPM)

## Advance Information RD-Series SiPM Sensors

The MicroRD family of sensors are a range of Silicon Photomultipliers (SiPM) that provide enhanced sensitivity in the red and NIR region of the electromagnetic spectrum. The MicroRD SiPMs feature high responsivity, fast signal response and a low temperature coefficient of operating voltage, all achieved at a low bias voltage. The sensor is packaged in a compact and robust MLP (micro lead frame) package that is suitable for reflow solder processes. The product is designed for high-volume, automotive applications and will be qualified to the AEC-Q102 standard.

SiPM sensors are an improvement over avalanche photodiodes (APD) and PIN diodes due to their high gain and single photon sensitivity. For LiDAR applications this enables the detection of low reflectivity targets at very long distances.

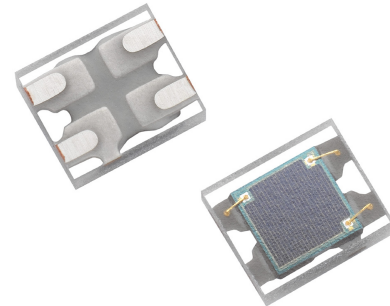
It is strongly recommended that those new to SiPM sensors consult the [Introduction to Silicon Photomultipliers](#) application note.

Evaluation boards (SMA and SMTPA boards – see pages 7–8) are also available for these products.



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### ORDERING INFORMATION

See detailed ordering and shipping information on page 9 of this data sheet.

### KEY SENSOR AND PACKAGE SPECIFICATIONS

| Parameter                      | Value            |      |     | Unit | Comment                            |
|--------------------------------|------------------|------|-----|------|------------------------------------|
| Silicon Process                | RD               |      |     |      | NIR enhanced                       |
| Number of Pixels               | Single pixel     |      |     |      |                                    |
| Active Area                    | 1 × 1            |      |     | mm   |                                    |
| Microcell Size                 | 10               | 20   | 35  | μm   |                                    |
| Number of Microcells per Pixel | 4370             | 1620 | 625 |      |                                    |
| Microcell Fill Factor          | 44               | 65   | 77  | %    |                                    |
| Package Size                   | 1.5 × 1.8 × 0.65 |      |     | mm   | MLP Package (W × L × H)            |
| Output Type                    | Analog           |      |     |      | Standard and Fast output per pixel |

This document contains information on a new product. Specifications and information herein are subject to change without notice.

## RD-Series SiPM Sensors

### PERFORMANCE SPECIFICATIONS

Typical values are measured at 21°C. Minimum and Maximum values (when available) will take into account operation over the full temperature range of -40°C to 105°C. All measurements made at typical Vop (see biasing table below). All timing measurements acquired using a MicroRD-SMA EVB.

| Parameter                | Microcell Variant | Min | Typ               | Max | Unit | Comment                                            |
|--------------------------|-------------------|-----|-------------------|-----|------|----------------------------------------------------|
| PDE @ 905 nm             | 10 $\mu\text{m}$  | –   | 6.0               | –   | %    |                                                    |
|                          | 20 $\mu\text{m}$  | –   | 9.8               | –   | %    |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 11.0              | –   | %    |                                                    |
| Dark Count Rate          | 10 $\mu\text{m}$  | –   | 1                 | –   | Mcps |                                                    |
|                          | 20 $\mu\text{m}$  | –   | 700               | –   | kcps |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 850               | –   | kcps |                                                    |
| Optical Crosstalk        | 10 $\mu\text{m}$  | –   | 25                | –   | %    |                                                    |
|                          | 20 $\mu\text{m}$  | –   | 25                | –   | %    |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 25                | –   | %    |                                                    |
| Gain                     | 10 $\mu\text{m}$  | –   | $0.7 \times 10^6$ | –   |      |                                                    |
|                          | 20 $\mu\text{m}$  | –   | $0.8 \times 10^6$ | –   |      |                                                    |
|                          | 35 $\mu\text{m}$  | –   | $1.6 \times 10^6$ | –   |      |                                                    |
| Afterpulsing Probability | 10 $\mu\text{m}$  | –   | 13                | –   | %    | 0.5 Photoelectron level                            |
|                          | 20 $\mu\text{m}$  | –   | 4                 | –   | %    |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 2                 | –   | %    |                                                    |
| 90% – 10% Recovery Time  | 10 $\mu\text{m}$  | –   | 45                | –   | ns   | See page 4 for further details on this measurement |
|                          | 20 $\mu\text{m}$  | –   | 45                | –   | ns   |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 110               | –   | ns   |                                                    |
| 10% – 90% Rise Time      | 10 $\mu\text{m}$  | –   | 1.9               | –   | ns   |                                                    |
|                          | 20 $\mu\text{m}$  | –   | 2.0               | –   | ns   |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 0.75              | –   | ns   |                                                    |
| Fast Output Pulse Width  | 10 $\mu\text{m}$  | –   | 1.3               | –   | ns   | FWHM                                               |
|                          | 20 $\mu\text{m}$  | –   | 1.5               | –   | ns   |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 2.5               | –   | ns   |                                                    |
| Fast Output Rise Time    | 10 $\mu\text{m}$  | –   | 240               | –   | ps   |                                                    |
|                          | 20 $\mu\text{m}$  | –   | 350               | –   | ps   |                                                    |
|                          | 35 $\mu\text{m}$  | –   | 590               | –   | ps   |                                                    |

### BIAS PARAMETERS

| Parameter                 | Microcell Size   | Min                        | Typ  | Max  | Unit | Comment                                                                |
|---------------------------|------------------|----------------------------|------|------|------|------------------------------------------------------------------------|
| Breakdown Voltage (Vbr) * | 10 $\mu\text{m}$ | –                          | 21.9 | –    | V    | See page 3 for the behavior of Vbr with temperature                    |
|                           | 20 $\mu\text{m}$ | –                          | 22.4 | –    | V    |                                                                        |
|                           | 35 $\mu\text{m}$ | –                          | 22.4 | –    | V    |                                                                        |
| Over Voltage (Vov)        | 10 $\mu\text{m}$ | –                          | 12.0 | 17.0 | V    | Typical values recommended for operation and used for characterization |
|                           | 20 $\mu\text{m}$ | –                          | 5.4  | 9.0  | V    |                                                                        |
|                           | 35 $\mu\text{m}$ | –                          | 3.6  | 6.0  | V    |                                                                        |
| Operating Bias            | 10 $\mu\text{m}$ | $V_{op} = V_{br} + V_{ov}$ |      |      |      |                                                                        |
|                           | 20 $\mu\text{m}$ |                            |      |      |      |                                                                        |
|                           | 35 $\mu\text{m}$ |                            |      |      |      |                                                                        |

\*The breakdown voltage (Vbr) is defined as the value of the voltage intercept of a straight line fit to a plot of  $\sqrt{I}$  vs V, where I is the current and V is the bias voltage.

## RD-Series SiPM Sensors

### TEMPERATURE COEFFICIENT OF Vbr

The breakdown voltage as a function of temperature is plotted for the three MicroRD variants in Figure 1. The behavior can be approximated by the equation

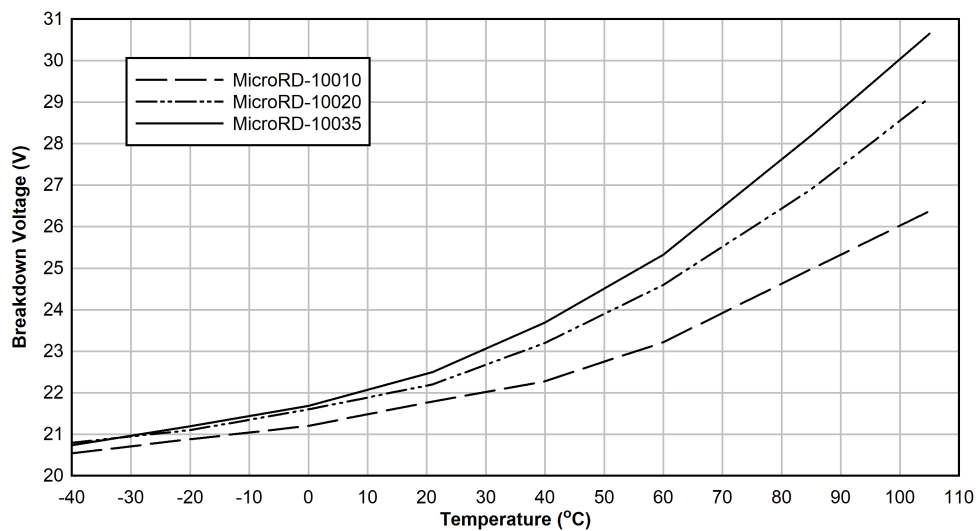
$V_{br} = aT^2 + bT + c$ , where T is the temperature in °C and the fit parameters are given in the Table 1. Note different fit parameters are used above and below 40°C.

**Table 1. COEFFICIENTS FOR CALCULATING BREAKDOWN VOLTAGE AS A FUNCTION OF TEMPERATURE**

| Fit Parameters | MicroRD-10010 |               | MicroRD-10020 |               | MicroRD-10035 |               |
|----------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                | -40°C to 40°C | 40°C to 105°C | -40°C to 40°C | 40°C to 105°C | -40°C to 40°C | 40°C to 105°C |
| <b>a</b>       | 0.00011       | 0.00026       | 0.00027       | 0.00044       | 0.00033       | 0.00045       |
| <b>b</b>       | 0.022         | 0.027         | 0.029         | 0.026         | 0.036         | 0.043         |
| <b>c</b>       | 21.25         | 20.76         | 21.55         | 21.42         | 21.69         | 21.23         |

### Temperature Coefficient of Breakdown Voltage

MicroRD-10010, -10020, -10035



**Figure 1. Breakdown Voltage as a Function of Temperature for the Different MicroRD Variants**

## RD-Series SiPM Sensors

### ABSOLUTE MAXIMUM RATINGS

| Parameter                   | Value       | Unit | Comment             |
|-----------------------------|-------------|------|---------------------|
| Maximum Current             | 3           | mA   | At typical Vop      |
| Maximum Storage Temperature | 125         | °C   |                     |
| Operating Temperature Range | -40 to +105 | °C   | Ambient temperature |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

### PACKAGE SPECIFICATIONS

| Parameter     | Value                                                                                          | Unit | Comment |
|---------------|------------------------------------------------------------------------------------------------|------|---------|
| ESD-HBM       | TBD                                                                                            |      |         |
| ESD-CDM       | TBD                                                                                            |      |         |
| $\theta_{JC}$ | 46                                                                                             | °C/W |         |
| $\theta_{JA}$ | 731                                                                                            | °C/W |         |
| MSL           | MSL 3 for tape and reel<br>(TR delivery option)<br>MSL 4 for cut tape<br>(TR1 delivery option) |      |         |

### 90% – 10% RECOVERY TIME PARAMETER

The recovery time indicates the time taken for the microcells to recover to fully biased state. Recovery time is measured by applying a low power 905 nm, 50 ps laser pulse at the SiPM and measuring the resulting pulse shape on the standard output. The 90% to 10 % recovery time is the time interval between the signal crossing the 90% threshold and

the 10% threshold, relative to the peak amplitude. Note that recovery time will depend on a number of factors including the circuit. The circuit used for this measurement is pictured in Figure 2. The actual pulse shapes are shown in Figures 3–5 below.

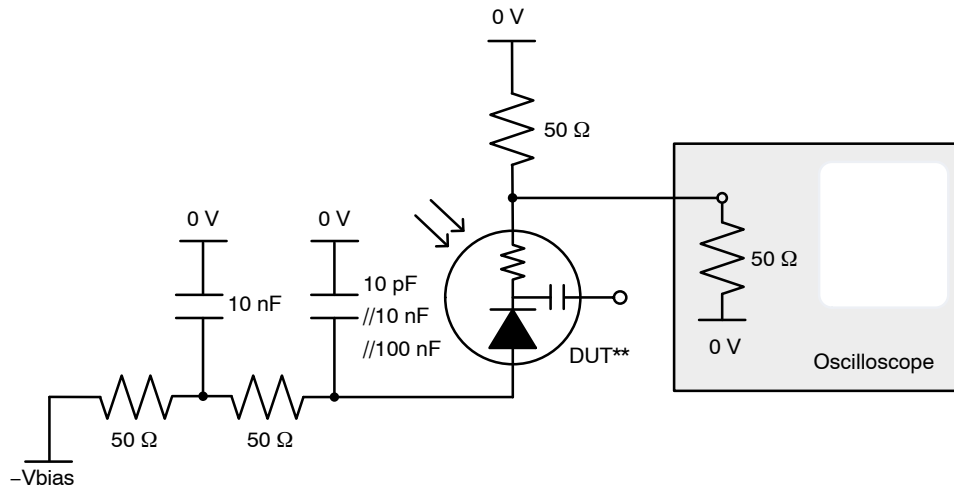


Figure 2. Circuit Used for Recovery Time Measurements

## RD-Series SiPM Sensors

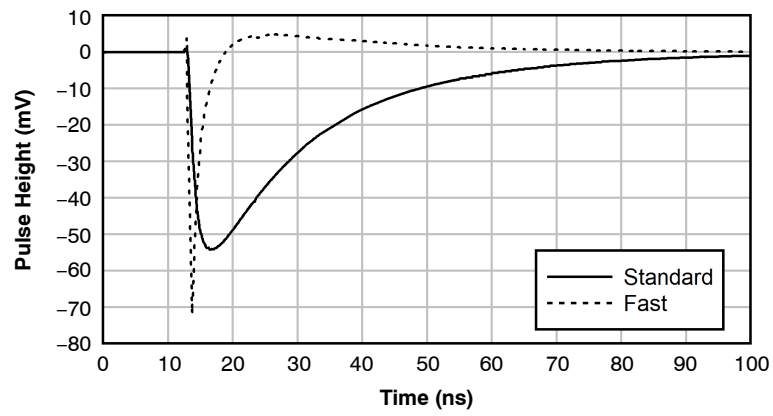


Figure 3. Pulse Shape – MicroRD-10010

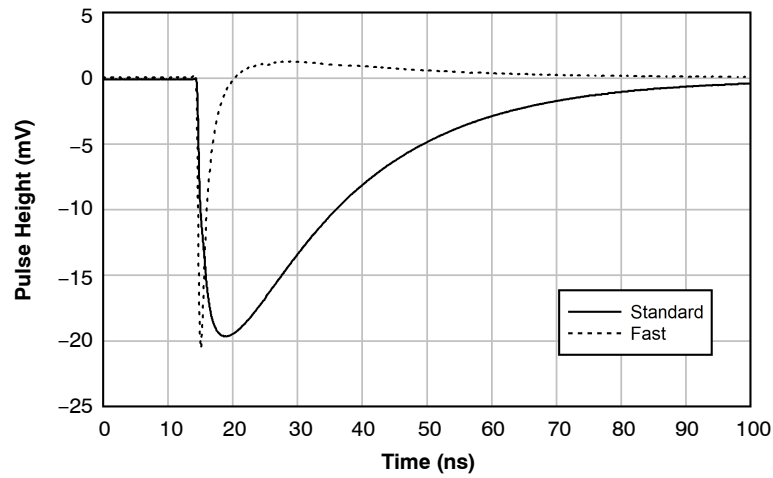


Figure 4. Pulse Shape – MicroRD-10020

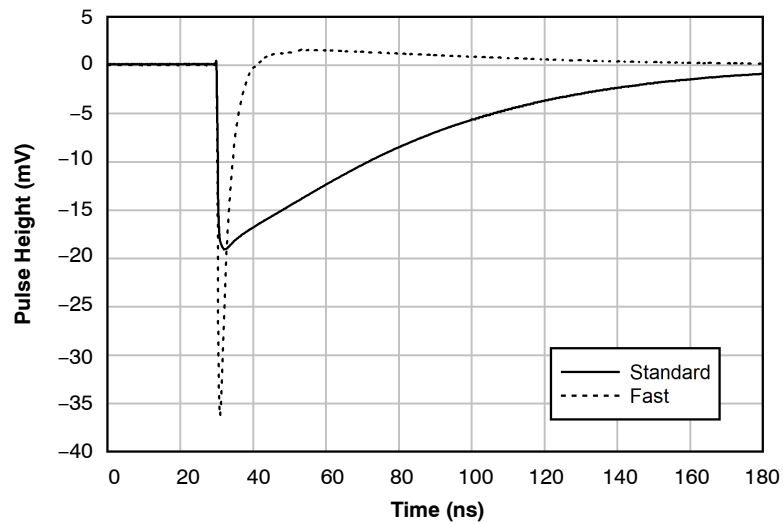
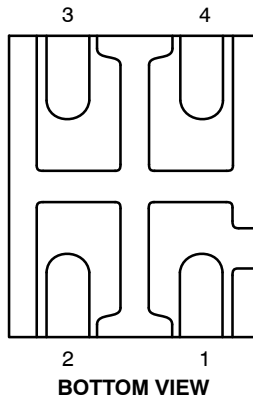


Figure 5. Pulse Shape – MicroRD-10035

## RD-Series SiPM Sensors

### PIN ASSIGNMENT



| Pin Number | Pin Assignment |
|------------|----------------|
| 1          | Anode          |
| 2          | Fast Output    |
| 3          | Cathode        |
| 4          | No Connect*    |

\*The 'No Connect' pins are electrically isolated and should be soldered to a ground (or bias) plane to help with heat dissipation.

### APPLICATION ADVICE

- For biasing and readout, please consult the [AND9782/D](#) Application note
- For handling and soldering advice, please consult the [AND9788/D](#) Application note

## RD-Series SiPM Sensors

### SMA BIASING BOARD (MicroRD-SMA-100XX)

The MicroRD-SMA is a printed circuit board (PCB) that can facilitate the evaluation of the MicroRD MLP sensors. The board has three female SMA connectors for connecting the bias voltage, the standard output from the cathode, and the fast output signal. The output signals can be connected directly to a 50  $\Omega$ -terminated oscilloscope for viewing. The biasing and output signal tracks are laid out in such a way as to preserve the fast timing characteristics of the sensor.

The MicroRD-SMA is recommended for users who require a plug-and-play set-up to quickly evaluate MicroRD sensors with optimum timing performance. The board also allows the signal from the cathode-anode readout to be observed at the same time as the fast output. The outputs can be connected directly to the oscilloscope or measurement device, but external preamplification may be required to boost the signal. The table below lists the SMA board connections. The SMA board electrical schematics are available to download in the [Board Reference Design](#) document.

| MicroRD-SMA-100XX |                             |
|-------------------|-----------------------------|
| Output            | Function                    |
| Vbias             | Negative bias input (anode) |
| Fout              | Fast output                 |
| Sout              | Standard output (cathode)   |

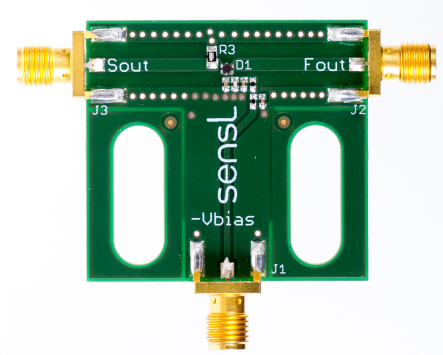


Figure 6. SMA Biasing Board

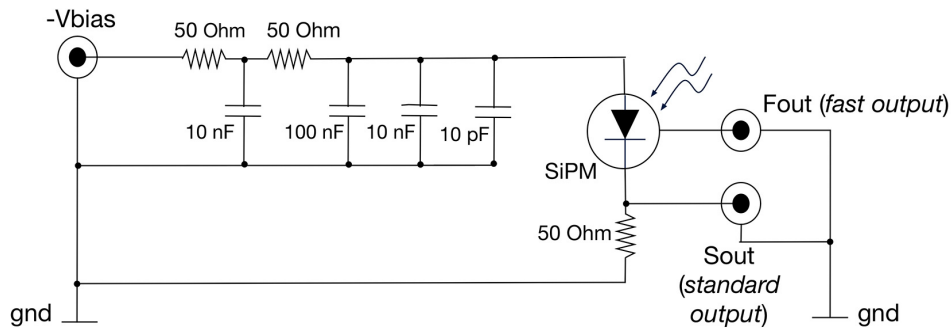


Figure 7. Schematic of SMA Biasing Board

## RD-Series SiPM Sensors

### PIN ADAPTER BOARD (MicroRD-SMTPA-100XX)

The Pin Adapter board (SMTPA) is a small PCB board that houses the SiPM sensor and has through-hole pins to allow its use with standard sockets or probe clips. This product is useful for those needing a quick way to evaluate the MLP-packaged sensor without the need for specialist surface-mount soldering. While this is a 'quick fix' suitable for many evaluations, it should be noted that the timing performance from this board will not be optimized and if the best possible timing performance is required, the MicroRD-SMA-100XX is recommended. The SMTPA circuit schematic is shown below. Please consult the [Biasing and Readout](#) Application Note for further information on biasing. The SMTPA board electrical schematics are available to download in the [Board Reference Design](#) document.

| MicroRD-SMTPA-100XX |             |
|---------------------|-------------|
| Pin. No.            | Function    |
| 1                   | Anode       |
| 2                   | Fast output |
| 3                   | Cathode     |
| 4                   | Ground      |
| 5                   | Ground      |

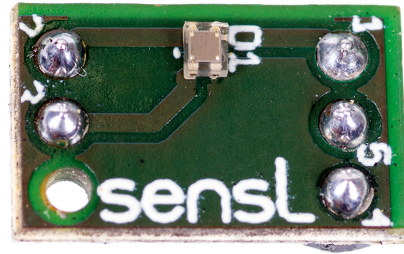


Figure 8. Pin Adapter Board

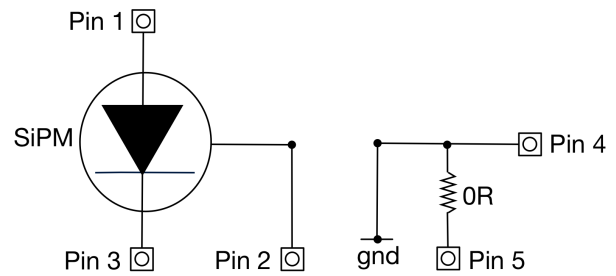


Figure 9. Schematic of Pin Adapter Board

# RD-Series SiPM Sensors

## ORDERING INFORMATION

### ORDERING INFORMATION

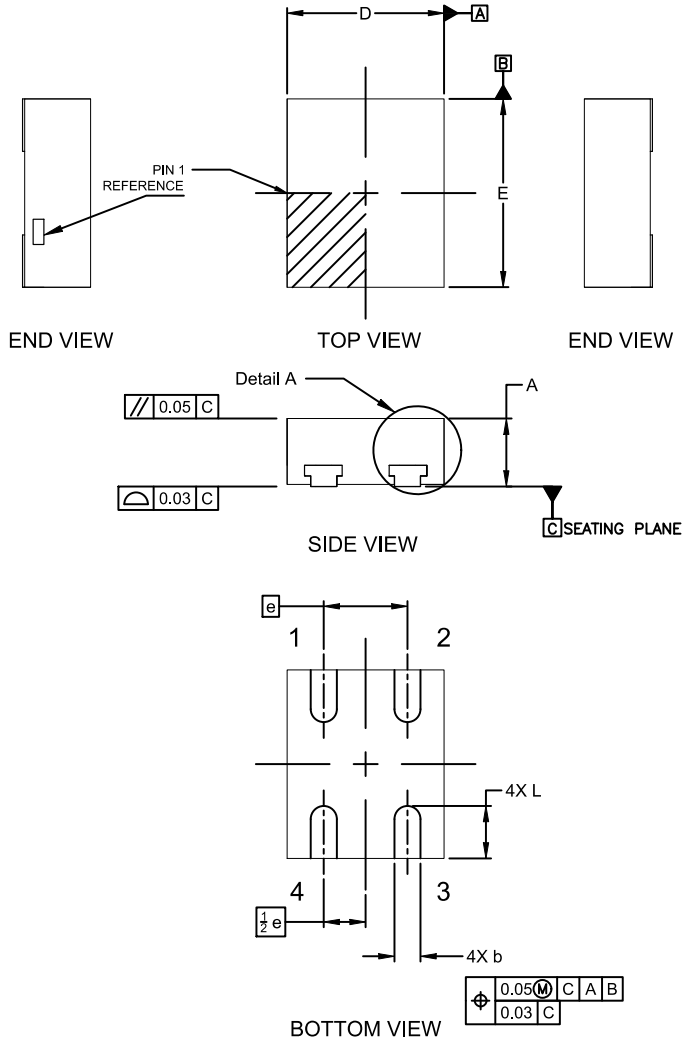
| Part Number              | Microcell Size   | Product Description                                                                                         | Shipping Format*              |
|--------------------------|------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------|
| MicroRD-10010-MLP-TR     | 10 $\mu\text{m}$ | 1 mm $\times$ 1 mm RD-Series Silicon Photomultiplier pixel (NIR enhanced) with fast output, packaged in MLP | Tape and Reel                 |
| MicroRD-10010-MLP-TR1    |                  |                                                                                                             | Cut Tape                      |
| MicroRD-10010-MLP-TR-E   |                  | Unqualified prototype part of the MicroRD-10010-MLP                                                         | Depends upon Quantity Ordered |
| MicroRD-SMA-10010-GEVB   |                  | MicroRD-10010-MLP sensor mounted onto a PCB with SMA connectors for bias and outputs.                       | ESD Package                   |
| MicroRD-SMTPA-10010-GEVB |                  | MicroRD-10010-MLP packaged sensor mounted onto a pin adapter board.                                         | ESD Package                   |
| MicroRD-10020-MLP-TR     | 20 $\mu\text{m}$ | 1 mm $\times$ 1 mm RD-Series Silicon Photomultiplier pixel (NIR enhanced) with fast output, packaged in MLP | Tape and Reel                 |
| MicroRD-10020-MLP-TR1    |                  |                                                                                                             | Cut Tape                      |
| MicroRD-10020-MLP-TR-E   |                  | Unqualified prototype part of the MicroRD-10020-MLP                                                         | Depends upon Quantity Ordered |
| MicroRD-SMA-10020-GEVB   |                  | MicroRD-10020-MLP sensor mounted onto a PCB with SMA connectors for bias and outputs.                       | ESD Package                   |
| MicroRD-SMTPA-10020-GEVB |                  | MicroRD-10020-MLP packaged sensor mounted onto a pin adapter board.                                         | ESD Package                   |
| MicroRD-10035-MLP-TR     | 35 $\mu\text{m}$ | 1 mm $\times$ 1 mm RD-Series Silicon Photomultiplier pixel (NIR enhanced) with fast output, packaged in MLP | Tape and Reel                 |
| MicroRD-10035-MLP-TR1    |                  |                                                                                                             | Cut Tape                      |
| MicroRD-10035-MLP-TR-E   |                  | Unqualified prototype part of the MicroRD-10035-MLP                                                         | Depends upon Quantity Ordered |
| MicroRD-SMA-10035-GEVB   |                  | MicroRD-10035-MLP sensor mounted onto a PCB with SMA connectors for bias and outputs.                       | ESD Package                   |
| MicroRD-SMTPA-10035-GEVB |                  | MicroRD-10035-MLP packaged sensor mounted onto a pin adapter board.                                         | ESD Package                   |

\*For information on tape and reel specifications, please contact [sensl\\_questions@onsemi.com](mailto:sensl_questions@onsemi.com).

# RD-Series SiPM Sensors

## PACKAGE DIMENSIONS

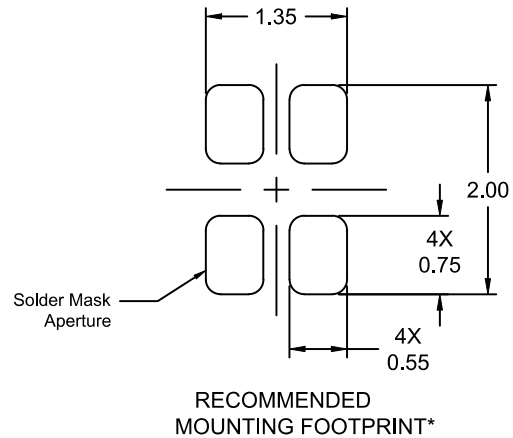
**CWDFN4 1.5x1.8, 0.8P**  
CASE 512AL  
ISSUE O



### NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
2. CONTROLLING DIMENSION: MILLIMETERS

| DIM | MILLIMETERS |       |       |
|-----|-------------|-------|-------|
|     | MIN.        | NOM.  | MAX.  |
| A   | 0.60        | 0.65  | 0.70  |
| A1  | 0.00        | ---   | 0.05  |
| A3  | 0.20 REF    |       |       |
| b   | 0.20        | 0.25  | 0.30  |
| D   | 1.40        | 1.50  | 1.60  |
| E   | 1.70        | 1.80  | 1.90  |
| e   | 0.80 BSC    |       |       |
| L   | 0.465       | 0.515 | 0.565 |

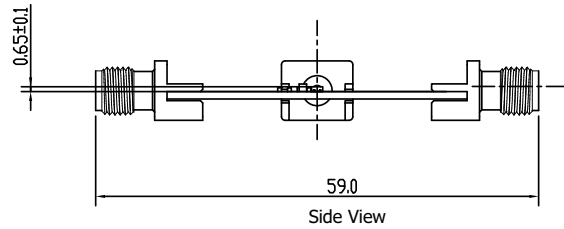
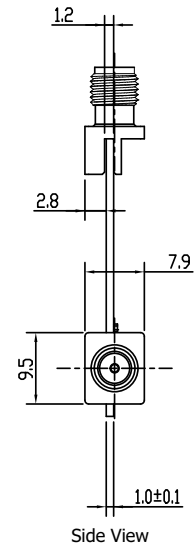
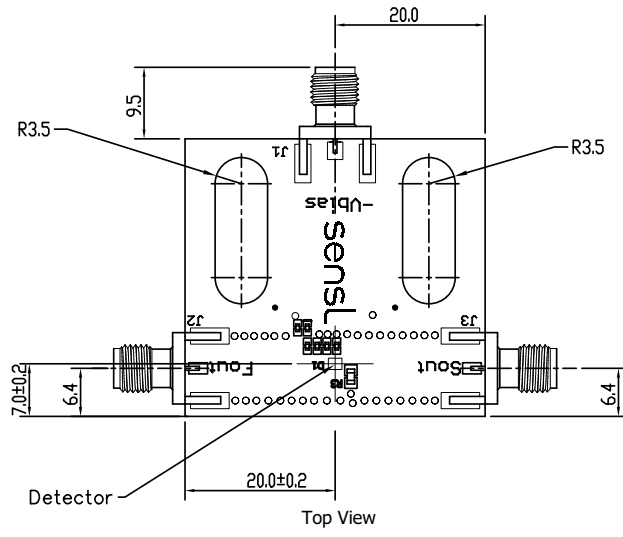


### RECOMMENDED MOUNTING FOOTPRINT\*

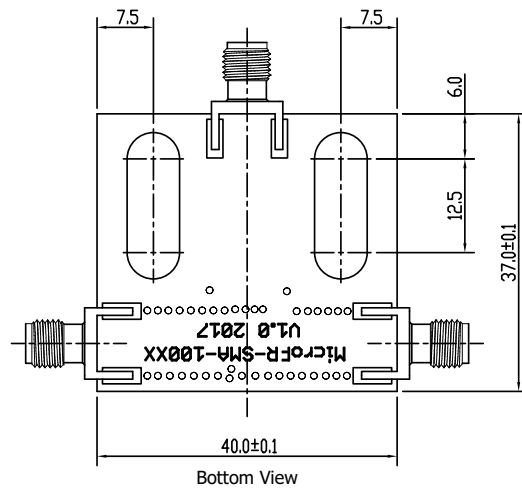
\* For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# RD-Series SiPM Sensors

## EVALUATION BOARD DIMENSIONS (MicroRD-SMA-100XX-GEVB)

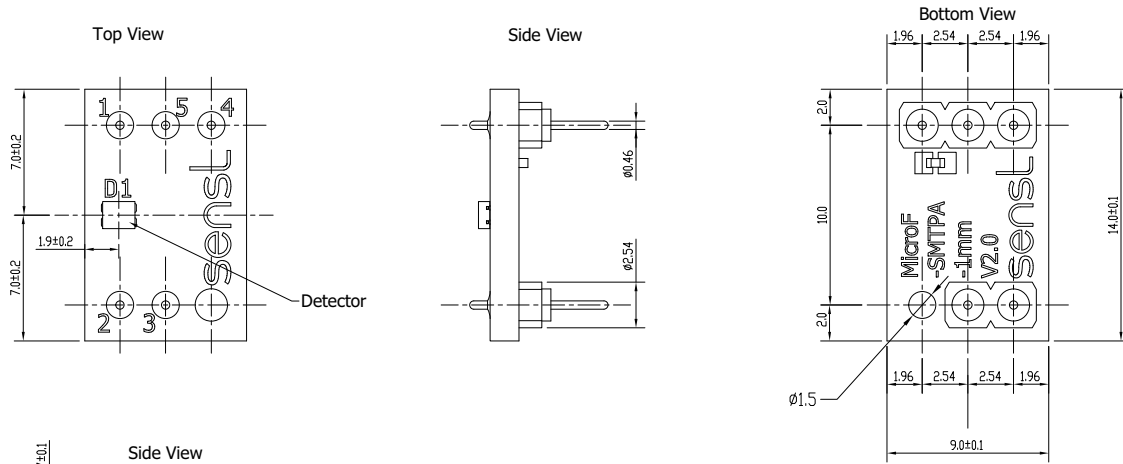


| SMA Assignments |                 |
|-----------------|-----------------|
| SMA ID          | Description     |
| -Vbias          | Bias Voltage    |
| Sout            | Standard Output |
| Fout            | Fast Output     |

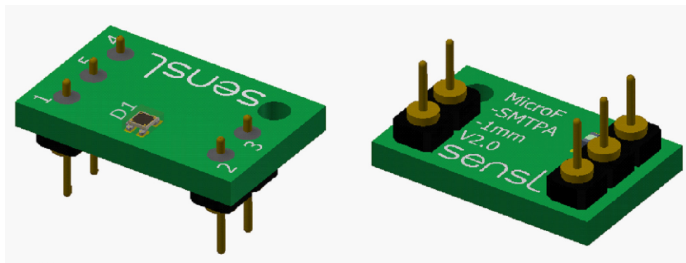


# RD-Series SiPM Sensors

## EVALUATION BOARD DIMENSIONS (MicroRD-SMTPA-100XX-GEVB)



| Pin Assignments |                              |
|-----------------|------------------------------|
| Pin #           | RD Series                    |
| 1               | Anode                        |
| 2               | Fast Output                  |
| 3               | Cathode                      |
| 4               | PCB Ground                   |
| 5               | Jumper to PCB Ground (0 Ohm) |



Top View

Bottom View

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