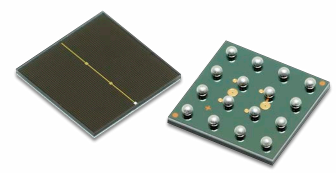
Data Sheet

# AFBR-S4N44C013

## NUV-HD Single Silicon Photo Multiplier

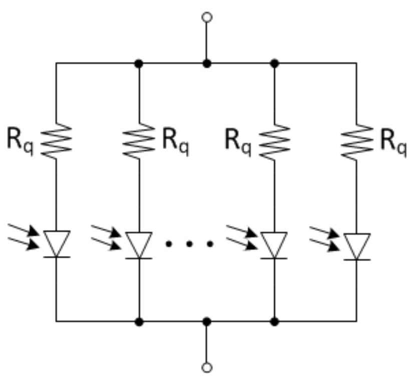


## Description

The Broadcom® AFBR-S4N44C013 is a silicon photo multiplier (SiPM) used for ultra-sensitive precision measurement of single photons.The active area is 3.72 × 3.72 mm$^2$. High packing density of the single chip is achieved using through-silicon-via (TSV) technology and a chip sized package (CSP). Larger areas can be covered by tiling multiple AFBR-S4N44C013 CSPs almost without any edge losses. The passivation layer is made by a glass that is highly transparent down to UV wavelengths, resulting in a broad response in the visible light spectrum with a high sensitivity toward the blue- and near-UV region of the light spectrum. The SiPM is best suited for the detection of low-level pulsed light sources, especially for detection of Cherenkov or scintillation light from the most common organic (plastic) and inorganic scintillator materials (for example, LSO, LYSO, BGO, NaI, CsI, BaF, LaBr). This product is lead free and compliant with RoHS and REACH.

## Block Diagram

**Figure 1: AFBR-S4N44C013 Block Diagram**




## Features

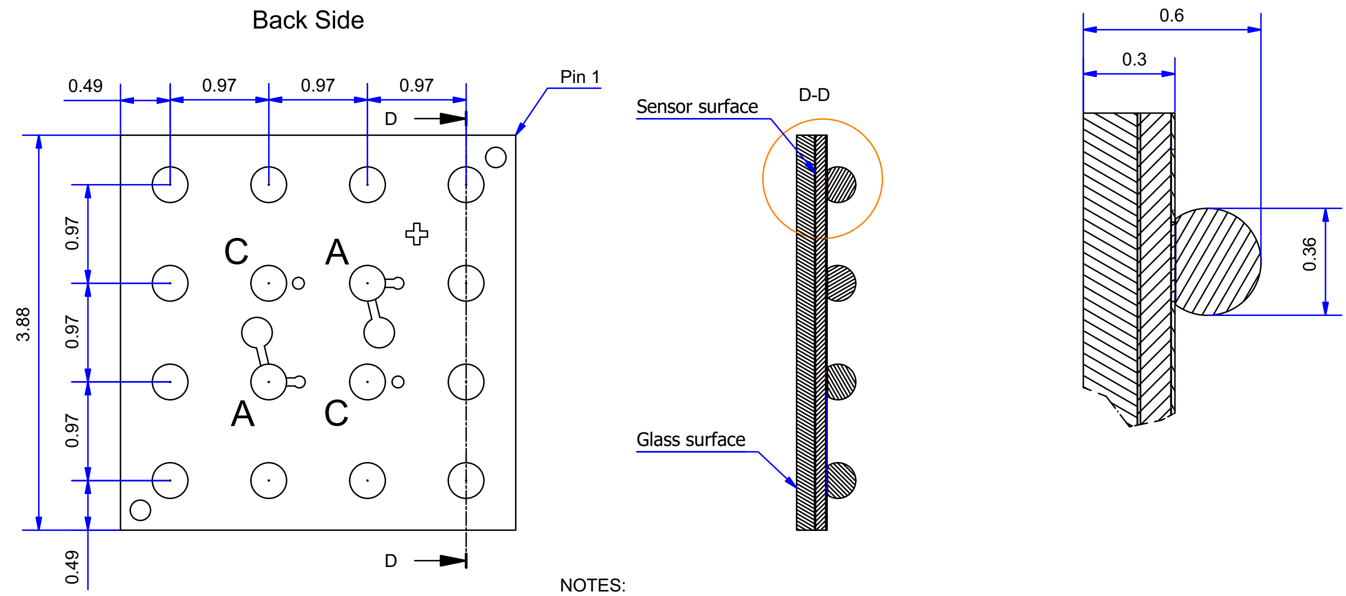
- High PDE of more than 55% at 420 nm
- Excellent SPTR and CRT
- Excellent uniformity of breakdown voltage, 180 mV (3 sigma)
- Excellent uniformity of gain
- With TSV technology (4-side tilable with high fill factors)
- Size 3.86 × 3.86 mm$^2$
- Cell pitch 30 × 30 μm$^2$
- Highly transparent glass protection layer
- Chip sized package (CSP)
- Operating temperature range from –20°C to +50°C
- RoHS and REACH compliant

## Applications

- X-ray and gamma ray detection
- Gamma ray spectroscopy
- Safety and security
- Nuclear medicine
- Positron emission tomography
- Life sciences
- Flow cytometry
- Fluorescence—luminescence measurements
- Time-correlated single photon counting
- High energy physics
- Astrophysics

# Pad Layout and Soldering Ball Geometry

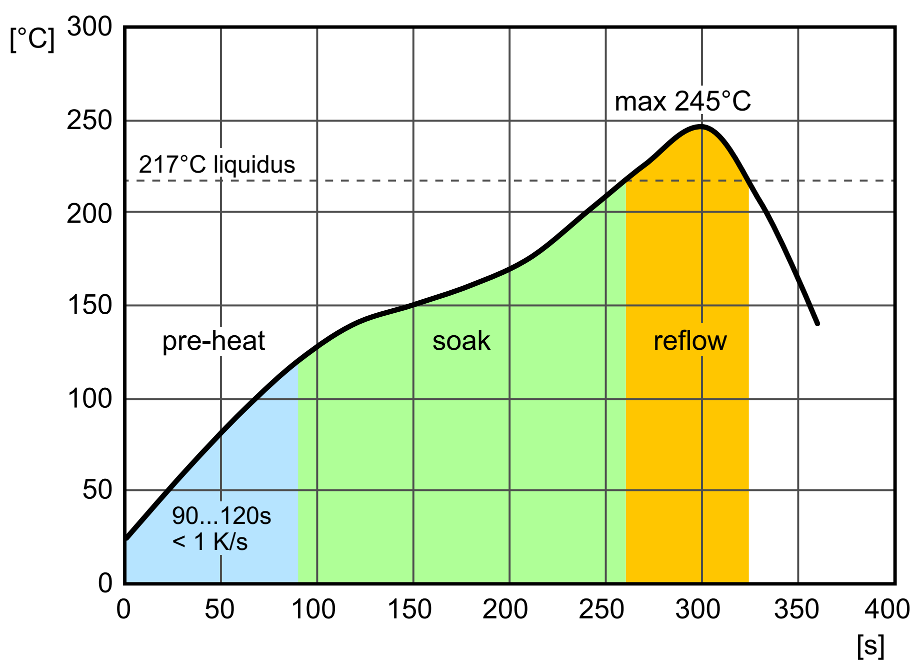
**Figure 2: Bottom View (Left) and Cross Sections (Right)**




NOTES:
1) Dimensions are in millimeters.
2) Nominal values rounded to two decimal places - Suppression of following zeros.
3) A is anode, C is cathode.

# Reflow Soldering Diagram

**Figure 3: Recommended Reflow Soldering Profile**



# Absolute Maximum Ratings

Stresses in excess of the absolute maximum ratings can cause damage to the devices. Limits apply to each parameter in isolation. Absolute maximum ratings are those values beyond which damage to the device may occur if these limits are exceeded for other than a short period of time.

**NOTE:** Only a minimum of mechanical load should be applied to the glass surface.

| Parameter | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Storage Temperature | $T_{STG}$ | –20 | +60 | °C |
| Operating Temperature | $T_A$ | –20 | +50 | °C |
| Soldering Temperature[a,b] | $T_{SOLD}$ | — | 245 | °C |
| Lead Soldering Time[a,b] | $t_{SOLD}$ | — | 60 | s |
| Electrostatic Discharge Voltage Capability HBM | $ESD_{HBM}$ | — | 2 | kV |
| Electrostatic Discharge Voltage Capability CDM | $ESD_{CDM}$ | — | 500 | V |
| Operating Overvoltage | $V_{OV}$ | — | 10 | V |

a. The AFBR-S4N44C013 is reflow-solderable according to the solder diagram as shown in Figure 3.

b. According to JEDEC J-STD-020D, the moisture sensitivity classification is MSL 3.

# Device Specification

Features are measured at 25°C unless otherwise specified.

## Geometric Features

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Device Area | DA | 3.86 × 3.86 | $mm^2$ |
| Active Area | AA | 3.72 × 3.72 | $mm^2$ |
| Micro Cell Pitch | $L_{cell}$ | 30 | µm |
| Number of Micro Cells | $N_{cells}$ | 15060 | — |
| Micro Cell Fill Factor | FF | 76 | % |

# Optical and Electrical Features

Parameters have been measured for two recommended working points: *Typical* for general purpose applications and *Performance* for best timing performance.

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Reference Plots |
|---|---|---|---|---|---|---|
| Spectral Range | $\lambda$ | 300 | — | 900 | nm | |
| Peak Sensitivity Wavelength | $\lambda_{PK}$ | — | 420 | — | nm | Figure 4 |
| Breakdown Voltage | $V_{BD}$ | — | 26.9 | — | V | Figure 6 |
| Temperature Coefficient of Breakdown Voltage | $\Delta V_{BR}/\Delta T$ | — | 26 | — | mV/K | |

| Parameter | Symbol | Typ.[a] | Perf.[a] | Unit | Reference Plots |
|---|---|---|---|---|---|
| Photo Detection Efficiency[b] | PDE | 43 | 55 | % | Figure 5 |
| Dark Current | $I_D$ | 0.5 | 3.4 | µA | Figure 6 |
| Dark Count Rate[c] | DCR | 1.7 | 3.7 | Mcps | Figure 7, Figure 10 |
| Dark Count Rate Per Unit Area | $DCR_{mm^2}$ | 120 | 270 | kcps/mm² | |
| Gain | G | 1.6 | 3.3 | $\times 10^6$ | Figure 8, Figure 11 |
| Optical Crosstalk | $P_{Xtalk}$ | 9 | 29 | % | Figure 9, Figure 12 |
| Afterpulsing Probability | $P_{AP}$ | < 1 | 1 | % | Figure 9, Figure 12 |
| Recharge Time Constant[d] | $\tau_{fall}$ | 55 | 50 | ns | Figure 13 |
| Nominal Terminal Capacitance[e] | $C_T$ | 990 | 760 | pF | |
| Temperature Coefficient of Gain | $\Delta G/\Delta T$ | 1.1 | 1.0 | $\times 10^4$/K | |

a. Typical values are measured at 3V above breakdown; performance values are measured at 7V above breakdown.

b. Measured at peak sensitivity-wavelength. The measurement does not include correlated noise, such as afterpulsing or optical crosstalk.

c. Measured at 0.5 p.e. amplitude. The measurement does not include delayed correlated events.

d. Measured on 1 × 1 $mm^2$ devices with an input impedance of 20Ω.

e. Measured using an input sine wave with f = 200 kHz and $V_{in}$ = 500 mV.

# Reference Plots

Features are measured at 25°C unless otherwise specified. Plotted data represents typical values.

**Figure 4: Spectral Sensitivity**

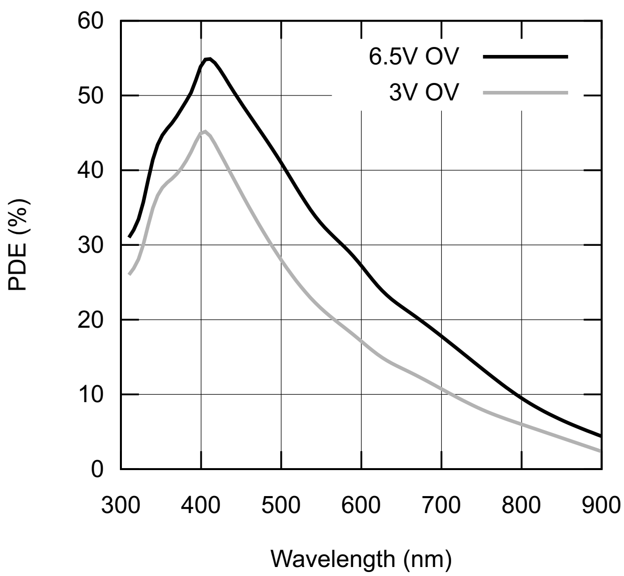



**Figure 5: PDE at Peak λ vs. OV**

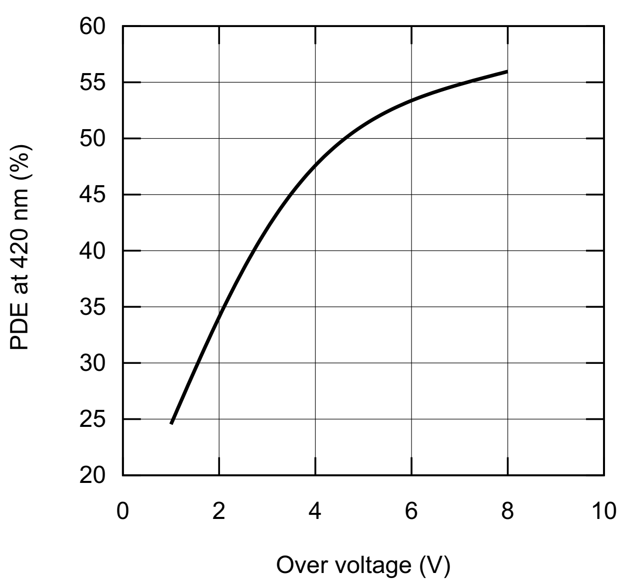



**Figure 6: Reverse IV Curve**

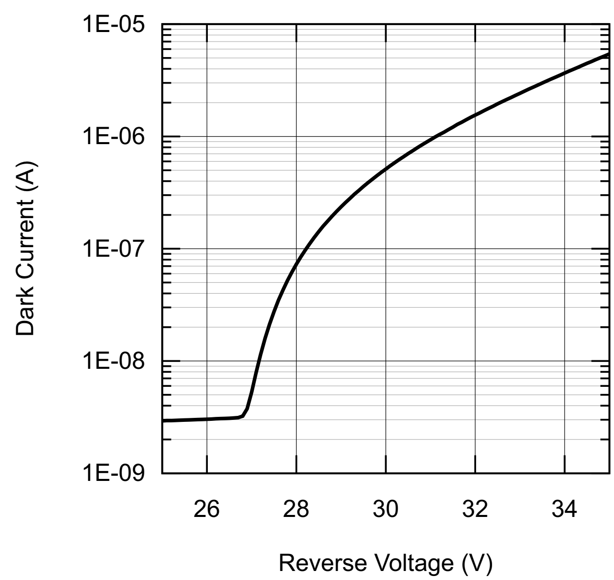



**Figure 7: Dark Count Rate vs. OV**

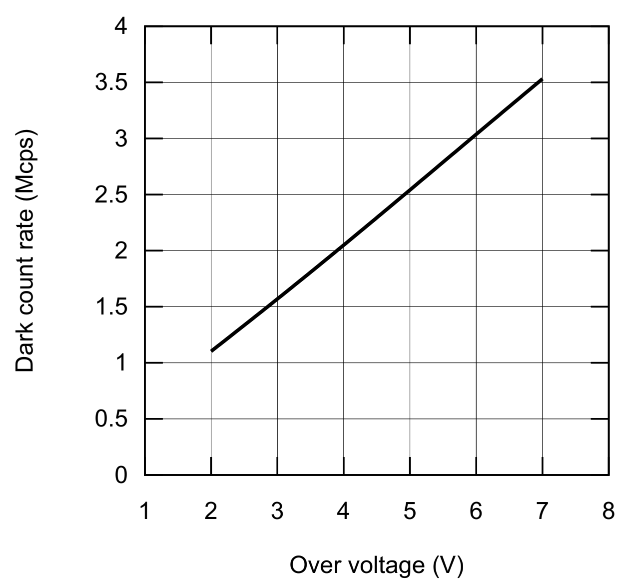


**Figure 8: Gain vs.OV**

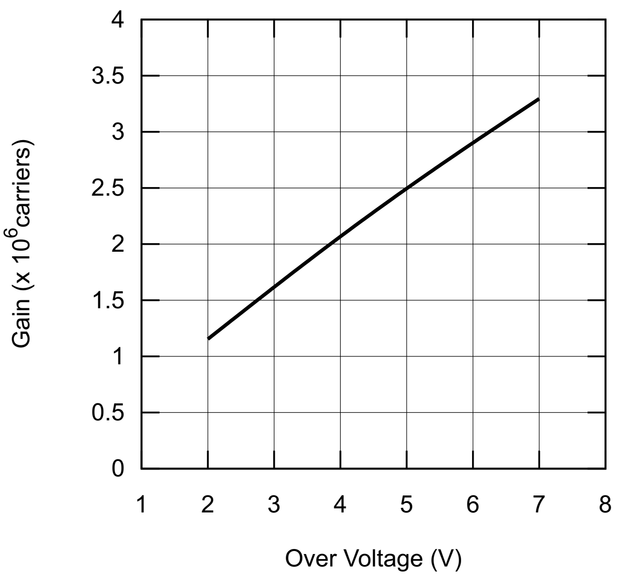



**Figure 9: Correlated Noise vs. OV**

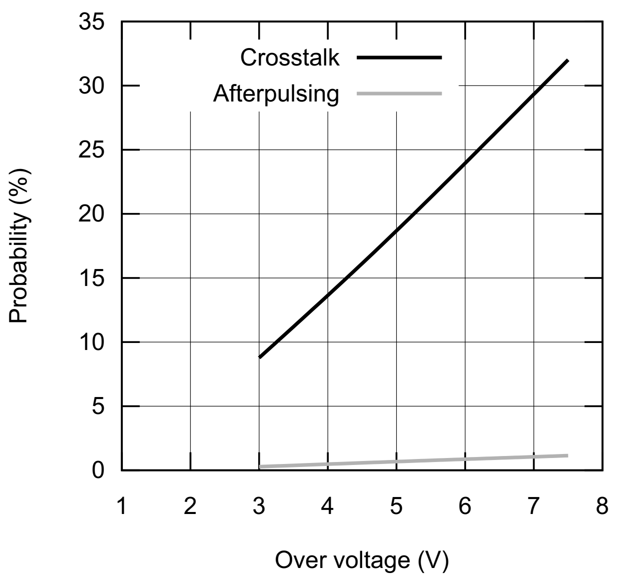



**Figure 10: Dark Count Rate vs. PDE at Peak λ**

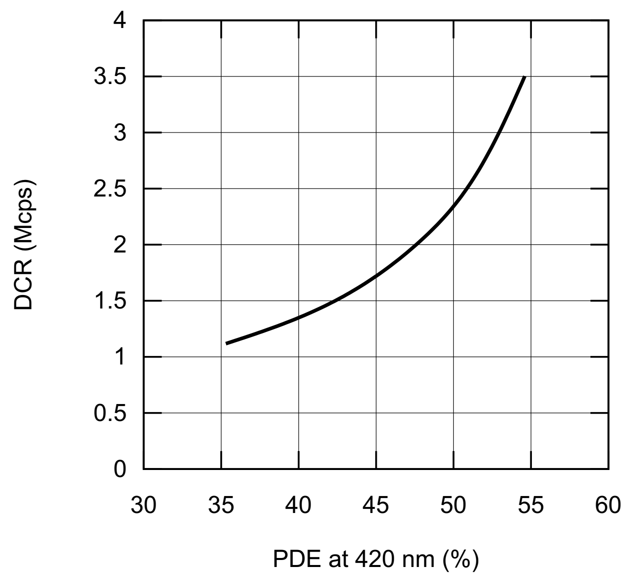



**Figure 11: Gain vs. PDE at Peak λ**

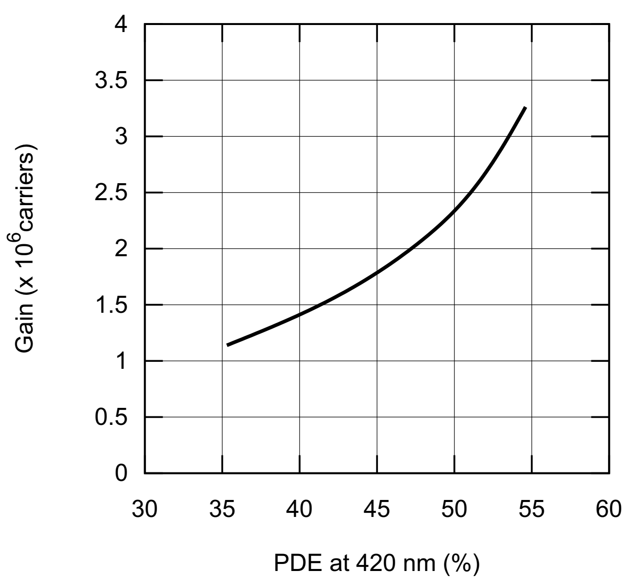


**Figure 12: Correlated Noise vs. PDE at Peak λ**

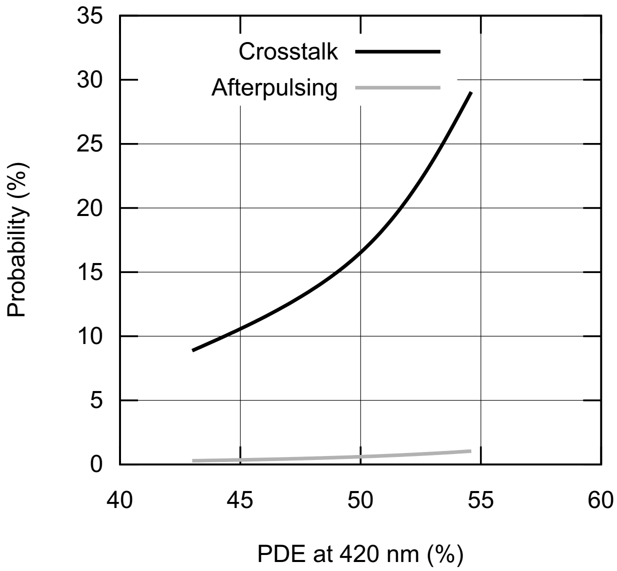
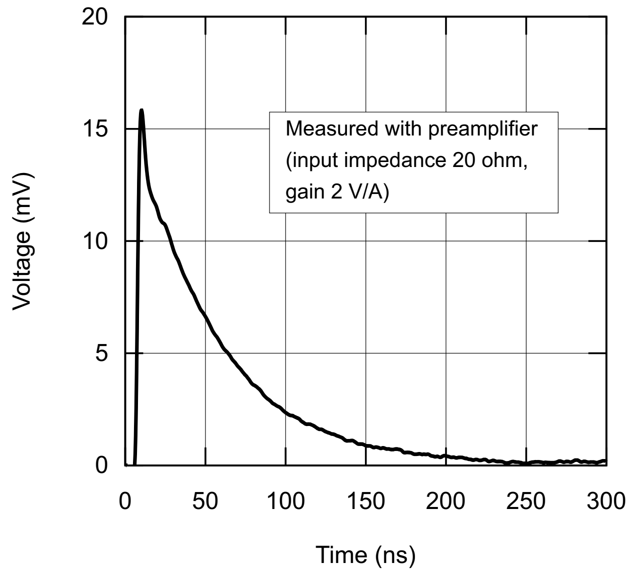



**Figure 13: Example Signal Measured at 3V OV**



BROADCOM®

Lead (Pb) Free
RoHS 6 fully
compliant