Photodiode PR5010

2 compact Silicon pn Junctions with a common anode

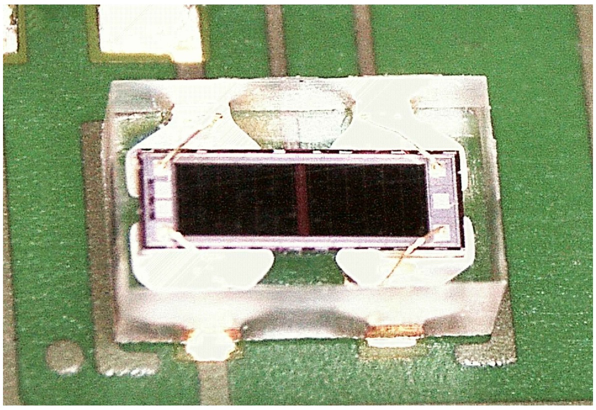
PR5010 is a double silicon photodiode with two symmetrical anodes (A1/A2) and a common cathode (C), sensitive for visible light. The cathode forms an additional photodiode to the substrate (Sub) that is sensitive for infrared light.
Key features are the low dark current combined with a high sensitivity and an antireflective coating on the die.
PR5010 is available in an optical DFN package with a very small formfactor.

FEATURES

- common cathode
- low dark current
- varied spectral sensitivities
- anti-reflective coating (ARC)

TYPICAL APPLICATIONS

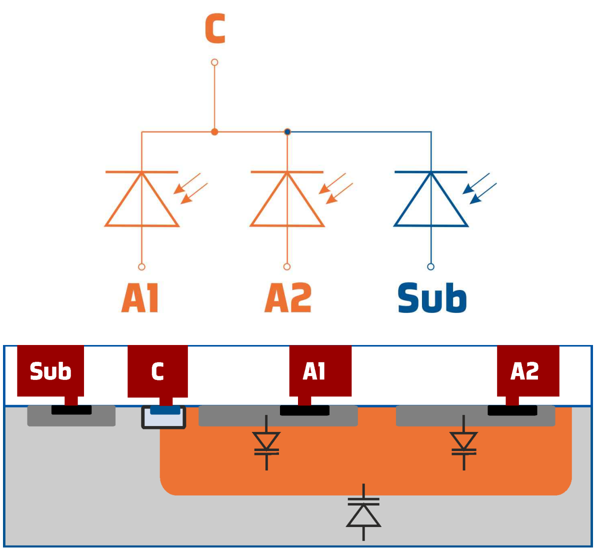
- Laser beam alignment
- Optical encoders
- Position detection
- Ambient light detection



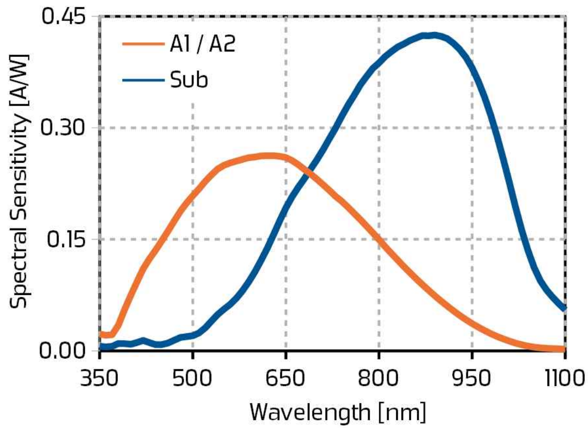
KEY CHARACTERISTICS

Parameter	Typ	Unit
Package size	2.9 x 1.8 x 0.9	mm
A1, A2 photodiode size	0.91 x 0.62	mm
A1, A2 peak wavelength	630	nm
A1, A2 dark current @ 27°C	8	pA
Capacitance A1 / A2 @ 10V Sub @ 10V	25 60	pF pF

CIRCUIT



SPECTRAL SENSITIVITY



Note: Spectral sensitivity is calculated and extrapolated from measurements using photodiodes with comparable structures.

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Electrical and optical Characteristics

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Min	Max	Units
V_{C-A}	V(C) – V(A1, A2)	A1, A2	-0.3	38	V
V_{C-Sub}	V(C) – V(Sub)	Sub	-0.3	33	V
T_A	Operating ambient temperature		-40	85	°C
T_S	Storage temperature		-40	85	°C
T_{peak}	Soldering peak temperature			260	°C
P_{tot}	Total Power Dissipation			100	mW

ELECTRICAL CHARACTERISTICS

Ta = 27°C, unless otherwise noted.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
$V_{r\ (C-A)}$	reverse voltage V(C) – V(A1, A2)	A1, A2				33	V
$V_{r\ (C-Sub)}$	reverse voltage V(C) – V(Sub)	Sub				28	V
A_{PD}	active area (geometrical)	A1, A2 Sub	A1 / A2 Sub		0.564 1.205		mm² mm²
I_d	dark current	A1, A2 Sub	A1 / A2 @ V_r = 2V Sub @ V_r = 2V		8 1		pA pA
$\Delta I_d/\Delta T$	temperature coefficient of dark current	A1, A2 Sub	A1 / A2 @ V_r = 2V Sub @ V_r = 2V		12.0 10.5		%/K %/K
λ_{peak}	peak sensitivity wavelength	A1, A2 Sub			630 890		nm nm
S_{peak}	peak sensitivity	A1, A2 Sub			0.26 0.43		A/W A/W
C_{j0}	zero-bias junction capacitance	A1, A2 Sub	V_r = 0V, f = 1 MHz V_r = 0V, f = 1 MHz		70 160		pF pF
Cj	biased junction capacitance	A1, A2 Sub	V_r = 10V, f = 1 MHz V_r = 10V, f = 1 MHz		25 60		pF pF

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Electrical and optical Characteristics

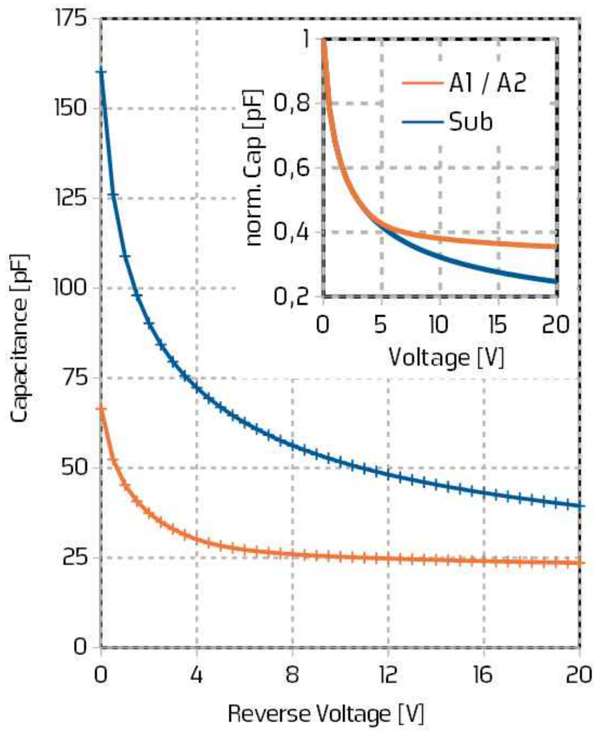
PHOTODIODE STRUCTURE

Due to the special structure of the PR5010, it contains two diffferent types of photodiodes, collecting photo-electrons at different depths. Photodiodes A1 and A2 are located near the silicon surface, while photo-electrons that are generated deeper in the substrate are collected at the Sub Pin.

This leads to different spectral sensitivities of A1/A2 and Sub photodiodes.
While PR5001 can be used as a dual photodiode with common anode, dumping the photocurrent of the Sub to ground, the properties of the Sub photodiode can be exploited as well.

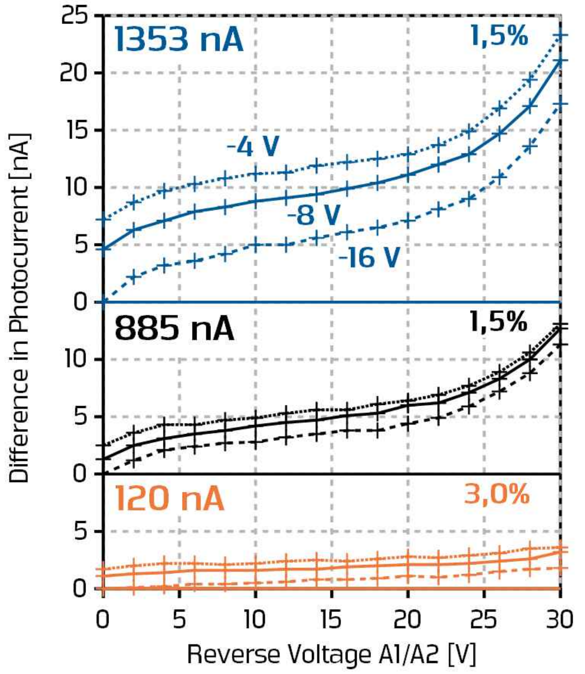
CAPACITANCE

The dependency of the capacitance between A1 or A2 and C on the applied reverse voltage V(A1)—V(C) or V(A2)—V(C) is shown in orange. The capacitance of the photodiode between C and the silicone substrate (Sub) as a function of V(C)—V(Sub) is given in blue.
While the bigger diagram illustrates the absolute numbers, the normalized capacitance is shown in the inset. It can be seen that a reverse voltage of about 3 V already reduces the capacitance by a factor of 2 compared with zero bias.



SENSITIVITY AFFECTED BY APPLIED VOLTAGES

The difference of photo-currents detected by varying the reverse voltage of the photodiodes A1/A2 and the substrate voltage (-4 V, -8 V and -16 V) is illustrated. Three levels of illumination (blue, black and orange) are applied. For zero reverse voltage and a substrate voltage of -16 V, photo-currents of 1353 nA, 885 nA and 120 nA are obtained. It can be seen that enhancing both voltages leads to slightly enhanced photocurrents. While the absolute difference increases with illumination, the relative deviation is at most ~1,5% for high illuminations.



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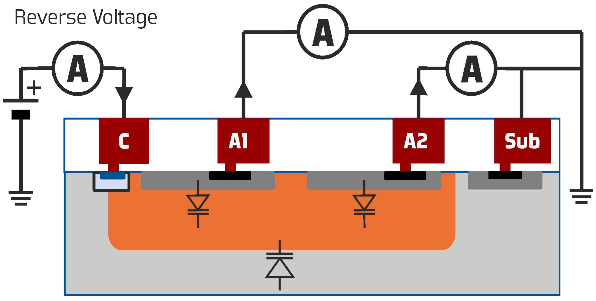
Dark Current

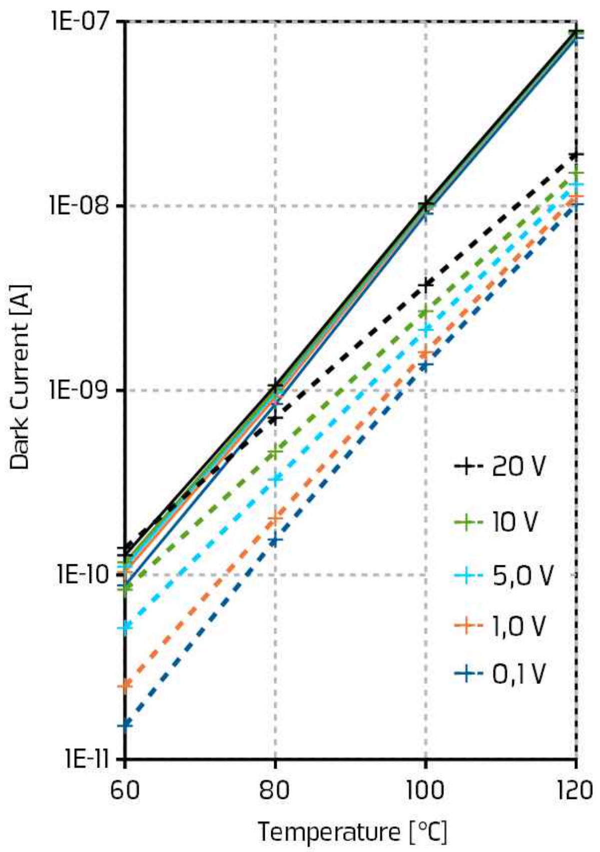
MEASUREMENT SETUP

Dark currents of A1, A2 and Sub photodiodes are measured as a function of the reverse voltage V(C)—V(Sub) and of temperature. A1, A2 and Sub are connected to Ground, while a positive voltage is applied to C.
The dark current of A1 can be obtained by subtracting I(A1 – Sub) – I(C – Sub).



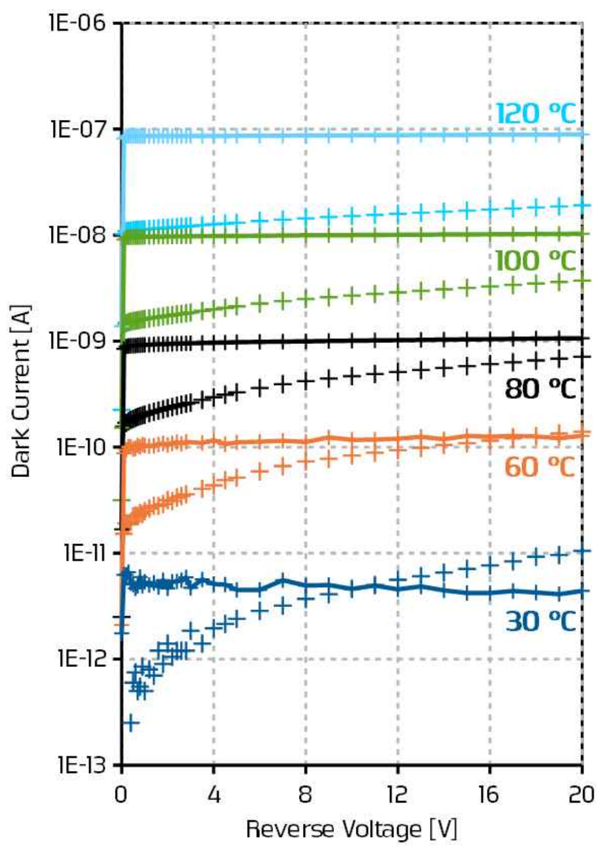
OVER TEMPERATURE

Dark currents of single photodiodes A1 or A2 are illustrated as dashed lines. By taking the dark currents of A1 and A2 into account, the dark currents of the photodiode between the N-well (C) and the substrate (Sub) can be calculated. For varied applied reverse voltages, these are shown as solid lines.



AS A FUNCTION OF REVERSE VOLTAGE

For varied applied temperatures, dark currents of single photodiodes A1 or A2 are illustrated as single points. Again, the dark current between the N-well (C) and the substrate (Sub) are shown as solid lines.
Both diagrams rely on the same numbers but illustrated differently.



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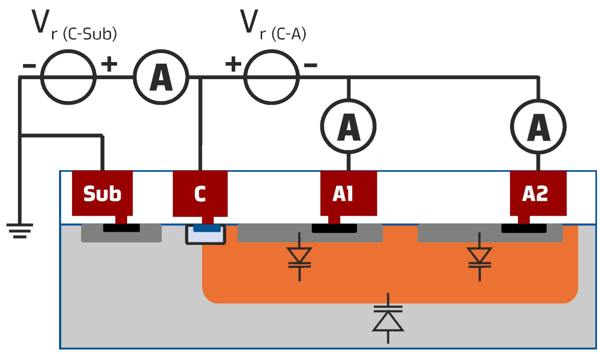
Application Notes

NEGATIVE VOLTAGE AT THE SUB PIN

The cathode of the photodiodes A1/A2 is formed by an N-doped well (C) that has also a parasitic photodiode to the silicon substrate. Under all circumstances, the Sub pin must be connected to a voltage that is more negative than the potential at C. The Sub pin must not remain unconnected. A1 and A2 must be connected to a voltage equal or more negative than connected at C.

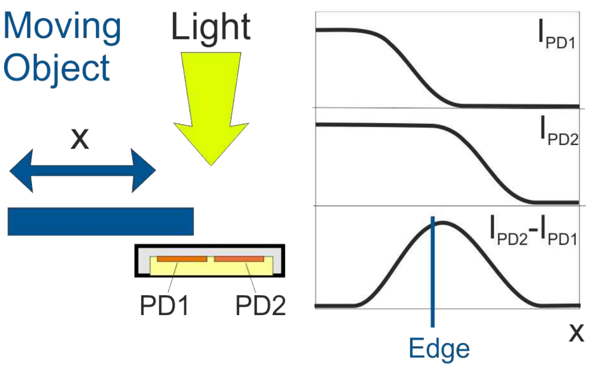
APPLICATION EXAMPLE

The application example shown here can detect photons generating free carriers within and below the N-well (orange). A reverse voltage between C and A1/A2 reduces the capacitance of A1 and A2. Measuring the photocurrent at each pin gives a spacial resolution. The reverse voltage between the common cathode (C) and the substrate (Sub) influences properties as capacitance or dark current of the photodiode below the N-well.
In the application example, the photocurrent of the shallow photodiodes A1 and A2 can be measured separately from the deep Sub photodiode.



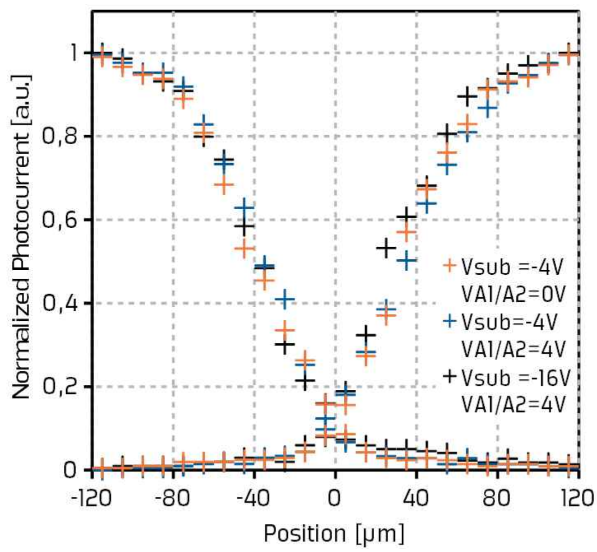
EDGE DETECTOR

The evaluation of the photo-currents detected at A1 and A2 can be used to measure the correct position of an object. If the object is right between both photodiodes, the difference of both signals is at maximum.



CHANNEL SEPARATION

The following diagram shows the crossover of a light beam between both photodiodes A1 and A2. A light beam with a diameter of 100 µm and a wavelength of 660 nm (red) was moved in increments of 10 µm over the gap between A1 and A2. The position of 0 µm corresponds to the center of the die.
Considering the beam diameter of 100 µm and a gap between both photodiodes of 80 µm, the observed behavior is consistent with a sharp channel separation. Neither the substrate bias (V_{sub}) nor the A1/A2 bias voltages $V_{A1/A2}$ have a significant influence on the results.



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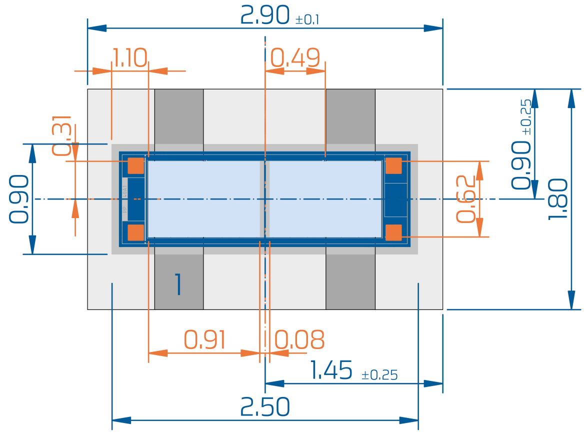
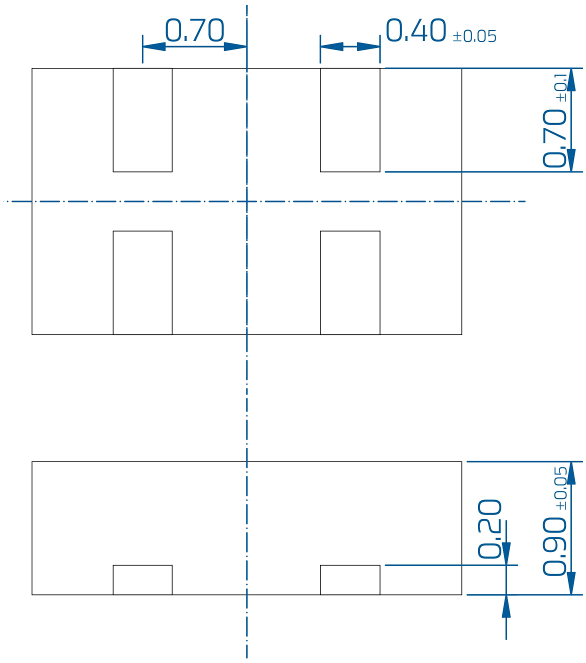
Package Information

DIMENSIONS ON DIE-LEVEL



DIMENSIONS OF THE DFN PACKAGE



SOLDERING INFORMATION

A lead-free solder profile with a peak temperature of 260°C or less, according to J-STD-020 should be followed.
Parts should be handled in accordance with the moisture sensitivity level as indicated on the moisture barrier bag, but at least to MSL 3.
Any parts without or with unsealed moisture barrier bag must be dry-baked according to JEDEC guidelines before soldering. Manual soldering must be done with utmost care.
Direct infrared heating should be avoided; pure convection heating is recommended.

TAPE & REEL

Standard form of delivery is on tape and reel.
Reel diameter: 7" (178 mm)
Quantity per reel: 3,000
Packaging: moisture barrier bag

BARE DIES

PR5010 is available as bare dies on request on tested and sawn wafers or in wafflepack.
Please contact us for minimum order quantities and delivery times.

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