

## Red, Green, Blue (RGB) SiPMs

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Silicon photomultipliers (SiPMs) from First Sensor are innovative solid-state silicon detectors with single photon sensitivity. SiPMs are a valid alternative to photomultiplier tubes. The main benefits of these detectors are high gain, extremely good timing performance and low operating voltage. They are insensitive to magnetic field and have a high integration level. The detectors are optimized for red, green and blue (RGB) light detection.



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### Features

- RGB light detection from 350 to 900 nm (peak efficiency at 550 nm)
- Low noise
- 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 Chip Scale Package (CSP)

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### Applications

- High energy physics
- Medical imaging
- Nuclear medicine
- Homeland security
- Analytical instruments

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### Certificates

- RoHS compliant (2011/65/EU)

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### Absolute maximum ratings <sup>(1)</sup>

Parameter	Min.	Max.	Unit
Operating temperature ( $T_A$ )	-25	+40	°C
Storage temperature ( $T_S$ )	-40	+60	°C
Lead temperature (solder) 5 s ( $T_{sol}$ )		+250	°C
Voltage working range (MVW)		Breakdown voltage +4	V

### Typical characteristics

Parameter	Product			
	SiPM-RGB1S-SMD	SiPM-RGB1C-SMD	SiPM-RGB3S-SMD	SiPM-RGB4S-SMD
Effective active area	(1×1) mm <sup>2</sup>	1.13 mm <sup>2</sup>	(3×3) mm <sup>2</sup>	(4×4) mm <sup>2</sup>
Cell count	625	673	5520	9340
Cell size (pitch)	40 μm × 40 μm			
Cell fill-factor	60 %			
Quenching resistance	550 kΩ			
Cell capacitance	90 fF			
Recharge time constant	50 ns			
Spectral response range	350 ... 900 nm			
Peak sensitivity wavelength	550 nm			
Photon detection efficiency <sup>(2)</sup>	32.5 %			
Breakdown voltage (BV)	typ. 27 V, min. 25 V, max. 29 V			
BV standard deviation <sup>(3)</sup>	50 mV			
Recommended overvoltage range (OV) <sup>(4)</sup>	min: 2 V, max: 4 V			
Dark count rate <sup>(5)</sup>	<100 kHz/mm <sup>2</sup> @ 2 V OV, <200 kHz/mm <sup>2</sup> @ 4 V OV			
Gain <sup>(6)</sup>	2.7×10 <sup>6</sup>			
Breakdown voltage temperature coefficient	27 mV/°C			
Refractive index of epoxy resin <sup>(7)</sup>	1.5115 (@ 589 nm, 23 °C, uncured)			
Spectral transmission of epoxy resin <sup>(7)</sup>	>97% @ 1000 ... 1600 nm ; >99% @ 400 ... 1000 nm			

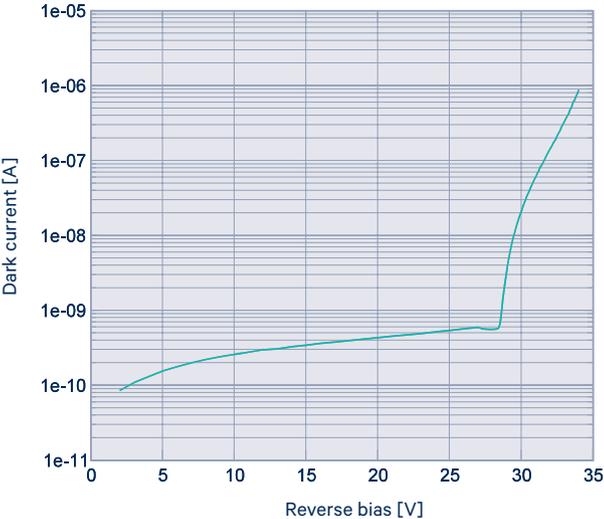
### Specification notes

- (1) 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.
- (2) Measured at peak sensitivity wavelength ( $\lambda = \lambda_p$ ) at +4 V overvoltage (not including afterpulse and crosstalk).
- (3) BV of SiPMs belonging to a same production lot are within 200 mV ( $\pm 2\sigma$ ) from mean BV value.
- (4) Operating voltage (SiPM bias) is BV+OV, to be applied in reverse mode, i.e.  $V_{AK} < 0$  (see "Pins Function" section).
- (5) 0.5 p.e. threshold level at 20 °C (primary dark count rate; not including afterpulse).
- (6) Measured at 20 °C at +4 V overvoltage.
- (7) To be used as a guide only, not as a specification. Reported data is not guaranteed.

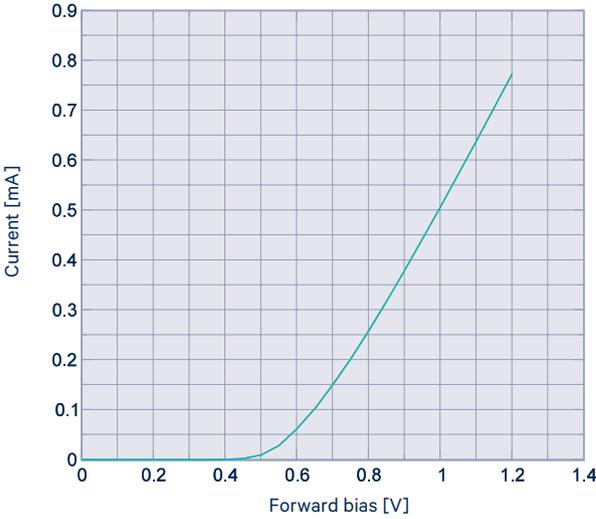
## Red, Green, Blue (RGB) SiPMs

Device characteristics <sup>(8, 9)</sup>

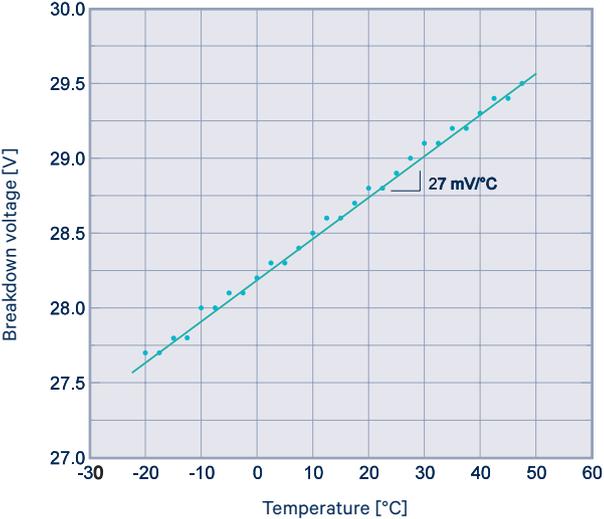
Typical reverse IV curve (SiPM-RGB1S-SMD)



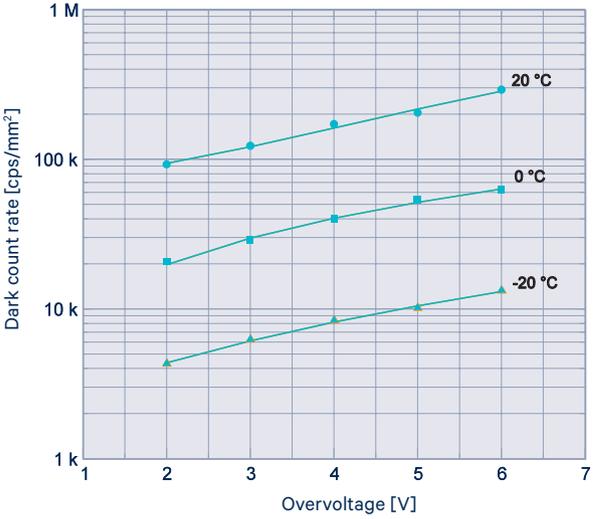
Typical forward IV curve (SiPM-RGB1S-SMD)



Breakdown voltage temperature dependence



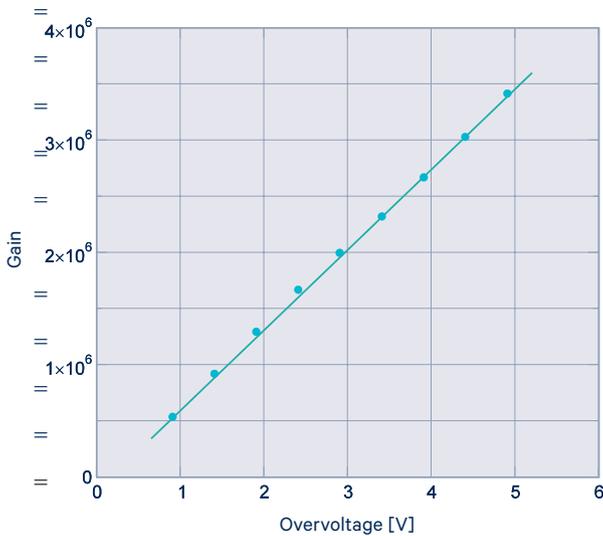
Dark count rate as fct of overvoltage and temperature (0.5 p.e. threshold level; primary dark count rate; not including afterpulse)



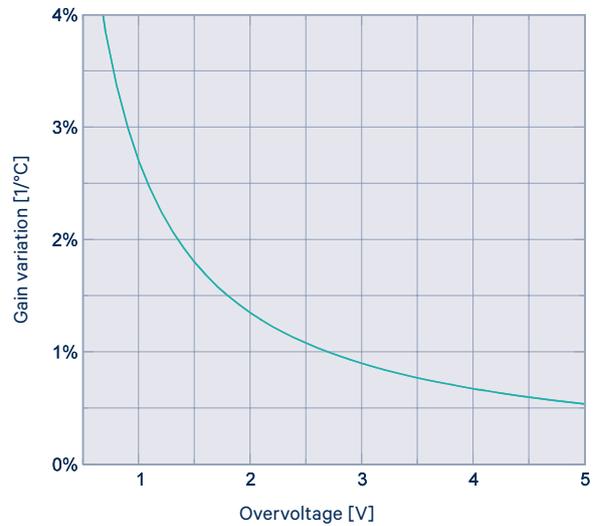
## Red, Green, Blue (RGB) SiPMs

Device characteristics (cont.) <sup>(8,9)</sup>

Gain as fct of overvoltage



Relative variation of gain with temperature as fct of overvoltage



Temperature dependence of poly-silicon quenching resistance

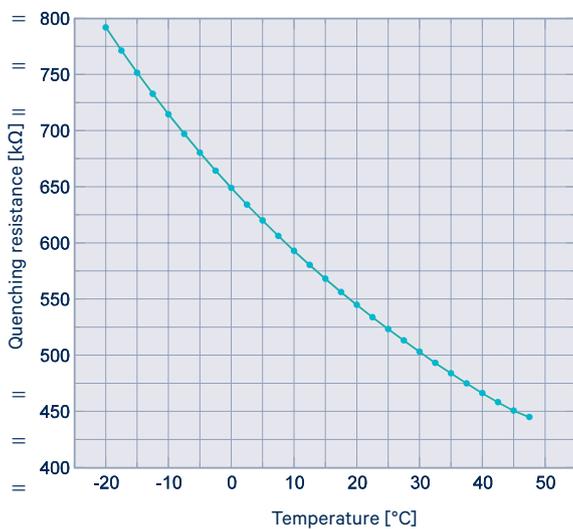
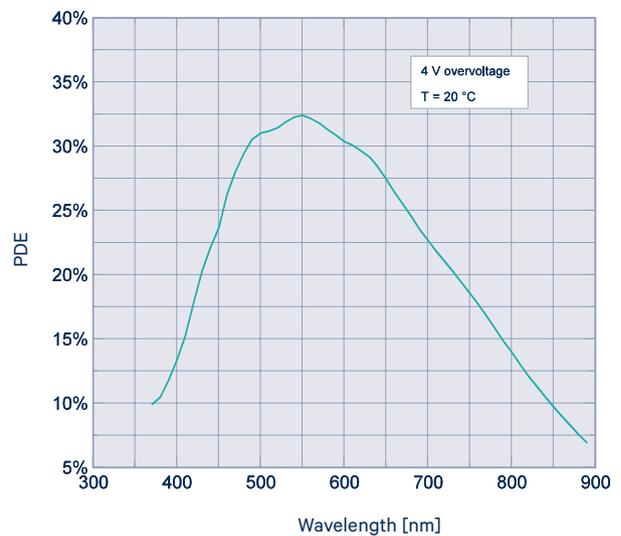


Photo detection efficiency (PDE) as fct of wavelength (crosstalk and afterpulse not included)

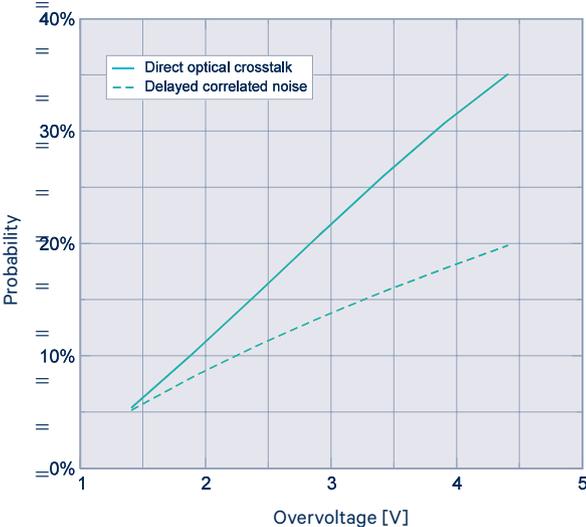


## Red, Green, Blue (RGB) SiPMs

Device characteristics (cont.) <sup>(8,9)</sup>

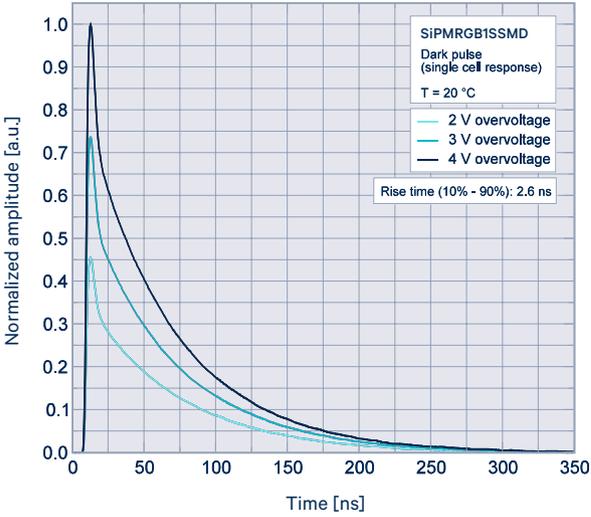
### Correlated noise probability as fct of overvoltage

(delayed correlated noise includes delayed crosstalk and afterpulse)



### Pulse shape at different overvoltage

(recharge time constant is 50 ns)



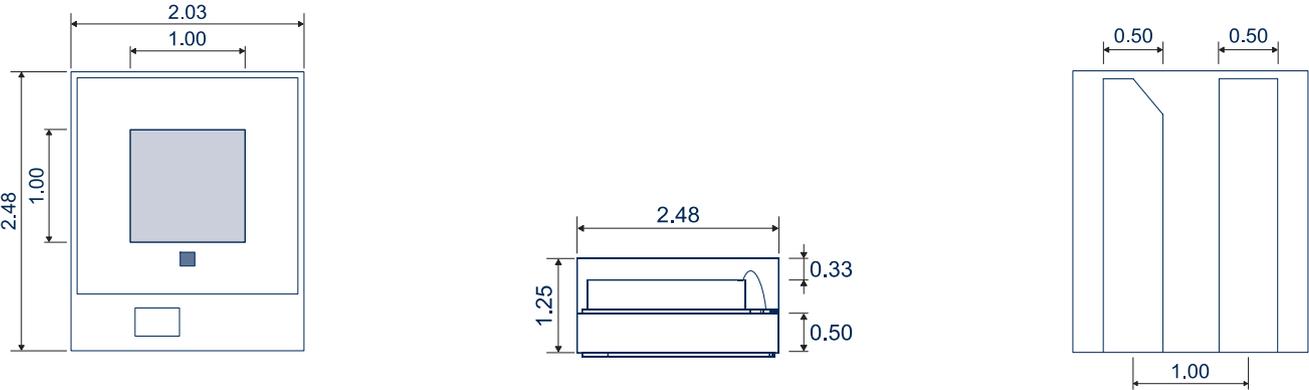
### Specification notes

- (8)  $T_A = 20 \text{ }^\circ\text{C}$
- (9) Refer to the data accompanying each shipped product for more detailed information.

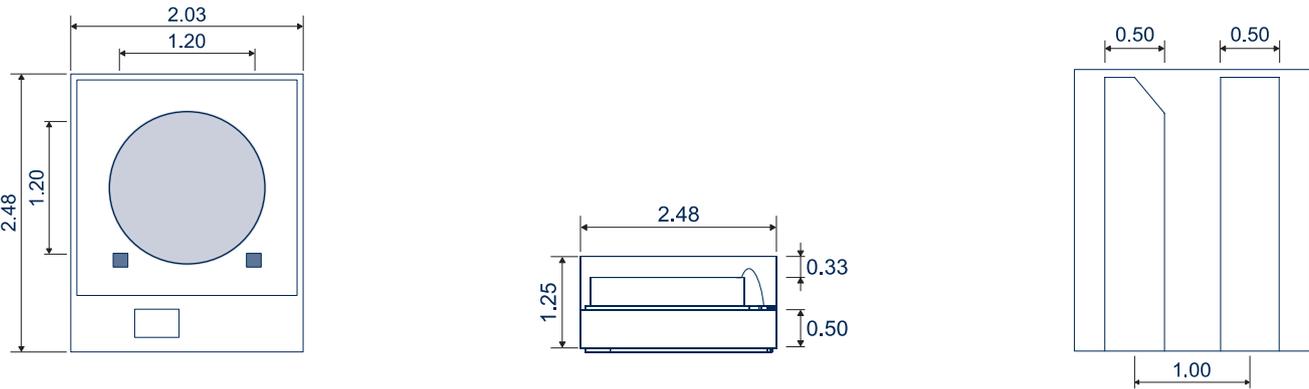
## Red, Green, Blue (RGB) SiPMs

### Physical dimensions

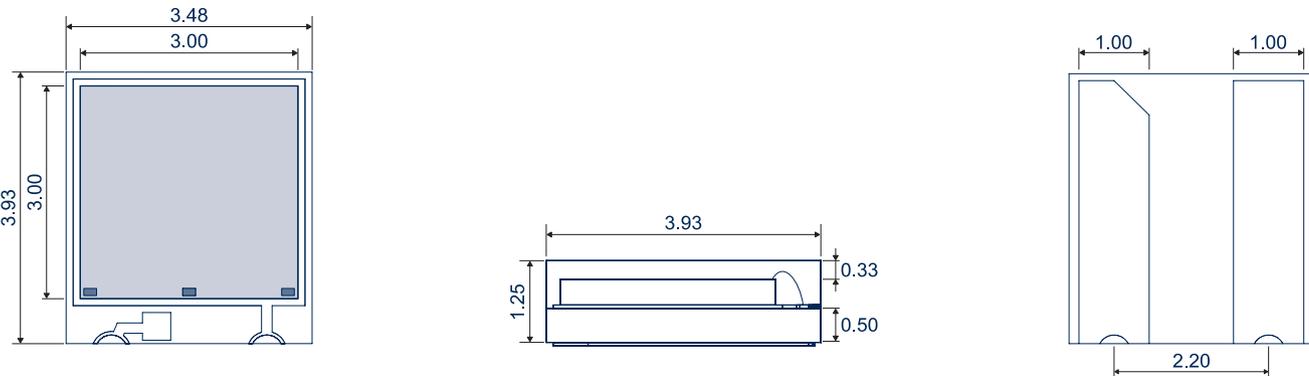
#### SiPM-RGB1S-SMD



#### SiPM-RGB1C-SMD



#### SiPM-RGB3S-SMD



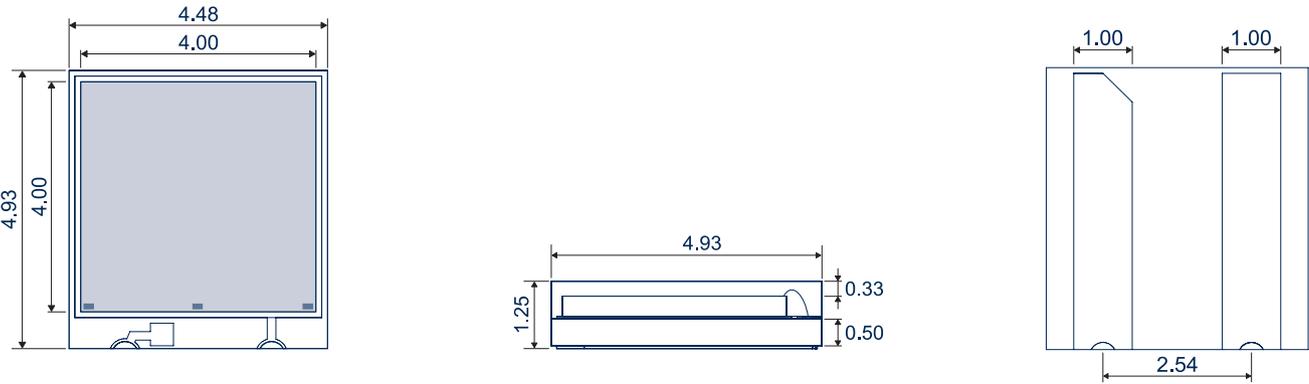
Material: Black FR4, transparent epoxy layer

dimensions in mm, mechanical tolerance  $\pm 0.15$  mm unless otherwise noted

## Red, Green, Blue (RGB) SiPMs

Physical dimensions (cont.)

### SiPM-RGB4S-SMD

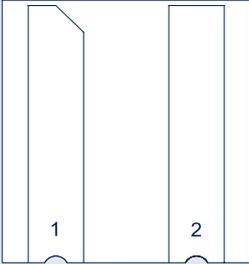


Material: Black FR4, transparent epoxy layer

dimensions in mm, mechanical tolerance  $\pm 0.15$  mm unless otherwise noted

### Electrical connection

CSP bottom view

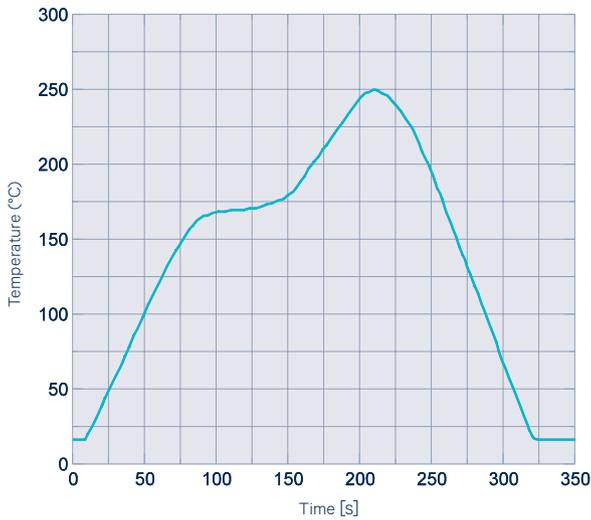




Pin	Name	Function
1	A	Anode
2	K	Cathode

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### Reflow soldering profile <sup>(10)</sup>



### Specification notes

(10) The reflow soldering must be performed within 24 hours once the device has been removed from package and stored in a 25 °C and <60 % RH ambient conditions. The reflow soldering profile is recommended for Pb-free solder such as Tin-Silver-Copper (SAC). The peak temperature must not exceed 250 °C.

### Ordering information

Order #	Series	Range	Active area	Housing
5000080	SiPM-	RGB [Red, Green, Blue]	1S	(1x1) mm <sup>2</sup> square
5000081			1C	∅ 1.2 mm circular
5000082			3S	(3x3) mm <sup>2</sup> square
5000083			4S	(4x4) mm <sup>2</sup> square
				-SMD [Plastic chip scale package (CSP)]