

Semiconductor Strain Gauges

Description

Based on piezoresistive effect, the semiconductor strain gauges (ScSG) from BCM SENSOR are made from p-type silicon wafers, and are manufactured in two series: N-series in which the ScSG is made without backing, and B-series the ScSG with backing.

The two series of ScSG have three options available for their gauge length: 2.6mm, 3.8mm. and 5mm.

In terms of leads/wires layout of ScSG, the B-series has three options, while the N-series has only one option as its leads are flexible and can be bent. The details are described at Layout of Leads or Wires on the page 1 and 2 of the datasheet.

If the difference of the ScSG resistance is particularly required to be smaller than the standard tolerance of BCM SENSOR, the ScSG will be specially sorted and packaged as the grouped gauges to guarantee the required limit. This is specified as the 6th and 7th codes in the ordering code.

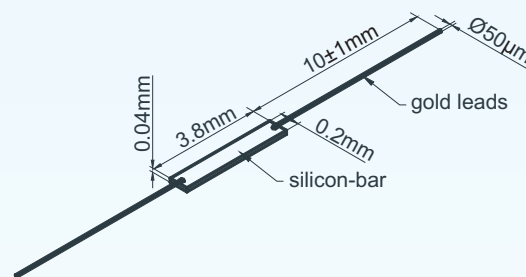
To ensure quick delivery, samples of both the N- and B-series of ScSG are available from stock of different gauge factor, gauge length and resistance.

The ScSG is mostly used either to measure small strain (in a few of microstrain, $\mu\epsilon$) or to compensate nonlinearity in transducer applications.

Layout of Leads/Wires and Dimensions

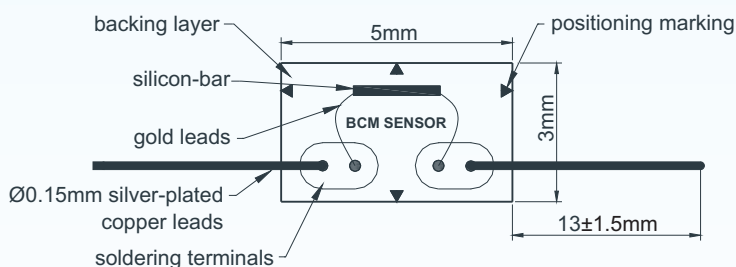
Layout-I

N-series:

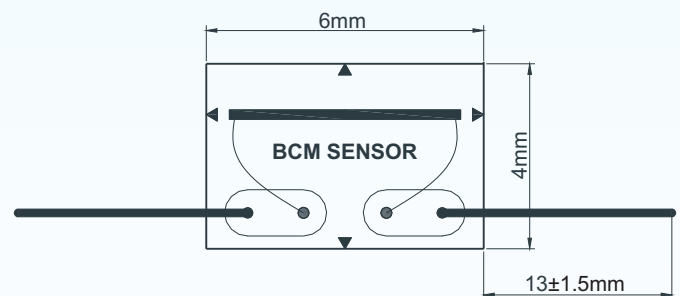


dimensions of N-series of gauge length of 3.8mm as example

B-series:



dimensions of B-series of gauge length of 2.6mm and 3.8mm



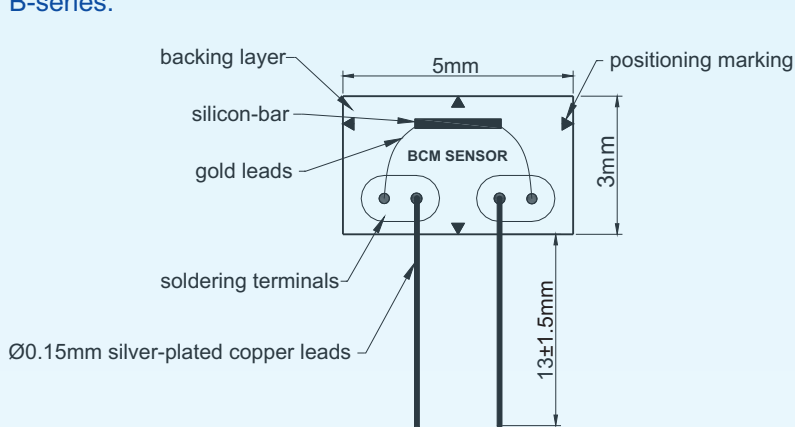
dimensions of B-series of gauge length of 5mm

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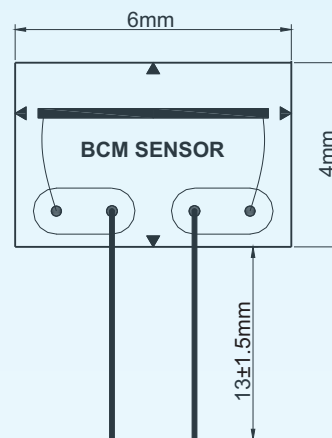
Layout-II

N-series: not applicable

B-series:



dimensions of B-series of gauge length of 2.6mm and 3.8mm

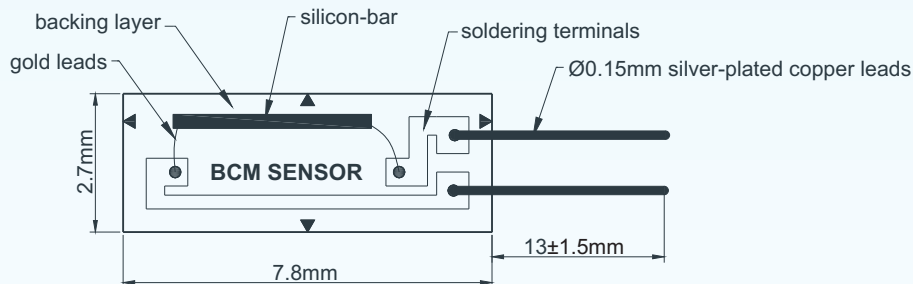


dimensions of B-series of gauge length of 5mm

Layout-III

N-series: not applicable

B-series:



dimensions of B-series of all gauge lengths

Technical Data

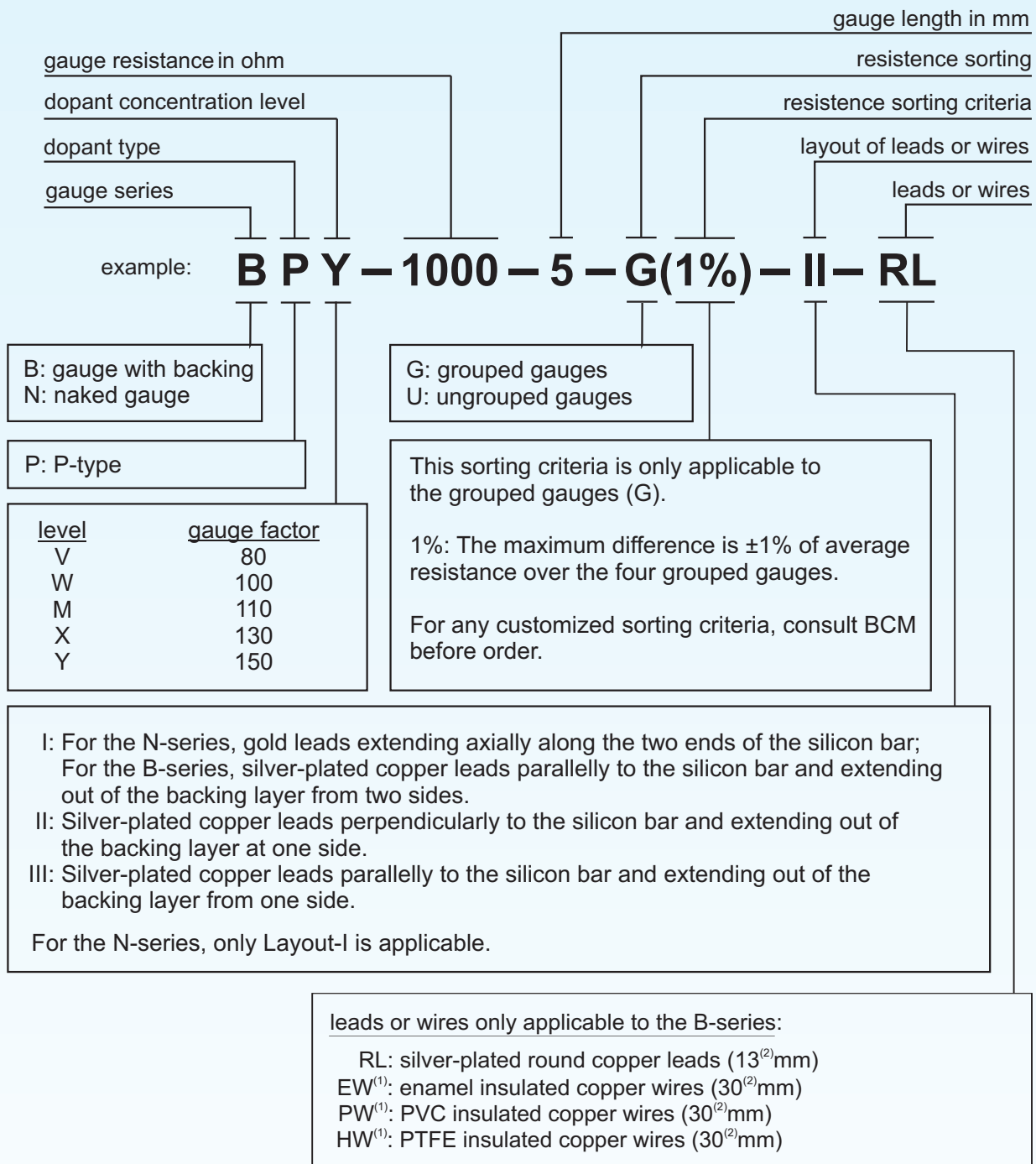
Parameters		Specifications
nominal gauge resistance ⁽¹⁾ (Ω) – R		15, 25, 30, 60, 120, 350, 1000
tolerance of nominal resistance	per package	$\pm 2\%$
	over production lots	$\pm 5\%$
nominal gauge factor ^{(1), (2)} (GF)		80, 100, 110, 130, 150
tolerance of GF	per package	$\pm 5\%$, $\pm 10\%$ (for GF ≥ 110)
	over production lots	$\pm 10\%$, $\pm 15\%$ (for GF ≥ 110)
gauge length ⁽³⁾ (mm) – L		2.6, 3.8, 5
nonlinearity ^{(1), (2), (4)} within $\pm 1000\mu\epsilon$		$\pm 0.15\%$, $\pm 0.2\%$, $\pm 0.5\%$
static tensile strain limit ($\mu\epsilon$)		2000
dynamic tensile strain limit ($\mu\epsilon$)		5000
fatigue life ⁽⁵⁾ (load cycle)		1×10^7
backing layer		modified polyimide resin
backing thickness		$30 \pm 5\mu\text{m}$
working temperature range for static applications	naked gauges	$-40 \sim +125^\circ\text{C}^{(6)}$
	backed gauges	$-40 \sim +125^\circ\text{C}^{(6)}$
max. temperature for dynamic applications up to two hours	naked gauges	$+200^\circ\text{C}$
	backed gauges	$+190^\circ\text{C}$
power loss (mW) per effective gauge length (mm) – P_0		$\leq 8\text{mW/mm}$
recommended load current		5mA
allowable working current ⁽⁷⁾ – I_{max}		$\leq 50\text{mA}$
smallest radius of curvature for bonding strain gauge		10mm

Notes:

- (1) Measured at room temperature (23°C).
- (2) Tested on the gauges which are bonded on steel.
- (3) Effective gauge length is adjustable according to the gauge resistance.
- (4) Determined by the dopant concentration level, referring to page 5.
- (5) The number of cycles of fatigue life of semiconductor SG was tested and obtained when the tensile strain level was set at $700\mu\epsilon$. The lower the tested strain level, the more cycles or longer fatigue life of the semiconductor SG under test. When the tested strain level is lower than $200\mu\epsilon$, the semiconductor SG under test may have much longer fatigue life.
- (6) The GF will decrease with the increase of temperature. The GF at 125°C is about 50% of GF at room temperature.
- (7) $I_{\text{max}} = (P_0 \times L / R)^{1/2}$.

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Ordering Information



Notes:

(1) Operating temperature ranges of the wires:

EW: -40~+150°C;

PW: -40~+105°C;

HW: -60~+180°C.

(2) The indicated length is a standard length. The customized length is available on request.

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Selection Chart

Doping Code	Key Specifications	Ordering Code	R (Ω) Gauge Resistance	# (mm) Gauge Length	* Resistance Sorting	& Layout of Leads/Wires	^ Leads/Wires
V	GF ⁽¹⁾⁺⁽²⁾ : 80 \pm 5% TCR ⁽²⁾ : 0.06%/R/ $^{\circ}$ C TCGF ⁽²⁾ : -0.10%GF/ $^{\circ}$ C NL ⁽¹⁾⁺⁽³⁾ : \pm 0.15%(Δ R/R)	NPV-R-#-*-&	15, 30	3.8, 5	U	I	NA (not applicable)
		BPV-R-#-*-&^	15, 30	3.8, 5	U	II, III	RL, EW, PW, HW
		NPV-R-#-*-&	25	5	U	I	NA
		BPV-R-#-*-&^	25	5	U	II, III	RL, EW, PW, HW
W	GF ⁽¹⁾⁺⁽²⁾ : 100 \pm 5% TCR ⁽²⁾ : 0.08%/R/ $^{\circ}$ C TCGF ⁽²⁾ : -0.12%GF/ $^{\circ}$ C NL ⁽¹⁾⁺⁽³⁾ : \pm 0.2%(Δ R/R)	NPW-R-#-*-&	60	3.8, 5	U	I	NA
		BPW-R-#-*-&^	60	3.8, 5	U	II, III	RL, EW, PW, HW
M	GF ⁽¹⁾⁺⁽²⁾ : 110 \pm 10% TCR ⁽²⁾ : 0.15%/R/ $^{\circ}$ C TCGF ⁽²⁾ : -0.15%GF/ $^{\circ}$ C NL ⁽¹⁾⁺⁽³⁾ : \pm 0.2%(Δ R/R)	NPM-R-#-*-&	120	3.8, 5	U	I	NA
		BPM-R-#-*-&^	120	3.8, 5	U	II, III	RL, EW, PW, HW
X	GF ⁽¹⁾⁺⁽²⁾ : 130 \pm 10% TCR ⁽²⁾ : 0.30%/R/ $^{\circ}$ C TCGF ⁽²⁾ : -0.28%GF/ $^{\circ}$ C NL ⁽¹⁾⁺⁽³⁾ : \pm 0.2%(Δ R/R)	NPX-R-#-*-&	350	3.8, 5	U, G(1%)	I	NA
		BPX-R-#-*-&^	350	3.8, 5	U, G(1%)	II, III	RL, EW, PW, HW
Y	GF ⁽¹⁾⁺⁽²⁾ : 150 \pm 10% TCR ⁽²⁾ : 0.40%/R/ $^{\circ}$ C TCGF ⁽²⁾ : -0.40%GF/ $^{\circ}$ C NL ⁽¹⁾⁺⁽³⁾ : \pm 0.2%(Δ R/R)	NPY-R-#-*-&	1000	2.6, 3.8, 5	U, G(1%)	I	NA
		BPY-R-#-*-&^	1000	2.6, 3.8, 5	U, G(1%)	II, III	RL, EW, PW, HW

Notes:

- (1) Measured at room temperature (23 $^{\circ}$ C).
- (2) Tested on the gauges which are bonded on steel.
- (3) Tested at \pm 1000 $\mu\epsilon$.

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Application Notes

1) N-series (naked gauges) vs B-series (gauges with backing layer)

The advantage of N-series is that, they have no creep-, hysteresis- and nonrepeatability-errors which are mostly introduced by the backing layer. In addition, the response time of the naked gauges is faster than that of the backed gauges. As there is no backing layer, one has to take more care when handling the N-series in the bonding process, compared to the B-series.

As the N-series have no the backing-layer, it is necessary to first create an insulation layer on the surface of the sensor body where the gauges are to be bonded. This can be done by curing a proper amount of strain gauge adhesive on the sensor body surface. One can refer to [Installation of BCM Strain Gauges](#) for more details.

The B-series have the advantage of easier handling in the gauge bonding process. Nevertheless, as the backing layer introduces creep-, hysteresis- and nonrepeatability-errors, it is not recommended to use the B-series for high precision sensor applications.

2) Gauge Length

The gauge lengths available from BCM SENSOR are 2.6mm, 3.8mm, and 5mm. The shorter gauge length is suitable for a limited bonding area.

3) Measurable Strain

The minimum strain is in a level of about $1\mu\epsilon$ (microstrain), which is measurable by the naked gauges (N-series). In practice the minimum probed strain will depend on the working conditions of the specific application on site such as measuring devices, signal conditioning electronics and working environment.

To keep reasonable linearity, the maximum strain to measure is limited to $\pm 1000\mu\epsilon$ for all ScSG from BCM SENSOR. The higher the strain level beyond the strain limit of $\pm 1000\mu\epsilon$, the larger the nonlinearity will be observed.

4) Bonding on Curved Surface

In general, it is not recommended to bond the ScSG onto a curved surface because silicon can easily be broken due to the curvature of the surface.

Nevertheless, in case a very small strain in a spring element of a curved surface has to be measured, the radius of curvature is limited to 10mm.

One can also try with the ScSG of the shortest gauge length (i.e., 2.6mm from BCM SENSOR) as long as it cannot be broken during bonding process.