Bonding Procedures of BCM Strain Gauges

1. Introduction

This document describes the working steps required for bonding and soldering of BCM strain gauges on to the load-cell element or on to the surface of the object for stress analysis. The described processes are tailored and proven to be helpful for manufacturing of precision load cells or for precision strain measurement. The described procedures can be applied to both foil strain gauges and semiconductor strain gauges.

It is assumed that the strain gauges are mainly got bonded with heat curing adhesives, like BCM B-610 adhesive. So the application notes described below will mainly focus on the gauge installation with the heat curing adhesives, especially on the use of BCM B-610 adhesive.

2. Surface Preparation

It is important to be sure that the load-cell element had no any contact with silicon-containing cutting oil during machining. Otherwise the silicon residuals have to be removed completely by means of suitable solvents before starting the working steps described below. This is very necessary because the smallest amount of silicon contamination can make a bond useless. Therefore, we recommend very much to keep the working area free from any silicon containing product.

The staff in charge of strain gauge application should know that cosmetics such as hand cream frequently contain silicon. Therefore, it is recommended using the hand cream that is free of silicon.

2.1. Clean load-cell element first with degreasing solvent such as methyl-ethyl-ketone (MEK), acetone, or isopropyl alcohol (IPA). After the cleaning, do not touch application area by hand for all further working steps.

2.2. Make it ready in hand of sandpaper adhesion surface area with grit size 320 - 400 or sandblast with aluminum oxide grit 120 - 400. When using a sandblast system, operate it with oil-free compressed air and use it for surface preparation only. By using the system for other than surface preparation there is the danger of contaminating the system with silicon or other chemicals that may cause a bad bond.

2.3. Remove grinding dust with a non-fluffy throw-away cloth and a solvent, e.g. IPA, or by brushing with IPA.

2.4. If required, the position of strain gauge to be bond can now be marked by a brass needle or a hard 4H-pencil.

3. Handling and Cleaning of Strain Gauges

Strain gauges are handled only with rounded tweezers or vacuum pen, but never touched with the fingers. Hold the strain gauge at the backing support, not at the grid sensing area.

To manufacture high precision load cells, it is recommended to clean BCM strain gauges before the bonding process. One can clean the gauges with ethyl alcohol, MEK, acetone, or IPA. After the cleaning, never touch the gauges until bonding. Should the strain gauges have been touched accidentally by hand, clean it immediately with MEK or IPA and cotton tipped applicators (do not use cotton buds with plastic grip). Put the cleaned gauge onto a chemically cleaned glass plate with the gauge bonding side upper.

BCM SENSOR TECHNOLOGIES BVBA

Industriepark Zone 4, Brechtsebaan 2
B-2900 Schoten - Antwerpen, BELGIUM

Tel.: +32-3-238 6469
Fax: +32-3-238 4171

website: www.bcmsensor.com
email: sales@bcmsensor.com

4. Bonding of Strain Gauges

To have quality bonding of strain gauges, utmost cleanness is essential. Therefore the bonding is preferably to be made on a dust-free workbench with filtered air supply.

4.1. Clean application area of the load-cell element with cotton tipped applicators dipped into a solvent, e.g., IPA or MEK (do not use cotton buds with plastic grip). Renew the cotton tips frequently until the application surface is completely clean (cotton tips remain clean). If possible, the surface area cleaned should extend beyond the space required for the strain gauge.

4.2. Coat the application area of the load-cell element with B-610 adhesive and wait for a few minutes to let B-610 get drying and form a thin layer of the adhesive. As to the desired thickness of adhesive layer, please refer to "thickness of adhesive layer versus creep" as described below (refer to step-15).

4.3. Place the strain gauge in correct position, cover the strain gauge with a piece of teflon film, slightly press and smoothly squeeze out by the thumb the excess amount of B-610 and possible air bubbles underneath the gauge.

4.4. For BCM open-faced foil strain gauges and semiconductor strain gauges, the grid side of the foil gauge and upper side of semiconductor gauge can be coated with a thin layer of adhesive to protect the gauge during the application process.

4.5. Cover strain gauge with the teflon film of 0,08 mm thick, take a 1,6 mm thick silicon rubber of the same size as the foil strain gauge and put this silicon rubber onto the gauge. Keep the silicon rubber at least on one side not extend over the teflon film, so the excess adhesive can easily pressed out by the clamping pressure. The silicon rubber, teflon film, strain gauge, and the substrate (the surface of load-cell element) form a so-called "Sandwich" structure.

5. Clamping Tools

During setting of the adhesive, the strain gauges have to be clamped with a defined and constant pressure. Spring clamps can be used as a universal clamping tool. For economic production and best results of bonding, a specific "tailor-made" clamping tool would be recommended for use to create the pressure. This tool must provide constant and reproducible pressure to ensure a constant glue line thickness. The backup plate that is pressed onto the "sandwich" must emulate the shape of the load-cell element. Normally it is a plane surface. In case of a cylindrical load cell element the backup plate has to have the radius of the cylinder plus the thickness of the silicone rubber so that a homogenous pressure would be guaranteed on to the strain gauges.

5.1. Put the "sandwich" into the clamping tool and adjust the pressure according to the specified pressure as stated in the adhesive specifications.

5.2. Check whether the teflon film and silicon rubber are in correct position.

6. Curing of Adhesives

6.1. Put the clamped load-cell element into the cold oven and heat it to the desired temperature (see specifications of B-610). Though it is not critical, it is recommended to increase the furnace temperature by 5 °C ~ 10 °C per minute.

6.2. After reaching to the specified temperature, keep it for the certain time as required (see specifications of B-610). Let the clamped load-cell element cool down to the temperature less than 40 °C before removing the clamping tool, pressure pad and the teflon film.

6.3. Post cure the load-cell element in the oven at the higher temperature as requested for a certain time duration as specified in the adhesive specifications.

Industriepark Zone 4, Brechtsebaan 2
B-2900 Schoten - Antwerpen, BELGIUM
Tel.: +32-3-238 6469
Fax: +32-3-238 4171
website: www.bcmsensor.com
email: sales@bcmsensor.com

7. Inspection of Bonding Quality

The bonding quality of strain gauges can be inspected through a checking of creep errors. Generally speaking, higher positive creep are often due to the poor quality of spring element of load cells, while higher negative creep results mostly from poor installation in gauge bonding process.

7.1. Inspection of the bonding quality can be done by using a magnifier or a microscope with 10 times magnification, and check for the following irregularities:

a) Voids, which is fairly large un-bonded areas.

INDICATION: an improper clamping or adhesive application.

b) Bubbles, which is similar to voids but is always small in a round shape and appear in a great number.

INDICATION: an improper drying time of adhesives.

c) Uneven adhesive thickness.

INDICATION: an improper clamping.

7.2. Should bubbles or voids be under the gauge grid, the bonded gauges have to be removed off and the load-cell element has to be re-gauged.

When bubbles are located outside of the gauge grid, the element may be used to build a load cell.

Note: Should one of the above faults occur, it indicates a problem on the gauge installation process. It is recommended to check thoroughly in order to find out the cause and eventually correct the problem.

8. Soldering Tools and Stuffs

Use a temperature-controlled soldering iron. Do not mix different types of solder. As long as different solders are in use, take the specified soldering tip for a specific solder. Use only small amount of solder.

8.1. Select the type of solder and flux according to the required load cell operating temperature.

Typical solder used in electronics contains 60% tin and 40% lead, with melting point of 183 °C. It is suitable for operating temperatures up to 170 °C. A suitable flux is liquid rosin. Do not mix different types of flux. For BCM gauges made from Karma foil (for instance, EKF series gauges), a special made BCM flux has to be used to assist solder and easy the soldering process of Karma gauges.

8.2. The temperature of the soldering iron should be set to approximately 380 to 400 °C.

9. Soldering of Strain Gauges

As long as it is necessary, it is recommended to solder strain gauges under a magnifier of 2 ~ 10 times magnification.

9.1. If excess adhesive has contaminated the strain gauge tabs, remove the adhesive layer on the tabs prior to soldering, by using an eraser pen or an electrical eraser.

Industriepark Zone 4, Brechtsebaan 2
B-2900 Schoten - Antwerpen, BELGIUM
Tel.: +32-3-238 6469
Fax: +32-3-238 4171
website: www.bcmsensor.com
email: sales@bcmsensor.com

9.2. The following steps may be followed when tin the gauge tabs:

a) Clean solder tip and wet it with solder.
b) Apply some flux to the strain gauge tab.
c) Tin the gauge tab.
d) After soldering, assure that the resulting solder dot is in good connection to the gauge tab.

9.3. Solder the wire to the gauge as follows:

a) Cut wire to length, remove insulation and tin the ends, using the same solder as in the step 9.2.
b) A small amount of flux may be applied to the gauge tab.
c) Hold wire flat onto the gauge tab in the suitable direction.
d) Solder for approximate 1 second. Hold the wire in the position until the solder becomes solid.

10. Inspection of Solder Joint

10.1. The soldering point has to be homogeneous, smooth and shiny.

10.2. The wire should lay flat on the gauge tab.

11. Flux Removal

Flux residues have to be removed. Rosin flux is removed by brushing the part with a middle-sized brush soaked with IPA. Flux removing systems as used for cleaning of printed circuit boards are usually also suitable to be used for load cells.

12. Protection of Strain Gauges

The strain gauge and the area around it should be protected with a coating against moisture and other chemical influences. The selection of a suitable coating depends on the environmental conditions and the expected temperatures. See BCM Strain Gauge Accessories catalog for recommendations.

13. Checking of Insulation Resistance

Finally the insulation resistance of the strain gauge grid to the load-cell element is measured. Normally it should be >1000 MO. This value can easily be achieved and is usually exceeded by magnitudes. When the insulation resistance is too low, the load-cell element must be re-gauged or rewired.

14. Additional Instructions for Strain Gauge Adhesive B-610

For manufacturing of precision load cells, preferably heat curing and liquid adhesives, such as B-610, are recommended for use. Therefore the following instructions are given especially for this adhesive. Following curing conditions can be considered as an optimum:

14.1. For the load-cell element made from mild steel or stainless steel, the following curing conditions may be followed:

curing pressure: 3 ~ 5 bar
curing temperature: 170 °C for 2 hours
post cure temperature: 200 °C for 4 hours

BCM SENSOR TECHNOLOGIES BVBA

Industriepark Zone 4, Brechtsebaan 2
B-2900 Schoten - Antwerpen, BELGIUM

Tel.: +32-3-238 6469
Fax: +32-3-238 4171

website: www.bcmsensor.com
email: sales@bcmsensor.com

14.2. For the load-cell element made from aluminum alloy, it is recommended to apply the following conditions:

curing pressure: 1 ~ 3 bar
curing temperature: 135 °C for 2 hours
post cure temperature: 165 °C for 2 hours

However, for some types of aluminum alloys these temperatures may be too high. In such a case the staff in charge of strain gauge application had better apply the maximum permissible temperature and extend the curing time to 4 hours. But a minimum curing temperature of B-610 has to be 120 °C.

14.3. It is recommended to apply the maximum curing pressure in curing process. Calculate the required curing force by using the following formula:

force = pressure pad size x pressure.

e.g.: if pressure pad size = 10 x 5 = 50 (mm2)
and curing pressure = 5 bar (according to adhesive specifications)
then, the required curing force = 5 x 50 -2 = 2.5 kg (= 24.5 N)

15. Curing Pressure and Thickness of Adhesive-Layer versus Creep Error

When bonding strain gauges on to the substrate (e.g., load-cell element), apply a higher pressure during curing process to get smaller creep error in load-cell output. Same consideration applies to the thickness of adhesive layer. A thicker adhesive layer results in a bigger negative creep, while a thinner adhesive layer leads to a smaller creep in load cell output. Therefore, to reduce the creep it is recommended applying a higher curing pressure and a thinner adhesive layer of 15~20 µ on to the strain gauge substrate.

16. Insulation of Naked Semiconductor Strain Gauges

SN-series semiconductor strain gauges are the naked gauges (bar gauges) without any backing materials beneath the gauges. Compared to the SB-series semiconductor gauges that have the backing underneath the gauges, it is recommended to apply the SN-series gauges on to the loadcell element to have smaller creep.

Since the SN-series gauges are naked gauges, it is necessary to form an insulation layer for the gauge before bonding it. Cover the gauge application area with adhesive (e.g., B-610) and curing it completely to form a cured adhesive layer. This layer could provide insulation for the gauge. Again, to reduce the creep, it is better to apply a thinner layer of adhesive on to the gauge substrate as long as the layer provides a sufficient insulation to the gauge. It is recommended to apply a layer of 30 micrometer thickness for insulation purpose.

17. Bonding of Naked Semiconductor Strain Gauges

There are two ways to bond the SN-series semiconductor strain gauges: bonding with pressure and bonding without pressure (free bonding process).

As long as the creep error is within the requested limit of loadcell specifications, free bonding process may be recommended, that is, glue the gauge on to the insulation layer and cure the gauge in an oven at the requested temperature for a certain time.

If the creep is beyond the limit of loadcell specifications, it is recommended to apply an adhesive layer as thinner as possible on to the substrate and bond the gauge with pressure in curing process, in the same way

BCM SENSOR TECHNOLOGIES BVBA

Industriepark Zone 4, Brechtsebaan 2
B-2900 Schoten - Antwerpen, BELGIUM

Tel.: +32-3-238 6469
Fax: +32-3-238 4171

website: www.bcmsensor.com
email: sales@bcmsensor.com