1. Introduction – heritage, scope and objectives

1.1 Heritage and scope

As of today, various space experiments, like those at LHC, successfally employed a bonding technology, mainly based on silicon glue (SIL). Although this technology has been widely tested and implemented for space applications, they did not consider the mechanical requirements for future missions. This paper is aimed to show that a simple modification of the adhesives’ mechanical behavior could improve the mechanical bond between substrate and structure.

1.2 Classical approach to the mechanical design

Space detector mechanical design

Structural stress analysis and optimization

Are the requirements met?

Yes

No

Are the tests successful?

Yes

No

Test it (space qualification)

Launch it!

1.3 Improved approach to the mechanical design

Are the requirements met?

Yes

No

Silicon tabbers mechanical design and optimization

Are the requirements met?

Yes

No

Test it (space qualification)

Launch it!

1.4 Pull test for bond strength analysis

Goal: gather information on the bonds' yielding stress

2.1 Test subject

Bond and wire properties:

- Wire: 36 µm x 10 µm
- Max force: 3.1 N
- Bending: 1 – 6 %
- Pass distance 1 / 1.2 mm

Bonds manufacturing pictures:

Conclusions: it is important to optimize all mechanical requirements of this system.

2.2 Test description and execution

Test objective: verify the bond's quality (geometrical and performace adherence)

Requirements: bond must be above

Reference: ± 1.5 mm

Results:

- Small strain: 157 MPa
- Large strain: 315 MPa

Notes: 20 samples

2.3.2 Test campaign

Results:

- Small strain: 93.1 MPa ± 23.0
- Large strain: 175.0 MPa ± 44.0

Notes: 20 samples

3. Silicon Detectors mechanical characterization

Goal: retrieve detectors' mechanical properties

3.1 Physical properties and general information

- Test subjects: master SIL (approx. <1 mm)
- Dimensions: 1/10 to 1/20 mm (0.01 mm was measured)
- Density: 0.249 ± 0.065 (1 sample used)

3.1.2 Mechanical properties estimation with three-points bending test

Three-points bending test

- For each set of bonds, the test subject placed between two supports
- Applied load measured by means of a load cell
- Superficial stress computed from the measurement load and the geometrical parameters
- Stiffness measured by means of strain gauges

Conclusions: it is important to optimize all mechanical requirements of this system.

3.4.3 Conductive glue

Introduction: although inevitably beneficial, the glue is not employed in a completely out of the box manner. The glue is electrically conductive, which potentially may lead to the shorting of the detector. The conductive glue was employed in the electrical connection of the bias path on the substrate.

Silicon glue: 1 - 2 Mpa

Conclusions: it is important to optimize all mechanical requirements of this system.

4.2 Structural glue

Stiffness: typical adhesive

Silicon glue: 1 - 2 Mpa

Conclusions: it is important to optimize all mechanical requirements of this system.

4.3 Conductive glue

Stiffness: typical adhesive

Silicon glue: 1 - 2 Mpa

Conclusions: it is important to optimize all mechanical requirements of this system.