Tracker Thermal Testing Plan   Phase One Test

Objectives: This series of tests is proposed to characterize the strength and stiffness of the silicon material used in the tracker, as well as the materials' behavior over the required temperature range when adhesively bonded to a relatively high CTE substrate. Additionally, the properties of various adhesives and their effects on the fragile silicon layer will be determined.

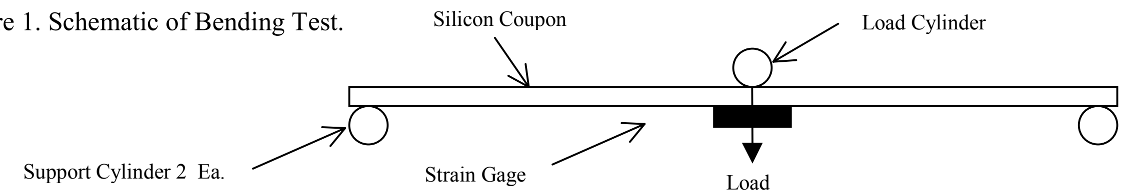
Sequence 1. Silicon Strength Testing

It is desired to experimentally characterize the strength of the silicon used in the tracker so that the design may be optimized with respect to the thermal environment. This will be achieved by performing strength testing of a number of silicon coupons, 410 microns thick. The primary objective of this first round of tests is to determine the strain values at both tensile and bending failure so that these values can serve as a baseline for future tests involving other components of the tracker design.

Test 1: Pure Bending of a Simply Supported Beam

This quick test will determine the approximate strain value of the silicon specimens under pure bending loads. The specimen will be simply supported by two cylinders and loaded by a single cylinder at the center of the two supports. The strain gage instrumented on the opposite face of the load cylinder will measure the bending strain.

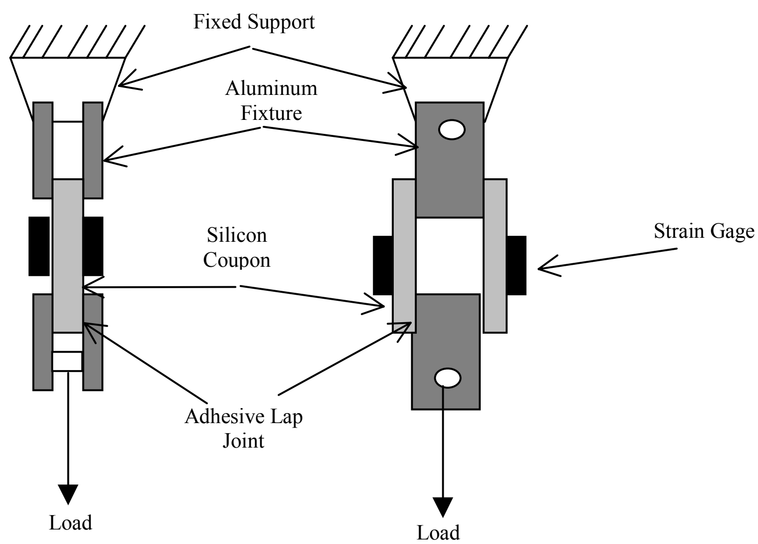
Figure 1. Schematic of Bending Test.



Test 2: Tensile Test

This test will determine the strain signature of a silicon coupon undergoing tensile failure. It is hoped to test a sufficient number of specimens to achieve a high level of statistical confidence with the strain value associated with the material's failure. The simple tests shown in Figure 2 are ideal at this time, as we are currently seeking access to a suitable tensile testing machine.

Figure 2. Potential Configurations for Tensile Testing



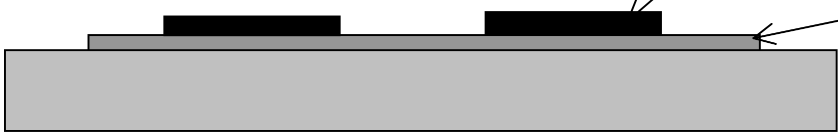
Test 3: Baseline CTE Mismatch Test

The primary objective of this test is to provide first hand insight to the failure of the silicon when adhesively bonded to a substrate that has a significantly higher CTE, in this case, aluminum. This test will take place in the environmental chamber at SLAC, and will be subjected to increasingly demanding temperature cycling per Table 1 until the silicon fails. The maximum rate of change of temperature will be ~0.5**°C** /min, this is slow enough not to induce thermal shock and yet rapid enough to facilitate numerous tests per day. The strain measurements will be compared to those from the tensile tests. The adhesive used in these tests, initially 3M Scotchweld 2216, will be of a relatively high modulus and applied uniformly over the interface surfaces, as different adhesives and adhesive configurations will be evaluated in later testing.

Table 1 Base line Temperature Ranges

Silicon Temperature Ranges	**T_{min}(°C)**	**T_{max}(°C)**
Design Operational	-10	25
Design Survival	-20	40
Design Burn In	-50	75
Qualification Test Operational	-20	35
Qualification Test Survival	-30	50

Figure 3. Schematic of the Initial CTE Test Fixture.



Sequence 2. Shear Coupling Tests

Depending on the results of the first round of testing, two possible routes may be taken in this series of tests. Both tests would use a fixture and instrumentation scheme similar to that used in Test 3 of Sequence 1.

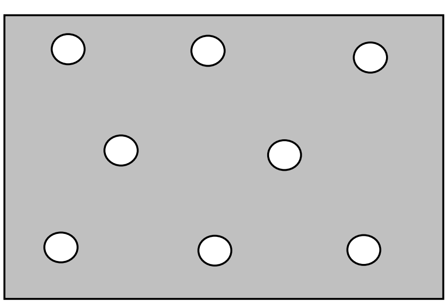
Test option 1.

The first option would be to test adhesives of varying strength (modulus of elasticity) to gain insight on their strain transmission characteristics. In this test the adhesive would be applied uniformly in the interface. Although this method of applying the adhesive is not desirable for the flight configuration (due to potential air bubbles trapped between the surfaces which might expand once in orbit), it must be maintained for this stage of testing so that the only parameter changed from the previous tests is the modulus of the adhesive.

Test Option 2

The issue of air bubbles leads to the next possible option: testing various application patterns of the same high modulus adhesive used in previous tests. This approach will yield information on the ability of discrete patches of adhesive to absorb the strain transferred between materials. The high modulus adhesive will be used so that the only variation from Test 3 of Sequence 1 is the pattern of the adhesive, hence determining the effectiveness of this technique. A possible configuration is shown below.

Figure 4 Possible Adhesive Application Pattern.



Finally the insight from these test may be used to test low modulus adhesives in the most probable configurations from Test Option 2, assuming the results are promising.

Other parameters of interest not mentioned in this preliminary outline include: adhesive thickness, shear area, various adhesive vendors, strain gage type, precise strain gage configuration, source of the test coupons (and/or how a 150 mm wafer should be sectioned to yield the maximum number of useful samples), technique used to cut wafer (laser or diamond cutting), crystal orientation in the silicon, including the Kapton layer (and potentially a strain gage within that layer), the electrical conductivity of potential adhesives, surface preparation, adhesive application techniques, cost effectiveness of the various options, availability of particular components, and handling specifics. Additional tests may be planned using a lead brick for a CTE mismatch substrate but to start we would like to use aluminum for reasons relating to ease of fabrication and handling.