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D0 SILICON UPGRADE

LADDER REMOVAL STRESS ANALYSIS

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Abstract

The force necessary to remove an epoxied ladder from a bulkhead is calculated. The resulting silicon stress is also calculated.

I. Introduction

Two different methods will be used to affix ladders to the active bulkhead. Layer 1 and layer 3 ladders will be attached to the active bulkhead using pins. To provide a highly conductive thermal path between these ladders and the cooling channel in the active bulkhead, a small amount of thermally conductive grease will be applied to the bulkhead just prior to ladder installation. Layer 2 and layer 4 ladders will be attached using the same method with the exception that thermally conductive epoxy will be used in lieu of grease. The epoxy is necessary in the outer two layers to maintain barrel rigidity.

One major point of concern is the removal of the epoxied ladders. If removal of one of these ladders becomes necessary, it is unclear if the epoxy bond can be broken without damaging the silicon. This report is an attempt to estimate the amount of force necessary to remove a ladder, and the resulting stress that force produces in the silicon.

Figure 1: 5 Chip Ladder

Figure 2: Finite Element Model

II. Analysis

One end of a layer 4 ladder has been analyzed using IDEAS Master Series finite element software. A layer 4 ladder is shown in figure 1 and the corresponding finite element model is shown in figure 2. The actual ladder consists of the following five layers: 0.012" of beryllium, 0.002" of epoxy, 0.012" of silicon, 0.002" of epoxy and 0.012" of beryllium. An additional 0.002" of epoxy exists between the ladder and the bulkhead. The finite element model ignored the two epoxy layers on either side of the silicon. The model also assumed that the bulkhead was completely rigid.

To further simplify the model, only the active end of the ladder was included. The opposite end of the ladder will be held in place with strictly mechanical means (no grease or epoxy). Also, the ladder removal force will be applied very close to the active bulkhead. This force will initially be resisted completely by the epoxy on the active bulkhead. Thus, restricting the finite element model to the area near the active bulkhead should not have affected the results.

Figure 3 shows the deflection of the ladder end for a 1.35 lb ladder removal force. The force was applied 0.1" from the bulkhead edge at the edge of the ladder over a 0.065" by 0.065" area. Figure 4 shows the resulting stress in the epoxy. Note that the 1.35 lb force produces a 1 ksi maximum stress in the epoxy. This is equal to the yield stress of the epoxy. Thus figures 3 and 4 represent the ladder at the moment the epoxy is beginning to yield. Figure 5 is a plot of the silicon stress at the same instant. Note that the maximum silicon stress is 800 psi, or about 5% of silicon's ultimate stress of 15,000 psi.

Figure 3: Ladder Deflection

Figure 4: Epoxy Stress

Figure 5: Silicon Stress

III. Conclusion

The analysis suggests that an epoxied ladder can be removed from the bulkhead without mechanically damaging the silicon. However, the silicon's electrical properties may be affected by a stress level much less than ultimate stress.