D0 ENGINEERING NOTE

No. 3823.112-EN-412

D0 SILICON UPGRADE

WEDGE
HEAT TRANSFER

September 19, 1994

Paul Ratzmann

Approved: _____

Herman J. Stedje

Wedge Heat Transfer

Paul Ratzmann

August 18, 1994

The Silicon Mechanical group has submitted a wedge drawing to the Fermilab Analysis Group (Zhijing Tang) to determine the temperature distribution in the ladder during detector operation. Heat transfer by convection and radiation is assumed negligible and two dimensional FEA conduction solutions were performed.

The heat flux at the SVX II chip region is assumed to be 8.359 mW/mm^2 which corresponds to roughly 0.48 W per SVX II chip. The heat flux in the region of the transceiver is assumed 5.556 mW/mm^2 , corresponding to 2.56 W in this region. Total heat load of the wedge is assumed to be 10.24 W .

The wedge submitted for analysis is shown in the figure below. The multi-chip module (MCM) is mounted on a beryllium plate which serves to carry the heat load of the chips and the transceiver to the cooling channel. Adhesive thermal conductivity is 1.6 W/m-K , based on the published value of the selected adhesive. Actual measurements of thermally conductive adhesives indicate that the assumed 1.6 W/m-K is high [1]. Experience gained in measuring adhesive thermal conductivity indicates $0.9\text{-}1.2 \text{ W/m-K}$ as a more reasonable number to use. The effect of the uncertainty of the adhesive thermal conductivity on silicon temperature is discussed in [2].

The following set of thermal conductivities was given to Zhijing for the FEA calculations, along with the corresponding thicknesses:

<u>Material</u>	<u>K (W/m-K)</u>	<u>Thickness (microns)</u>	
silicon	149	300	
beryllium	190	300	
wirebonds	237	25	
epoxy	1.6	75	
SVX chip	149	500	
			<u>Number of layers</u>
HDI-transceiver			
kapton	0.12	25.4	2
Cu	200.5	17.8	4
adhesive	0.22	25.4	2
pre-preg	0.12	25.4	1
HDI-chip			
kapton	0.12	25.4	1
Cu	401	17.8	2

Table 1 Thermal Conductivity and Component Thicknesses, Wedge

ANSYS 5.0
 AUG 22 1994
 08:21:37
 PLOT NO. 1
 NODAL SOLUTION
 STEP=1
 SUB =1
 TIME=1
 TEMP
 SMX =24.792
 A =0.888677
 B =2.068
 C =3.443
 D =4.821
 E =6.198
 F =7.575
 G =8.953
 H =10.33
 I =11.708
 J =13.085
 K =14.462
 L =15.84
 M =17.217
 N =18.594
 O =19.972
 P =21.349
 Q =22.726
 R =24.104

The cooling channel surface temperature has been assumed at 0 degrees C for the solution. Silicon and ladder component temperatures may then be determined by adding the true temperature of the channel surface to the output temperatures, since convective and radiative heat transfer is negligible on the ladder surface. Bulk temperature of the coolant is expected to be 5° C, with a channel surface temperature of 8.5°C due to the temperature gradient in the coolant.

The maximum temperature occurs on the wedge in the transceiver region. For a cooling channel of 0°C the maximum temperature achieved is 24.8°C. However the wedge design is substantially different from the ladder designs. The silicon does not extend beyond the cooling channel in the wedge, causing the silicon to be substantially cooler. As can be seen in Figure 2, the silicon stays essentially at the temperature of the cooling channel, 0°C. Taking into account the assumed 8.5°C channel surface temperature, the maximum temperature in the wedge is 8.5° C.

[1] H. Jostlein, T. Heger. private communication

[2] P. Ratzmann, 5 Chip Ladder Heat Transfer and Ambient Temperature Analysis, 1994