TRACE THERMAL TEST

Spartan IR Camera for the SOAR Telescope

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25 January, 2002

We are designing a circuit board that serves as a thermal resistor for the motor wires between the ambient outside and motors at 77K. This document describes the heating characteristics of a prototype circuit board at varying pressure.

Question

How does the heating of a PCB with depend on the current flowing through the trace and the surrounding pressure?

Circuit board

The circuit board is 0.062-in thick FR4. The 0.75A current runs through two 5-mil, ½ ounce traces.

Effect of the temperature sensing diode

Since the temperature sensing diode is larger than the thickness of the circuit board, the diode decreases the peak temperature of the board. We measured the temperature of the diodes and recorded an infrared image of the circuit board. Details are in Jason's Notebook 14, pp. 122-125. The diode (region 4 in Figure 1) is cooler than the trace nearby (region 3). The ratio of the temperature of the trace to that of the diode is 10:7.

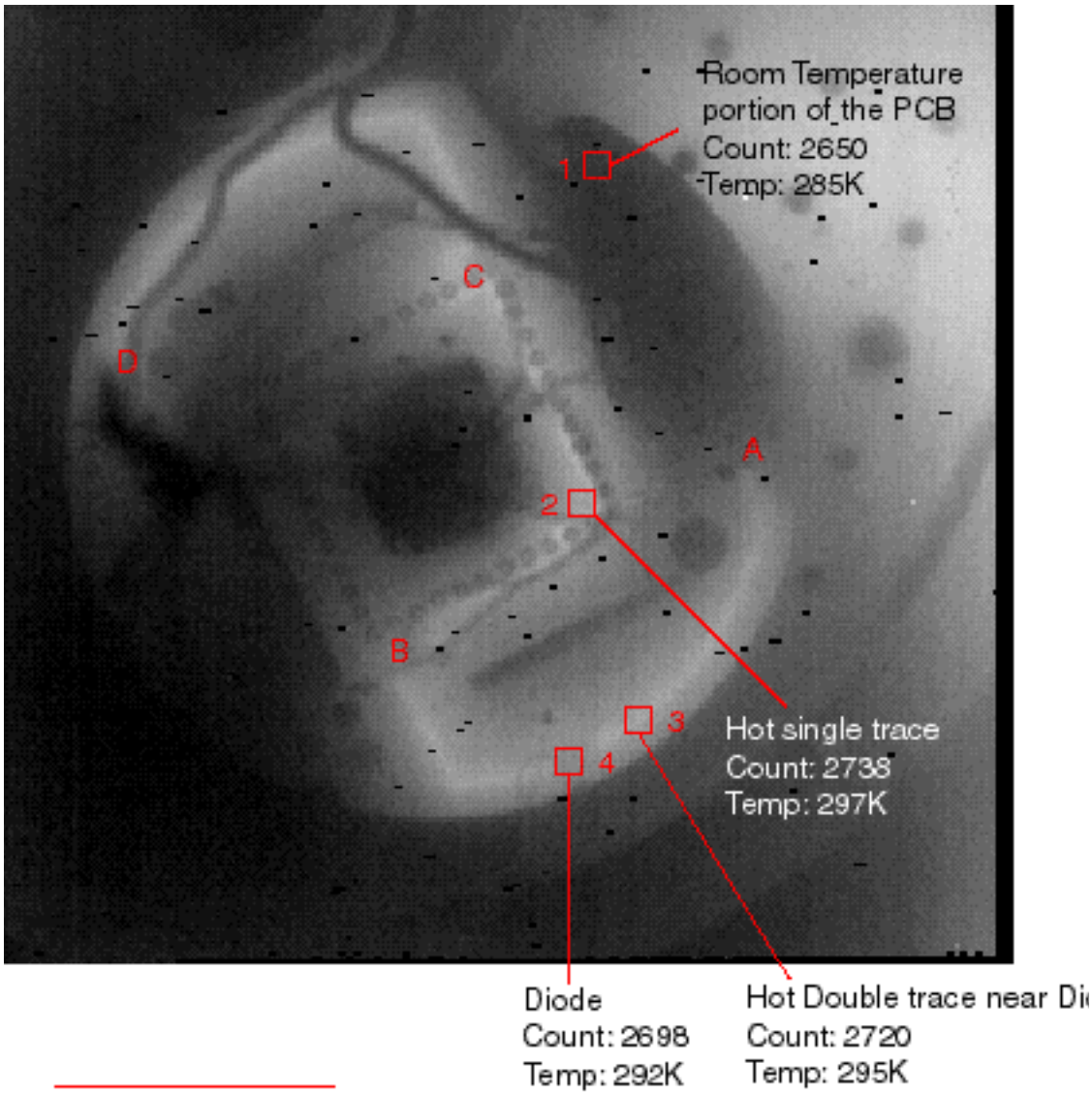

Figure 1 Thermal infrared image of prototype circuit board. Current runs from points A to D. Two traces run in parallel between points A and B and between C and D. Between points B and C is a single trace, and as expected region 2 is warmer than region 3.

Effect of Pressure

We mounted the circuit board inside a dewar that is cooled with nitrogen, and we measured the temperature of the trace with the diode. The nitrogen can was wrapped in two layers of aluminized mylar. The circuit board was held to the nitrogen can with nylon screws. The aluminized mylar layers covered the zeolite cage, but two holes were cut in the zeolite to ensure that the gas could get to the zeolite. Indium foil was sandwiched between the zeolite cage and the nitrogen can to ensure

good thermal contact between the zeolite cage and nitrogen can. The dewar was evacuated to a few milliTorr with a mechanical (Varian Tri-Scroll) pump. The pressure was further lowered with cryogenic pumping with the zeolite.

The temperature of the circuit board rises with decreasing pressure (Figure 2), presumably because conduction is reduced. For a pressure of 0.1mTorr, the temperature rise is 3 times greater than that at atmospheric pressure.

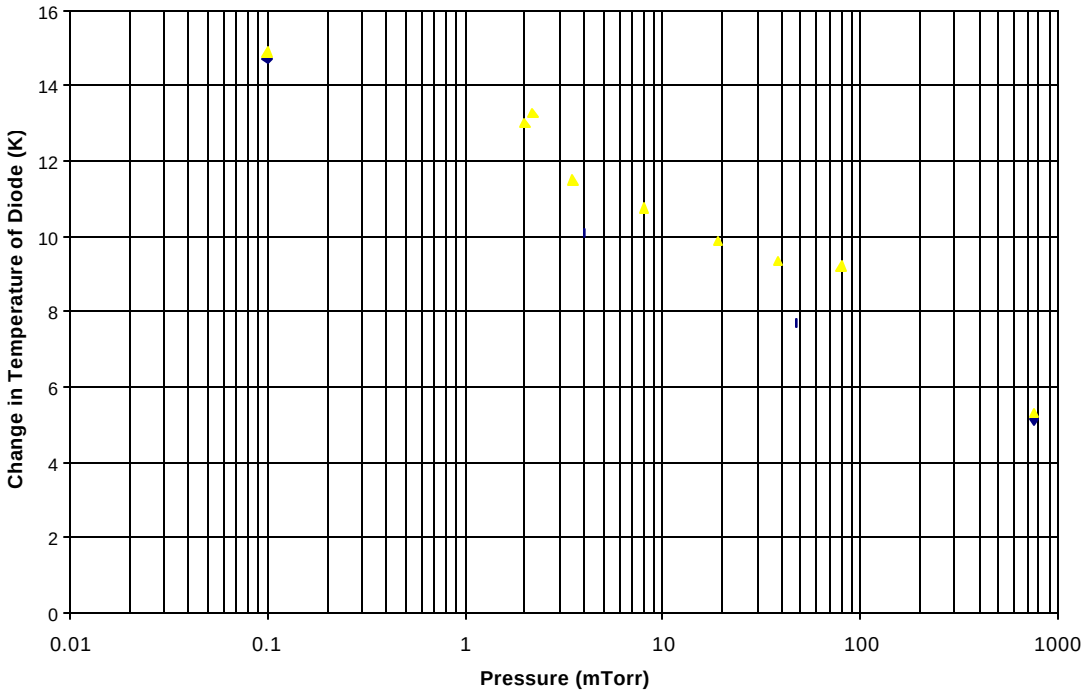

Figure 2 Heating vs pressure.

Temperature and Power

The relationship between power and temperature is linear (Figure 3).

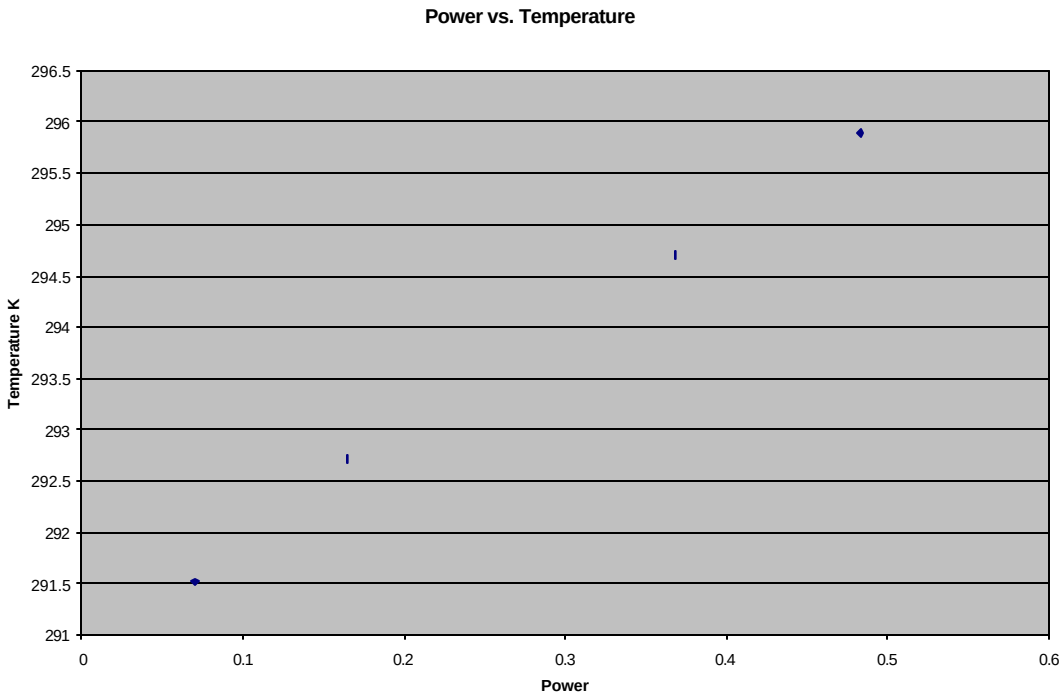

Figure 3 Power and temperature

Conclusions

The diode used to measure the temperature reduces the temperature by 30%.

The temperature of the circuit board increased linearly with respect to the power dissipated in the trace.

At a pressure of 0.1 mTorr, a 0.75-A current heats the board 21K. The board is 0.062-in FR-4 with two 5-mil wide, ½-oz copper traces.