5. Conclusions and Recommendations

The results of the dynamic electrothermal model are reviewed in this section. Suggestions for further research are also provided.

5.1 Conclusions

1. A dynamic electrothermal model of a thermocouple junction pair has been formulated which predicts the sensitivity of the nominal thermopile detector design (Figure 3.8) to be 0.0543 $\mu V/Wm^{-2}$ and its time constant to be 1.4 ms.

2. The model allows parametric studies aimed at improving the sensitivity and time response characteristics in the design of the thermocouple. The study shows that by illuminating the ramp connecting the active junction to the reference junction an improvement in the sensitivity of the instrument of seven percent may be obtained. We conclude that the new design of the thermopile linear array in its cavity should be such that the active junction and the ramp are directly illuminated by incoming radiation.

3. A parametric study has been performed with the active junction length and the ramp slope as variables. The sensitivity and time constant of the thermocouple pair are very sensitive to the active junction length. By increasing the junction length to greater than 1000 μm the design converges to a one-dimensional model with excellent sensitivity (0.278 $\mu V/Wm^{-2}$) and time

constant (7.8 ms). A relationship between the sensitivity and time constant as a function of the active junction length has been determined. This should prove to be a valuable tool to optimize the thermocouple according to the sensitivity and time constant specifications. The sensitivity of the thermocouple is less sensitive to the ramp slope and seems to be maximized for an angle of 45 deg. The time constant is essentially independent of the ramp slope.

4. For future CERES-like instruments a thermopile made of thermocouple junction pairs connected in series seems appropriate. This would maintain the nominal thermocouple size specifications (≅ 100-μm long active junction) while producing a sensitivity which increases directly as the number of thermocouple junction pairs. The pixel width would presumably be greater then 60 μm, which is the GERB specification.

5. The results of this study clearly establish that the precision with which the individual pixels of a thermopile linear-array detector must be constructed to ensure uniformity of sensitivity and time constant is much greater than previously thought.

5.2 Recommendations for futher study

1. The influence of the thermophysical properties and the thickness of the thermal resistance and absorber layers on the sensitivity of the device and its time constant should be studied in a parametric fashion.

2. A three-dimensional model should be developed to account for three-dimensional diffusion of heat through the thermocouple and also to account for heat conduction cross-talk among the adjacent elements of the array of thermopiles. The boundary conditions will be provided by the results of a ray-trace model of the cavity currently being completed by another member of the Thermal Radiation Group, Maria Cristina Sánchez.

3. A complete instrument simulation should be done by incorporating the reflective optics workbench developed by Walkup [1996] of the Thermal Radiation Group to accurately simulate illumination of the array. Such an end-to-end detector model could be used to design an optimum staring or scanning radiometric channel for the future generation of CERES-type instruments.

4. Experiments to evaluate the Peltier and Thomson coefficients of the material used in the detector should be carried out to verify the hypothesis that the Peltier and Thomson effects are negligible.

5. The effects of diffraction by the entrance slit to the cavity should be incorporated into any subsequent Monte-Carlo ray-trace model