AH11 Thermal Resistance Analysis

AH22 Included by Similarity

Introduction

Since the initial introduction of the AH11 product, more accurate Infra-Red imaging instrumentation has become available. As a part of WJ Communications' on-going monitoring of our products and processes, the thermal resistance properties of the AH11 were re-examined, and an improved estimate of the thermal resistance obtained. The procedure used and results obtained are reported in this Applications Note.

Measurements

All the measured data was taken on an Infrascope II Micro Thermal Imager. The resolution of the Imager is dependent on the Numerical Aperture, NA, of the lens as well as the emitted wavelength. Resolution is defined as FWHM = 0.5 (lambda/NA). For this calculation, an average wavelength of 4 um is used for the imaging light. The numerical aperture of the 25X lens is 0.55. This results in a physical resolution of the IR optics of 3.6 um.

In order to fully characterize the part, images and thermal resistances were determined at both nominal operating and worst case conditions. For the purpose of determining the final product thermal resistance value, defined as the difference in temperature between the ground tab and the channel divided by the applied DC power, the device was operated under conditions that resulted in maximum power dissipation. This condition has a base plate temperature of 85 ^{o}C with the part dissipating 1.62 W. Because the drain current of a MESFET falls by ten per-cent as the temperature increases from room temperature to 85 ^{o}C, 1.62 W at 85 ^{o}C is equivalent to 1.8 W at 25 ^{o}C.

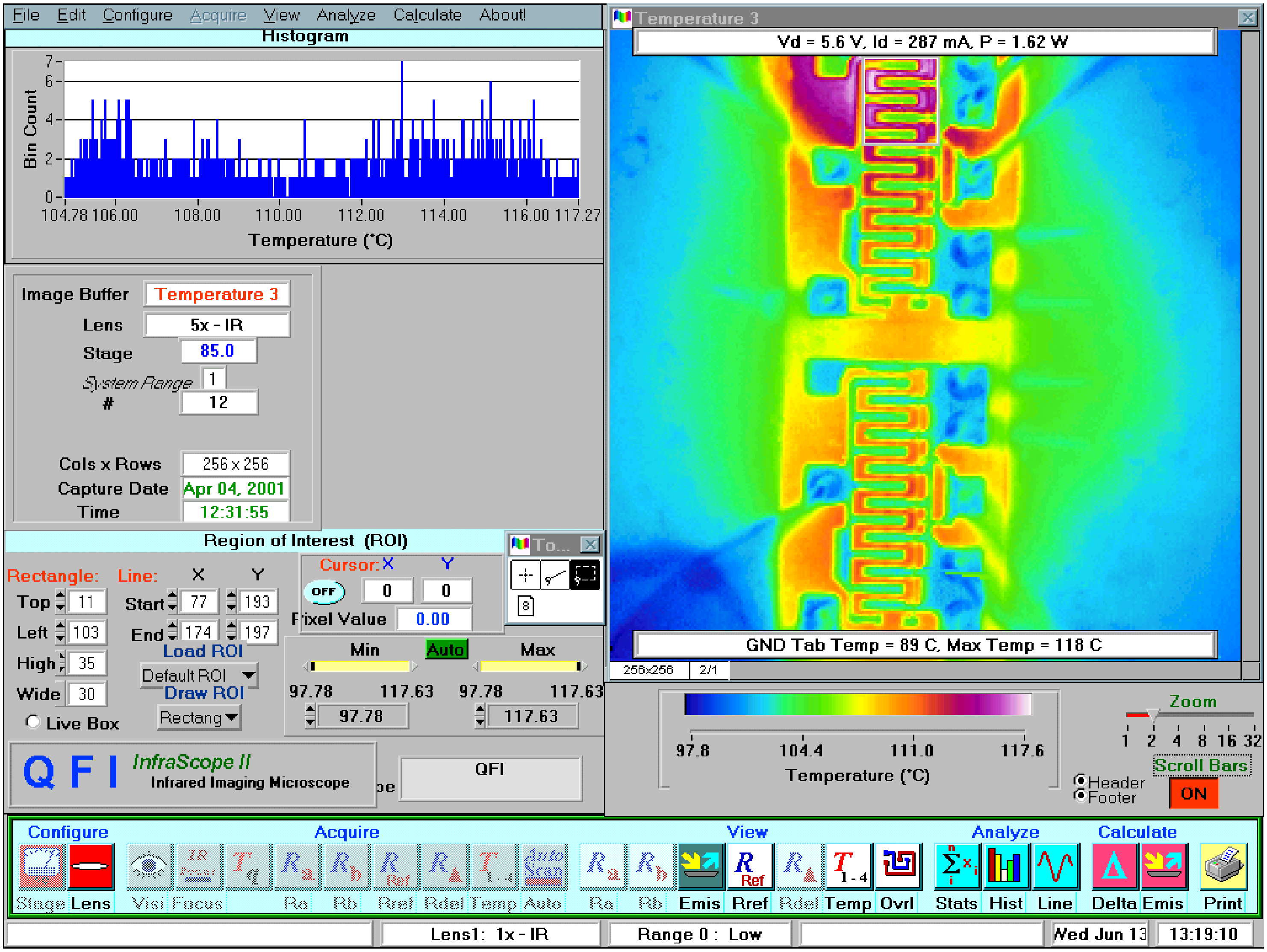
Results

During the course of the testing, two factors were recognized as affecting the accuracy of the measurement. The first is the conformal BCB coating used on the die. The second is a resolution effect that is a result of the small device features and the resolution limits of the IR optics.

Several AH1 devices were measured with and without the BCB coating in order to determine its effect. It was found that the 5 um coating acts to distort the image and cause a reading that is approximately 5 ^{o}C lower than the actual maximum device temperature. Although the AH11s were measured with a BCB coating, 5^{o}C are added to the final value to account for this effect.

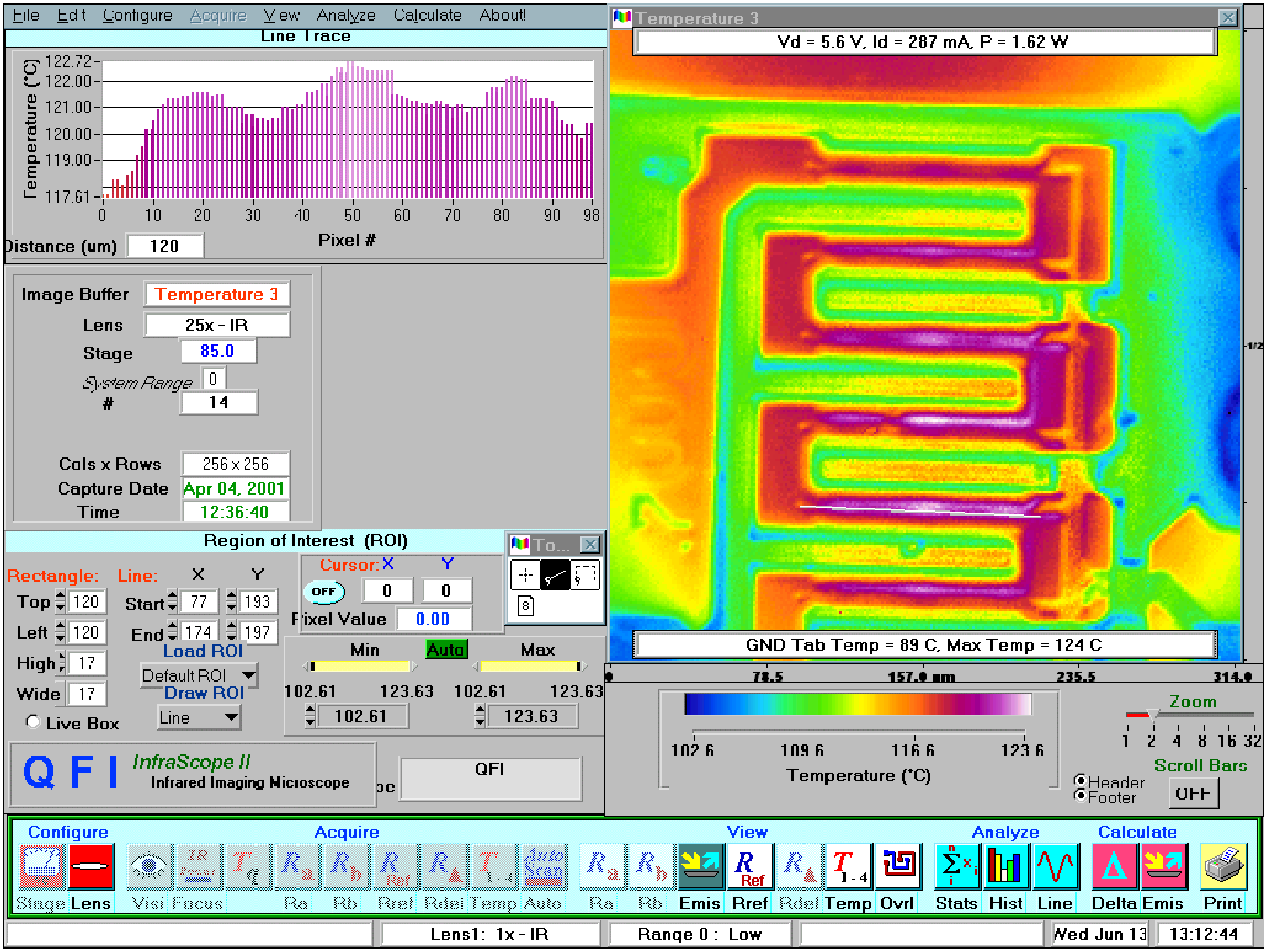
In order to account for the limited resolution of the IR optics, a modeled solution was used to account for thermal smearing effects. Devices which have features and thermal gradients that are less than the resolution of the IR optics will show an artificially low temperature due to thermal smearing. As a result, our final thermal resistance value is greater than the value determined solely from the measured data.

Figures 1 and 2 show IR images of a typical AH11 device. Figure 1 is a lower magnification image that shows the entire die. Figure 2 is a higher magnification image of the hottest section of the die. For this particular device, a Thermal Resistance Value of 21 ^{o}C/W is calculated from the measured data. With the thermal smearing and BCB corrections, the Thermal Resistance increases to 26 ^{o}C/W. As with any parameter in a semiconductor process, it is important to include the effects of process variation. To account for this, data was taken on devices from three different process lots. From the resultant data, we determined a worst case thermal resistance of 28 ^{o}C/W for the AH11.



5X Magnification

Figure 1



25X Magnification

Figure 2

Conclusions and Recommendations

Our current datasheet [6/01] for this part lists maximum operating specifications of 6 volts, 360 mA, and 85 °C case temperature. Using the thermal resistance of 43 °C/W specified therein, and correcting for the current decrease resulting from elevated case temperature, we obtain a die temperature of 1.95 Watts*43 °C/W + 85 °C = 168 °C, exceeding the allowed maximum die temperature of 155 °C by 13 °C. However, using the revised thermal resistance value obtained above (page 1), we obtain a worst-case die temperature of 139 °C, within the specifications for reliable operation. We recommend that users of the AH11 and related devices employ a worst-case thermal resistance of 28 °C/W in reliability modeling. We are in the process of updating our datasheets to reflect these new results.