AH101 Thermal Resistance Analysis

AH102 Included by Similarity

Introduction

As a part of WJ Communications' product introduction process, the thermal resistance of the AH101 packaged device was measured using infrared microscopy. 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 2.07 W. Because the drain current of a MESFET falls by ten per-cent as the temperature increases from room temperature to 85 ^{o}C, 1.86 W at 85 ^{o}C is equivalent to 2.07 W at 25 ^{o}C.

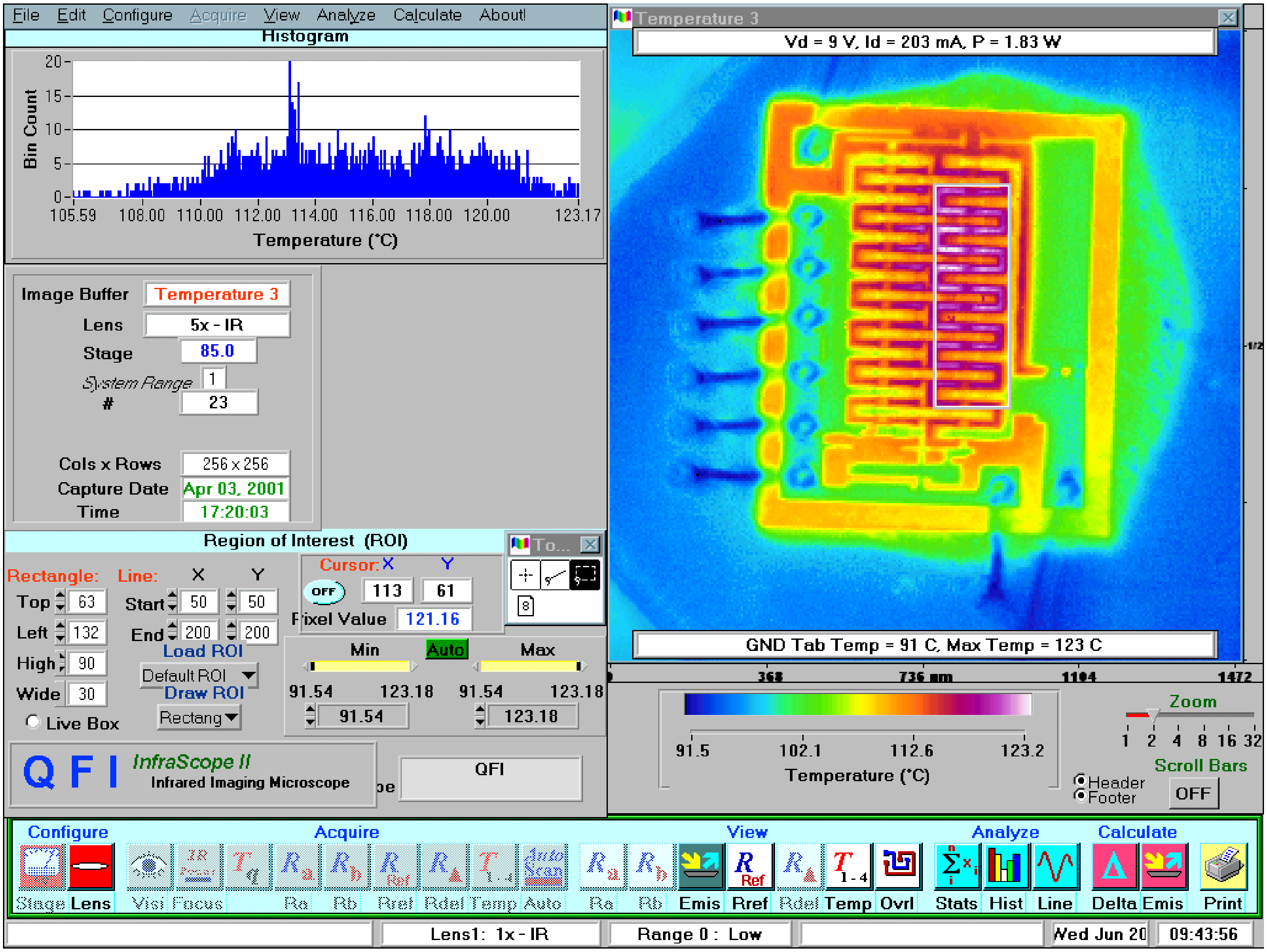
Results

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 AH101s 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.

Figure 1 shows an IR image of a typical AH101 device. Figure 1 is a lower magnification image that shows the entire die. Localized images of the hottest parts of the die were taken for the final thermal resistance analysis. For this particular device, a Thermal Resistance Value of 17.5 ^{o}C/W is calculated from the measured data. With the thermal smearing and BCB corrections and a higher resolution image, the Thermal Resistance increases to 24 ^{o}C/W. As with any parameter in a semiconductor process, it is important to include the effects of process variation. To account for variation, data was taken on devices from different process lots. From the resultant data, we determined a worst case thermal resistance of 25 ^{o}C/W for the AH101.



Vd = 9 V, Id = 203 mA, P = 1.83 W

GND Tab Temp = 91 C, Max Temp = 123 C

Image Buffer: Temperature 3
Lens: 5x - IR
Stage: 85.0
System Range #: 1 23
Cols x Rows: 256 x 256
Capture Date: Apr 03, 2001
Time: 17:20:03

Rectangle: Top 63, Left 132, High 90, Wide 30
Line: Start X 50, Y 50; End X 200, Y 200
Cursor: X 113, Y 61
Pixel Value 121.16
Min: 91.54 123.18 91.54
Max: 91.54 123.18 123.18

Lens1: 1x - IR
Range 0 : Low
Wed Jun 20 09:43:56

5X Magnification

Figure 1

Conclusions and Recommendations

Our current datasheet [6/01] for this part lists maximum operating specifications of 11 volts, 200 mA, and 85 ^{o}C case temperature. Using the thermal resistance of 25 ^{o}C/W specified above, and correcting for the decrease in current resulting from the elevated case temperature, we obtain a die temperature under this worst-case condition of 2 W * 25 ^{o}C/W + 85 ^{o}C = 134 ^{o}C, well below the maximum allowable die temperature of 155 ^{o}C. We conclude that the AH101 should be highly reliable when used within the maximum allowable DC operating conditions specified on the datasheet.