Socket Testing Protocol Summary

1 Introduction

In order to achieve accurate results on socket sample surfaces, a unique test protocol is required. The goal of this test protocol is to specify important test parameters and specifically, analysis methods, that will define a realistic surface shape for the PCB side of a socket without solder balls or pins. While, the test methods described are for sockets with no pins and balls, testing sockets with pins may also be possible with the same techniques as described in this document. Testing with solder balls attached is not considered feasible with the shadow moiré technique.

The testing methods described in this document are unique to socket testing applications. Users referencing this document should also be familiar with Akrometrix recommend best practices for more general testing applications. The “Die and Package Testing Protocol/Best Practices” white paper should be reviewed if not already familiar.

2 Hardware

An Akrometrix TherMoiré AXP or PS400 w/ Studio Upgrade is required for optimal surface characterization. In addition, a 200 line per inch (LPI) grating along with a zoom lens will also be required for socket testing. All efforts should be made to keep zoom levels consistent between tests. Zoom level will be particularly important if masks are reused for the same form factors.

3 Sample Characteristics

Most sockets provide a continuous surface in between the holes provided for pins and sockets. However, these continuous areas are typically quite thin and thus provide a unique challenge for the shadow moiré technique. These tight constraints on data density are the main reason that the Akrometrix Studio software and 200 LPI grating will be required for socket testing. Additionally, zoom levels should be set as high as possible without grating line aliasing/resolution, to better handle the thin surface areas.

A highly diffuse reflective surface will be a requirement for the challenges of socket testing. For this reason all sockets should be fully coated with high temperature white spray paint before testing. Akrometrix uses and recommends Rust-Oleum™ Specialty High Heat white enamel spray paint.

4 Sample Placement

A thin piece of high temperature glass is the recommended sample support method for socket testing. Akrometrix commonly uses 150 x 150 x 0.7 mm aluminosilicate glass for socket support during thermal testing. This piece can be placed on the standard sample support structure of an Akrometrix AXP or Studio PS400. Keep in mind that the sample supports should hold the glass piece near the edges of the glass to avoid “shadowing” the sample from the provide IR radiation of the oven.

Recommended vertical positioning of the socket is approximately 50 mils from sample contact with the 200 LPI grating. This is easily within the working distance of the 200

LPI grating and should provide enough room for sample warpage as well as sample support warpage over a thermal cycle.

5 Thermocouple Placement

Using a "dummy" sample for thermal readings is highly recommended for socket testing. This dummy sample should match the sample type currently under warpage testing. It is best to place the driving thermocouple on the bottom center of the sample. This area will receive the most IR energy and highest heating rates. All other points will typically be at the same temperature or lower during heating. Try to keep the dummy sample as flush with the sample support glass as possible. Because there will be a thermocouple on the bottom of the dummy sample, this may try to lift the sample upward. To counter this effect, the dummy sample should be taped down to the glass securely. See Figure 1 and Figure 2 for an example.

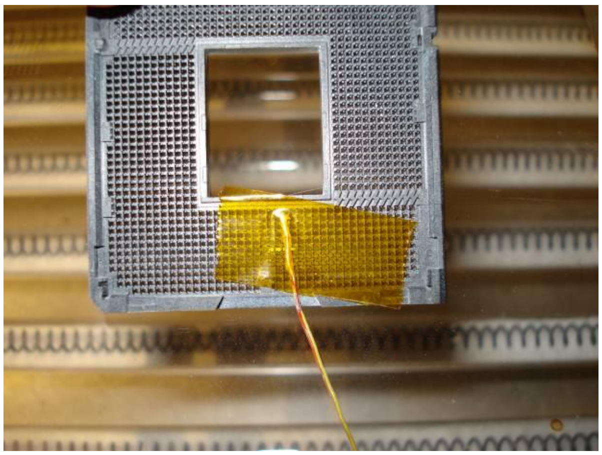

Figure 1. Thermocouple Attached to Dummy

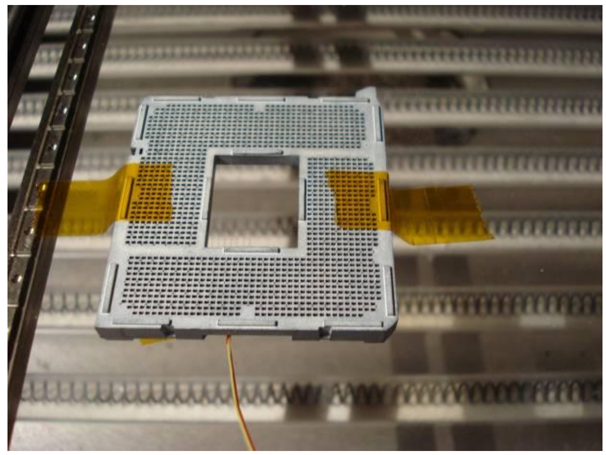

Figure 2. Dummy Sample Taped to Glass

Due to the porous nature of socket sample surfaces, thermocouples should be attached using some sort of high temperature thermally conductive epoxy when available. Alternatively, thermal grease and Kapton tape® can be used but will be much more challenging due to the limited surface area for the tape to adhere to.

6 Data Acquisition

For testing sockets, Akrometrix recommends capturing data such that the sample image is in focus. No blurring should be done on the image to average out step heights. In addition, the sample should be placed within 50 mils or 1270 µm of the recommended 200 LPI grating.

- **Phase Amplitude Threshold:** Phase amplitude threshold should be used to mask out the pin holes in sockets. Recommended phase amplitude threshold values will vary depending on sample to grating distance and fringe contrast, but typical values range from 5 - 20. See and Figure 3 and Figure 4 for examples of what different phase amplitude values result in. Notice how the higher phase amplitude setting results in more data removed from the phase image.

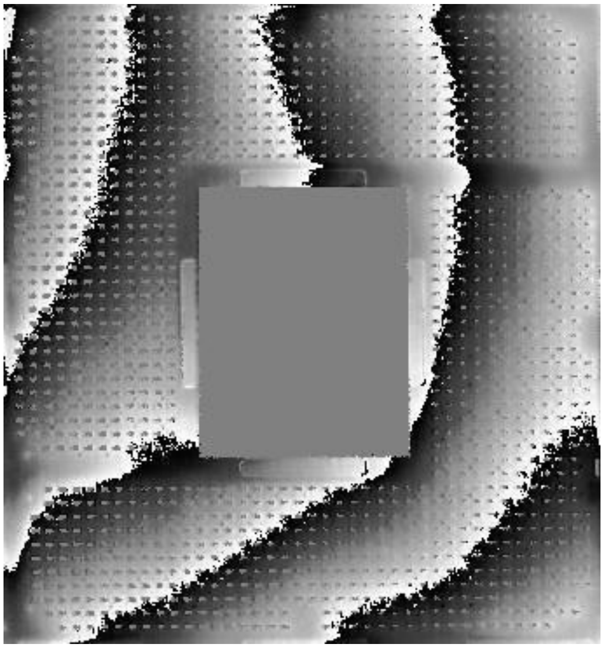

Figure 3. Phase Amplitude = 3

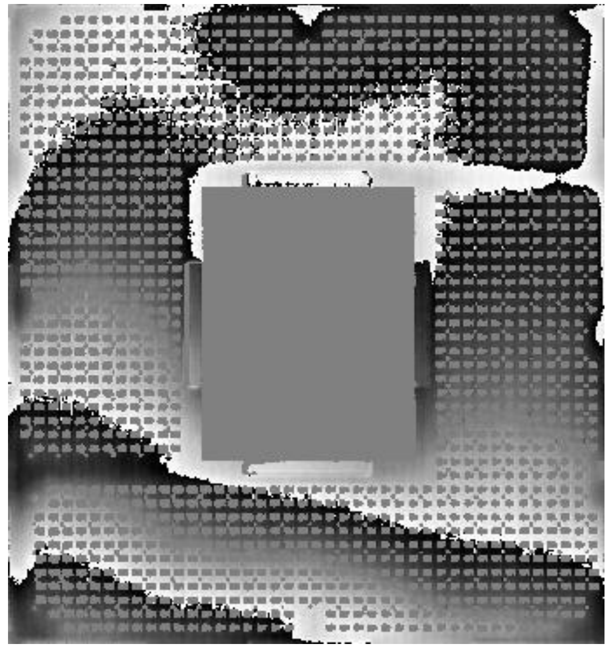

Figure 4. Phase Amplitude = 22

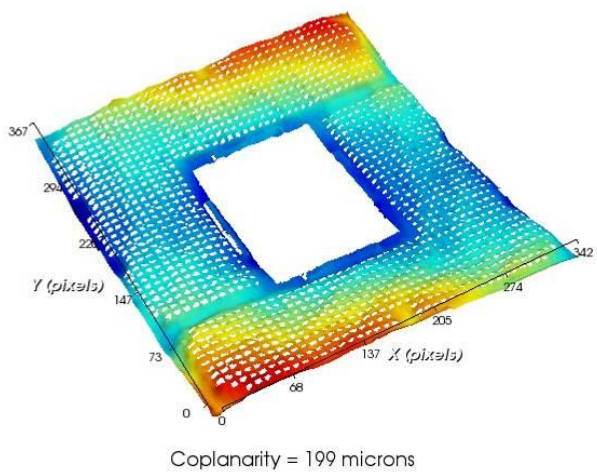

Figure 5. Phase Amplitude = 3 Result

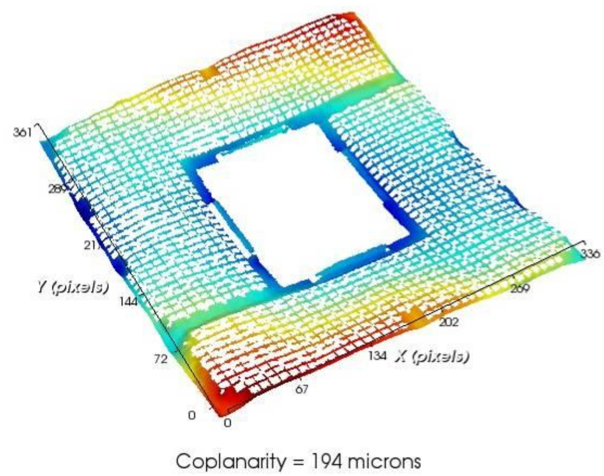

Figure 6. Phase Amplitude = 22 Result

- **Thermal Runs w/ Phase Amplitude Thresholding:** For samples that exhibit excessive out-gassing during thermal cycles, lower phase amplitude threshold values should be used to keep more data. Higher values introduce the possibility of losing good data on the sample surface, while lower values may not effectively mask the holes. Akrometrix Studio tracks the phase amplitude threshold used on any given phase image. Different samples may need to use different phase amplitude thresholds, but the same form factors should always be tested with the same phase amplitude thresholds. See the Figures below for an example thermal run performed on a socket with a Phase Amplitude of 8. Notice how valid data is removed due to sample outgassing at the 209°C heating image. This is where a balance must be struck using a phase amplitude threshold that is high enough to remove invalid data (holes), yet leave valid data.

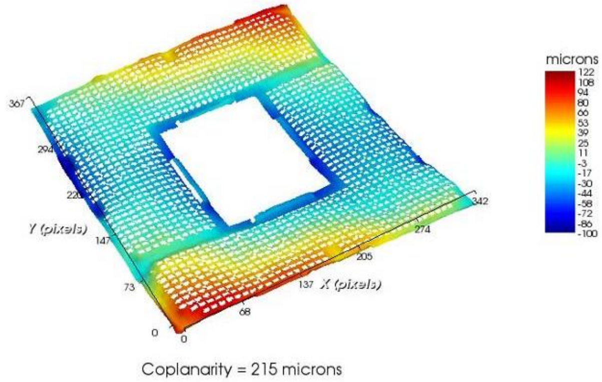

Figure 7. 24°C Initial

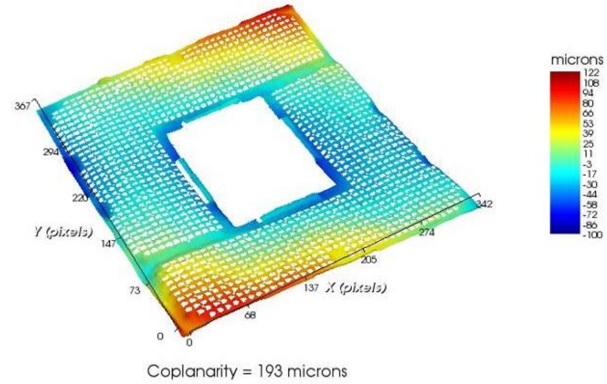

Figure 8. 98°C Heating

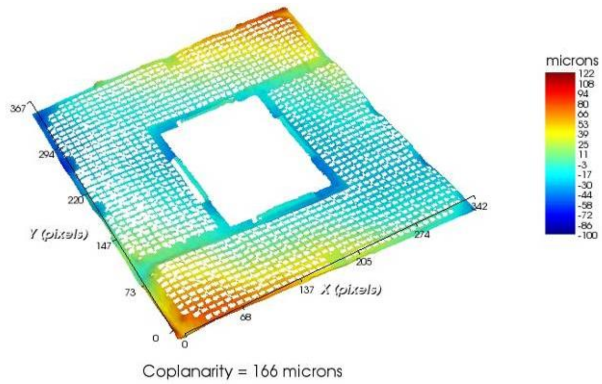

Figure 9. 171°C Heating

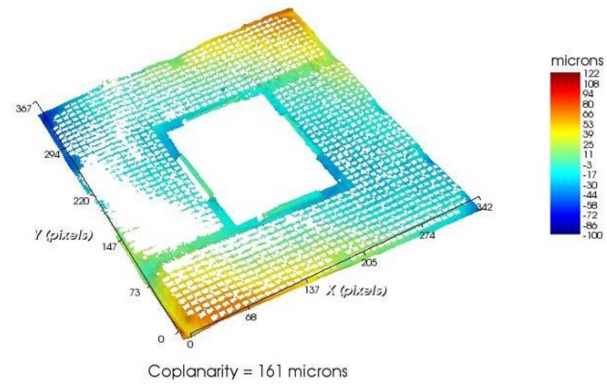

Figure 10. 209°C Heating

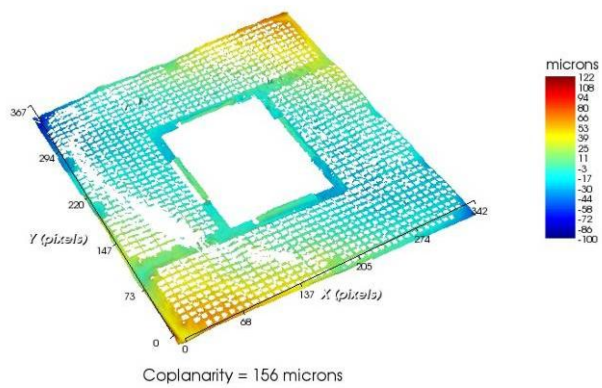

Figure 11. 233°C Maximum

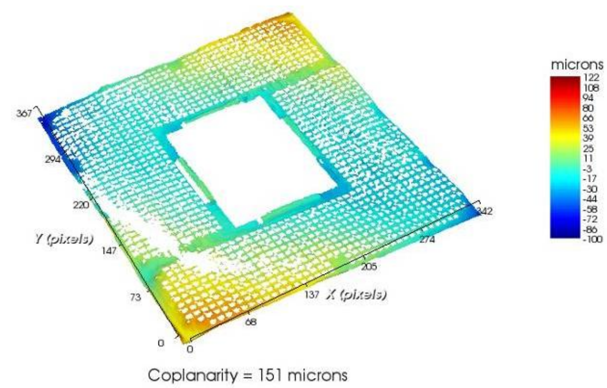

Figure 12. 209°C Cooling

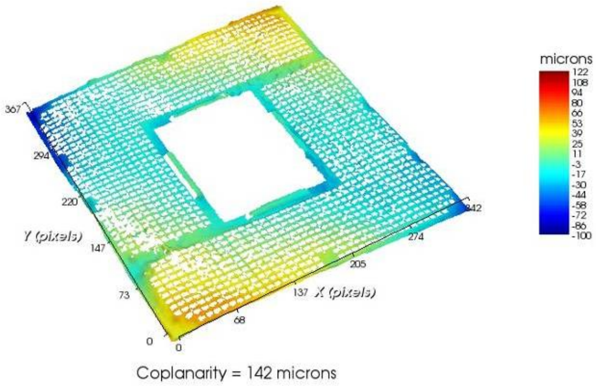

Figure 13. 173°C Cooling

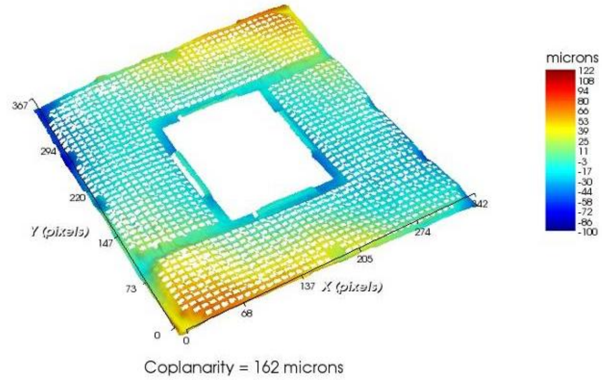

Figure 14. 104°C Cooling

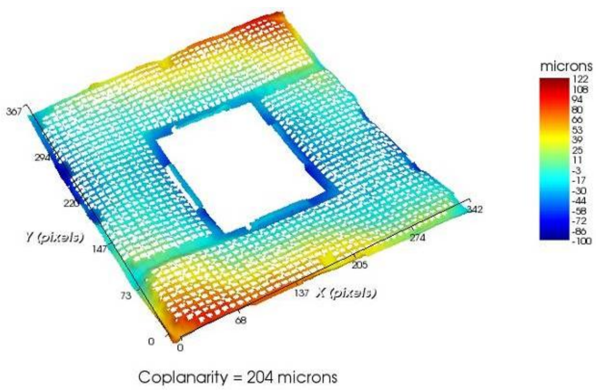

Figure 15. 26°C Final

- **Thermal Runs w/o Phase Amplitude Thresholding:** A highly recommended test method is to run socket tests with Phase Amplitude Thresholding turned off or set very low during thermal runs. A high Phase Amplitude Threshold room temperature image is taken manually before the thermal run and is used to create a mask file. Before starting the thermal run, Phase Amplitude Threshold is turned off. This process is further described in section 7 "Data Analysis" under "Create a Mask from a High Phase Amplitude Threshold Image".
- **Regions of Interest (ROI):** ROI selection in sockets is not terribly critical given that their final ROI is typically well inset from the actual extents of the part. Typically, an ROI should be chosen that coincides with the actual ROI (pinned area). In some cases, however, the sample will move laterally inside the heating chamber. In these cases ROI selection can be selected well outside the final ROI and cropped more carefully in post processing.

7 Data Analysis

The key to measuring sockets is in masking out all the holes that exist in the sample surface. These holes can be effectively and automatically masked by the Phase Amplitude Threshold function at data acquisition for some applications. However, the end result of this process can vary from one thermal run to the next depending on socket outgassing and image noise. For more consistent results alternative masking techniques should be used as described in the following procedures. In general, creating a mask from a high phase amplitude threshold image will be the preferred technique for socket testing, and this will be complimented by manual masking of any standoffs.

- **Manual Masking:** In all cases, standoffs on the socket surface should be manually masked out since these will not be removed by the Phase Amplitude Threshold function. In addition, the holes in the socket surface can be manually masked out in approximately 10 to 15 minutes. Every single hole does not need to be masked out; instead, rows of holes can be covered up with mask while still leaving strips of valid data behind. This is not the preferred technique. See Figure 16 below.

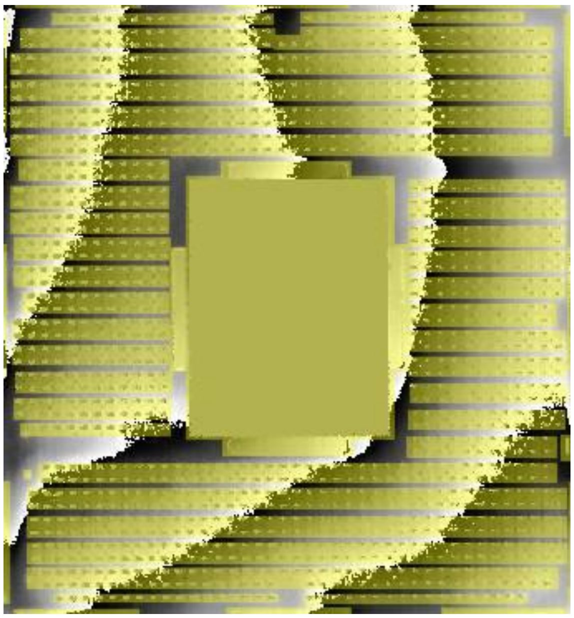

Figure 16. Manually Masked Socket Phase Image

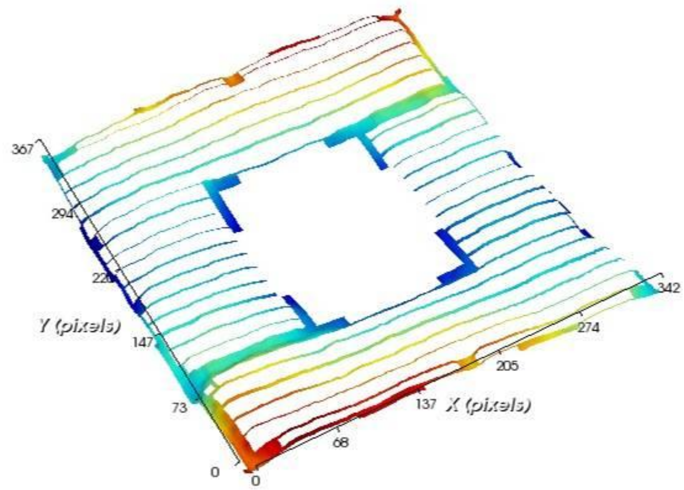

Figure 17. Manually Masked Socket Phase Image 3D Result

- **Create a Mask from a High Phase Amplitude Threshold Image:** If a high phase amplitude threshold cannot be used due to sample outgassing, a sample mask can be created by taking one phase image before the thermal profile is started with a high phase amplitude threshold. Then, the thermal profile can be run with low or no phase amplitude threshold. The high phase amplitude threshold phase image can then be used to make a mask which can be applied to the thermal profile data. The procedure for doing so is as follows.

    1. Save the high phase amplitude threshold image as a bitmap file, as shown in Figure 18.

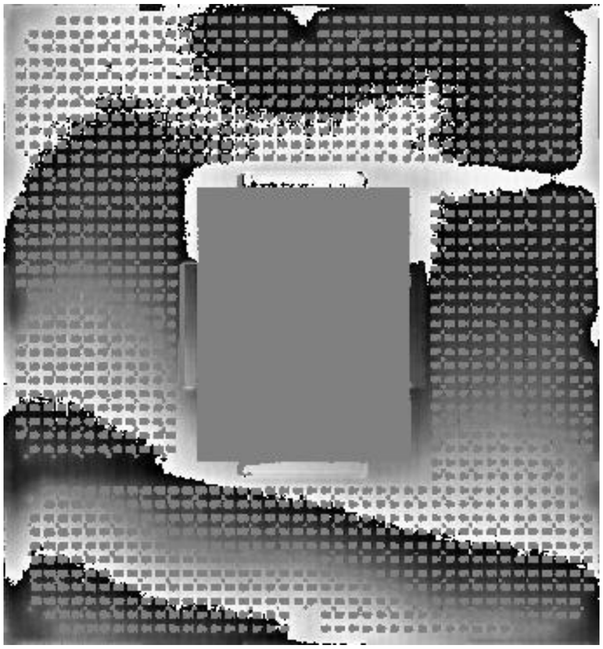

Figure 18. High Phase Amplitude Threshold Phase Image

2. Using a 3rd party image processing software, select all areas including the 128 bit gray-scale mask shade. This tool is commonly referred to as a "color picker". Be sure to select only the 128 bit grayscale value as this is the only value reserved for mask in the entire 0 to 255 grayscale range.
3. Paint all of these areas black, as in Figure 19.

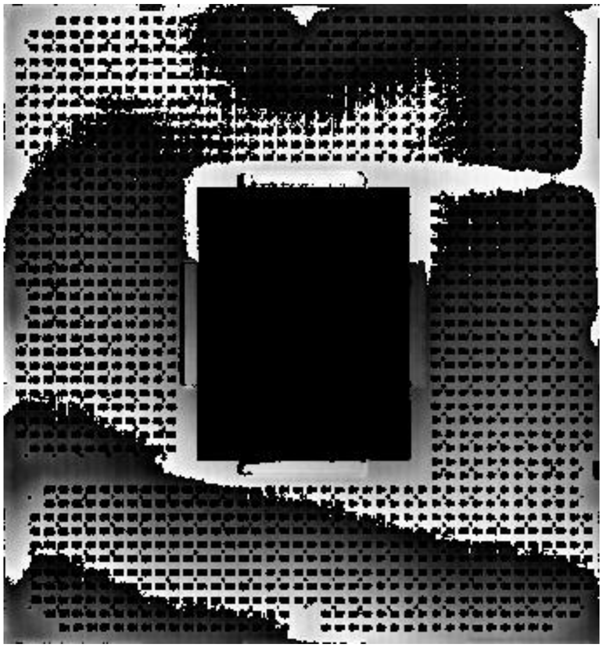

Figure 19. Masked Areas Selected and Painted Black

4. Select the inverse of these areas and paint the rest of the image white. This image can be saved as a mask (*.bmp) file. A typical mask file created in this fashion is shown in Figure 20.

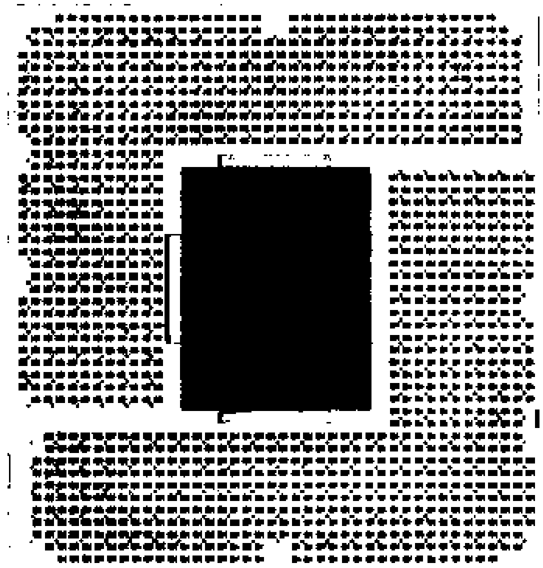

Figure 20. Mask Created from Phase Image

5. Apply this mask file to the data from the thermal run to eliminate data in the pin holes.
6. An additional manual mask will typically be required as well to eliminate standoff areas from the 3D result. The step heights for standoffs cannot be accurately measured using the shadow moiré technique. The phase image with masks created as described above is shown in Figure 21.

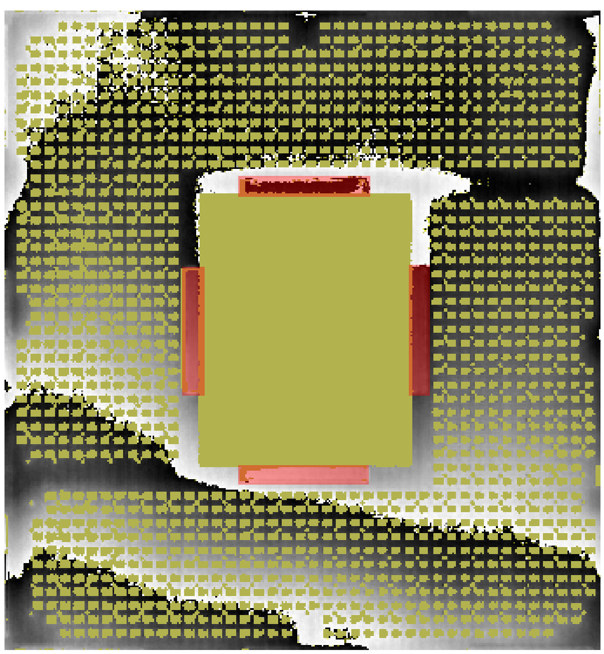

Figure 21. Final Masked Phase Image

This procedure requires precise alignment of the phase images that were captured during the thermal profile. If there is even 1 or 2 pixels of translation, this procedure is likely to cause noise spikes in the 3D data due to incomplete hole masking.

- **Sample Data Set:** Below is a series of images showing the 3D result using the technique described above. As you can see, the hole masking is more consistent in this case due to the fact that sample outgassing has been removed as a variable.

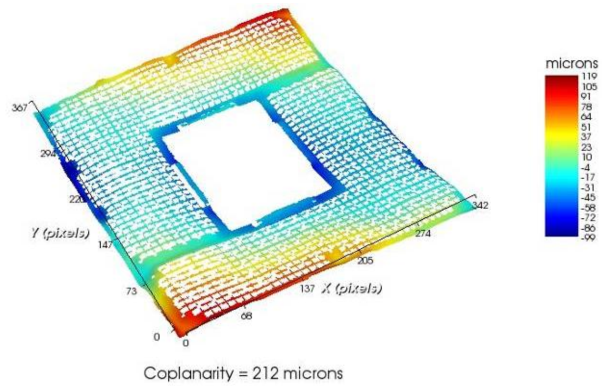

Figure 22. 24°C Initial

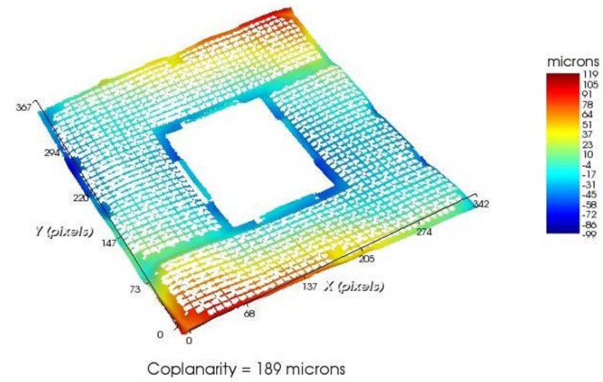

Figure 23. 98°C Heating

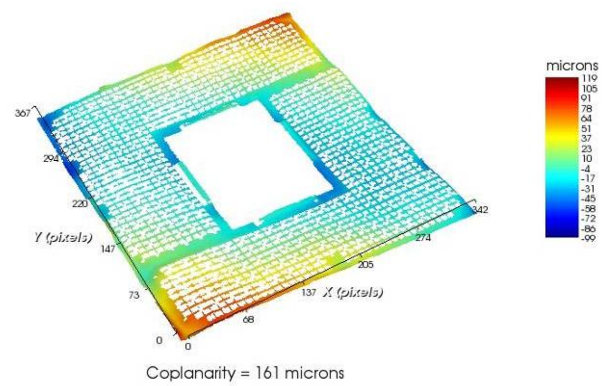

Figure 24. 171°C Heating

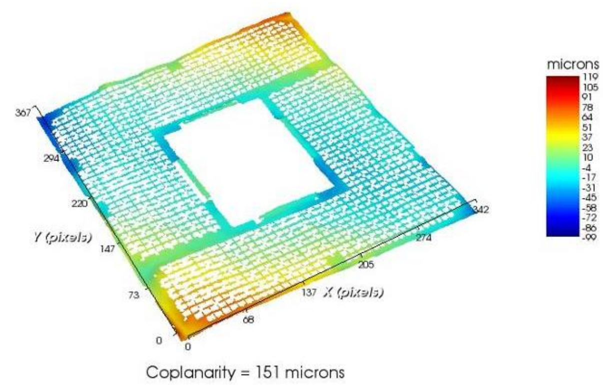

Figure 25. 209°C Heating

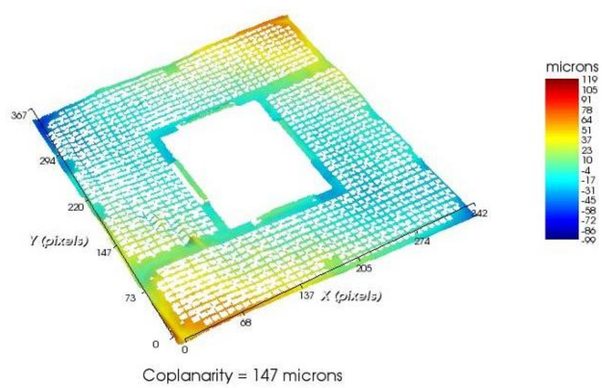

Figure 26. 233°C Maximum

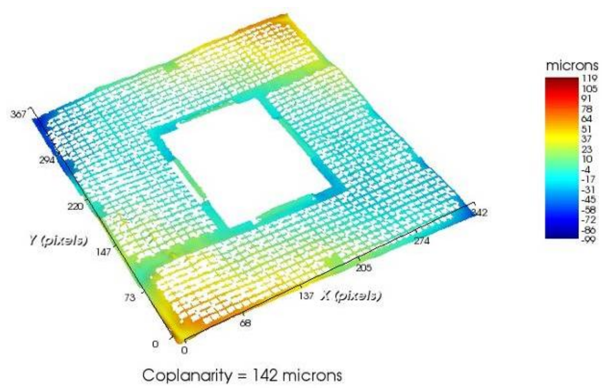

Figure 27. 209°C Cooling

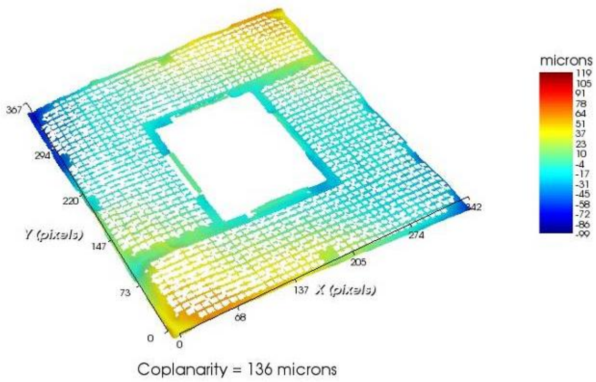

Figure 28. 173°C Cooling

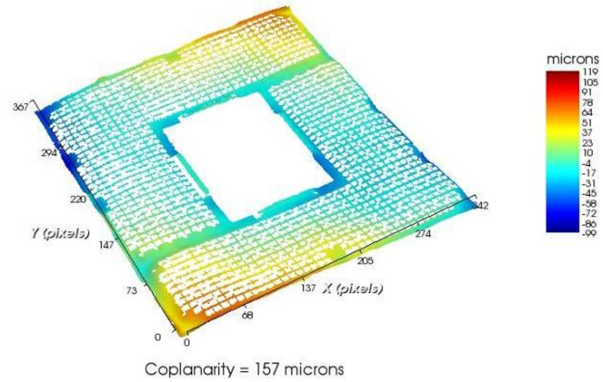

Figure 29. 104°C Cooling

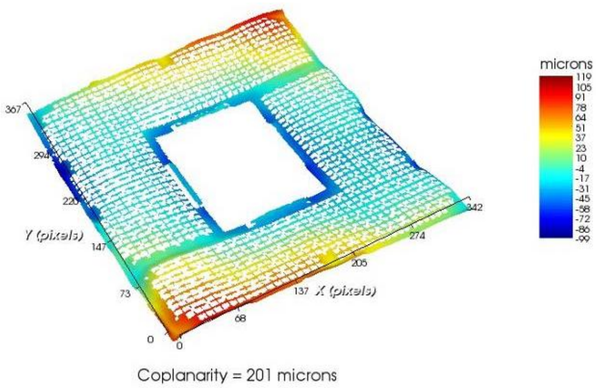

Figure 30. 26°C Cooling

- **Data Comparison:** Table 1 shows a comparison between the data captured using purely automatic phase amplitude thresholding, and data that was masked using a room temperature phase image captured with a high phase amplitude threshold. There is not much difference between the two. In this case, the extra data that was removed by the high phase amplitude room temperature mask resulted in no more than 10 microns difference compared to the other method.

Table 1. Data Comparison

			Coplanarity (µm)	
Sample Name	Time (s)	Temperature(°C)	PA = 8	PA Mask
Socket Sample	0001	24	215	212
	0199	98	193	189
	0562	171	166	161
	0815	209	161	151
	1045	233	156	147
	1155	209	151	142
	1315	173	142	136
	1566	104	162	157
	2500	26	204	201

8 Summary

Previous Akrometrix application knowledge and system capabilities did not lend themselves to effective socket surface measurement. While techniques based on blurred surfaces did provide a reasonable surface shape approximation, they had intrinsic error associated with the blurring method.

With the development of the Studio software, a higher resolution camera, and a 200 LPI grating, getting real data from socket surfaces is now a reality. This document presents two effective testing and analysis methods for realistic socket flatness measurement over temperature. Creating mask files from room temperature phase amplitude threshold images is a reliable technique for masking of socket "holes". Additionally, using phase amplitude threshold throughout a thermal profile is an easy, though less repeatable, way to exclude socket "holes" from the data set.