<u>Lead Free Solder and Potential Effect on X-ray Imaging</u>

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Introduction:

As the electronics industry is forced to eliminate lead from PCB, there is an increasing challenge to create new environmentally friendly solder. The new lead free solder comes with new challenges. Increased material costs, higher melting points, and manufacturing process changes are just some of the challenges that the industry faces. To assist with the control of these changes, X-ray imaging will become a valuable tool on the manufacturing line.

X-ray imaging will be used in the manufacturing line to analyze new lead free solder joints, characterizing good joints, and monitor the assembly process. With the ability to analysis joints on PCB's coming from the manufacturing line, a user can monitor quality and make needed changes to upstream processes. These upstream processes can vary from oven temperature to solder paste distribution. This type of process monitoring as industry changes solder alloys will become vital to increasing process yield.

Concerns may arise on the effectiveness of X-ray imaging on lead free solder. To alleviate these concerns, this paper will look at some of the popular lead free solder alloys using the HP5DX and profile several different joint types. The paper will discuss briefly how attenuation of these joints is similar. The main focus will be on comparing eutectic solder with the Tin, Silver, Copper (Sn, Ag, Cu) solder alloy, and examine defects that occur in solder. This study will demonstrate the effectiveness of the HP5DX and X-ray imaging on lead free solder alloys.

X-ray Imaging:

The HP 5DX was chosen for this study to analyze the lead free boards to gain a better understanding on how in-line automated process testing using X-ray imaging will be effected, and how the HP5DX may be used to study solder joint characteristics and monitor results of upstream process.

The X-ray imaging uses digital cross-sectional X-ray images and generates analysis results that include a complete quantitative description of each joint, as well as a list of all defective solder connections found. The cross-sectional images are gray-scale, with 256 gray levels. Each joint description has information containing relative solder thickness and solder distribution. Special solder thickness tables are generated to relate the digital gray level to a specified solder thickness. A user then defines parameters within various algorithms that will search and call out solder defects.

X-ray Imaging looks at several points of a joint, lead contact, solder distribution around the lead, and solder volume. For a gullwing, we are interested in the Center, Heel, Toe, and surrounding solder distribution. The following figure shows were the each point of region is located on the joint.

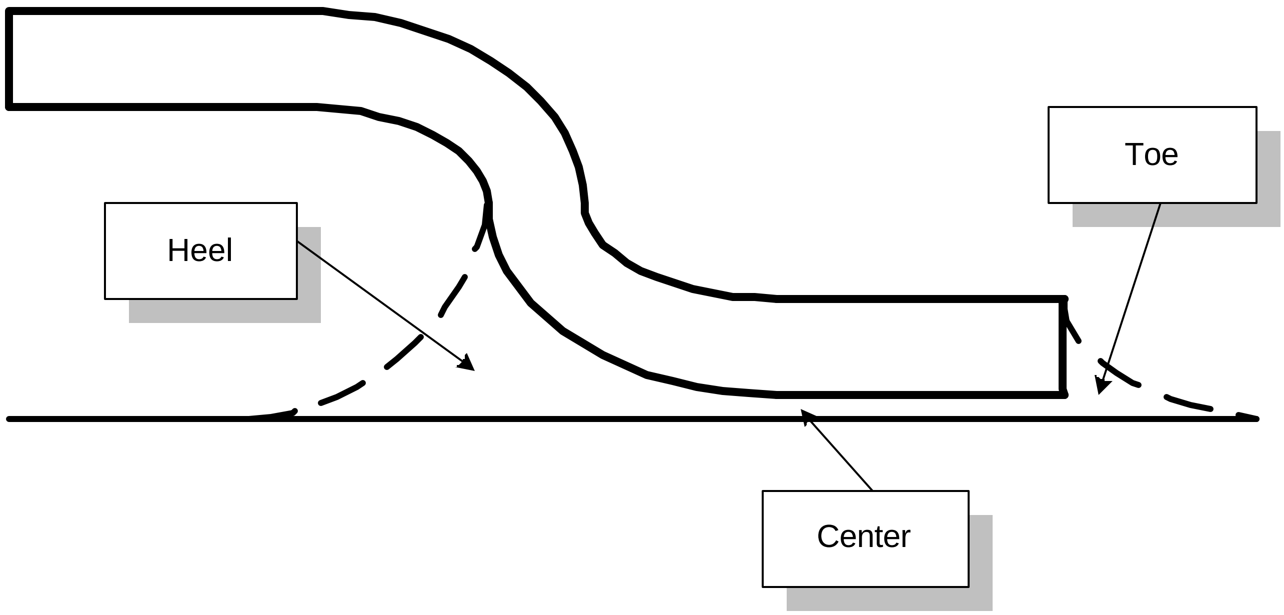

Figure:
Gullwing Joint showing the 3 important areas

When the gullwing joint is analyzed under X-rays, we get the following image.

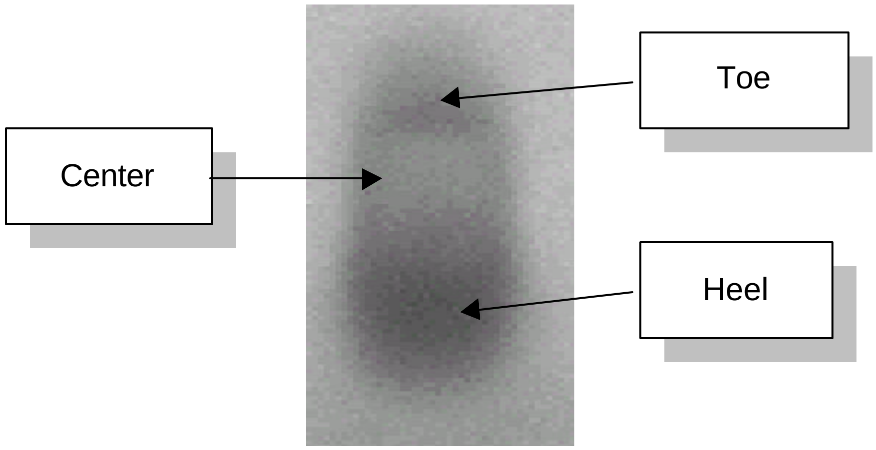

Figure:
Gullwing joint as seen by the 5DX

First, the three regions are analyzed using a thickness table that relates thickness to the gray scale value (0 to 256). These values are then compared to user-defined thresholds looking for excessive or insufficient amounts of solder. The values are then used to calculate missing/open joints or possible voids. The edges are then analyzed looking for shorts or bridges. Once a joint is flagged for being a bad joint, the measurement and defect information is then sent to a file. A user then uses software to read these files and repair the bad joints.

Lead Free vs. Eutectic Solder:

First, Alpha Metals supplied a series of boards containing a solder alloy of 95% Tin (Sn), 4.5% Silver(Ag), and .5% Copper(Cu) with an immersion Ag board coating. The boards contain a BGA, 6 leaded devices, and 108 discrete devices (resistor and capacitors).

Although the solder is lead free, components still have a lead (Pb) finish on the leads. This causes little contamination for the solder. As seen in the following figure[1], lead contamination from a component lead accounts for only 5% of the total lead found in a solder joint[1].

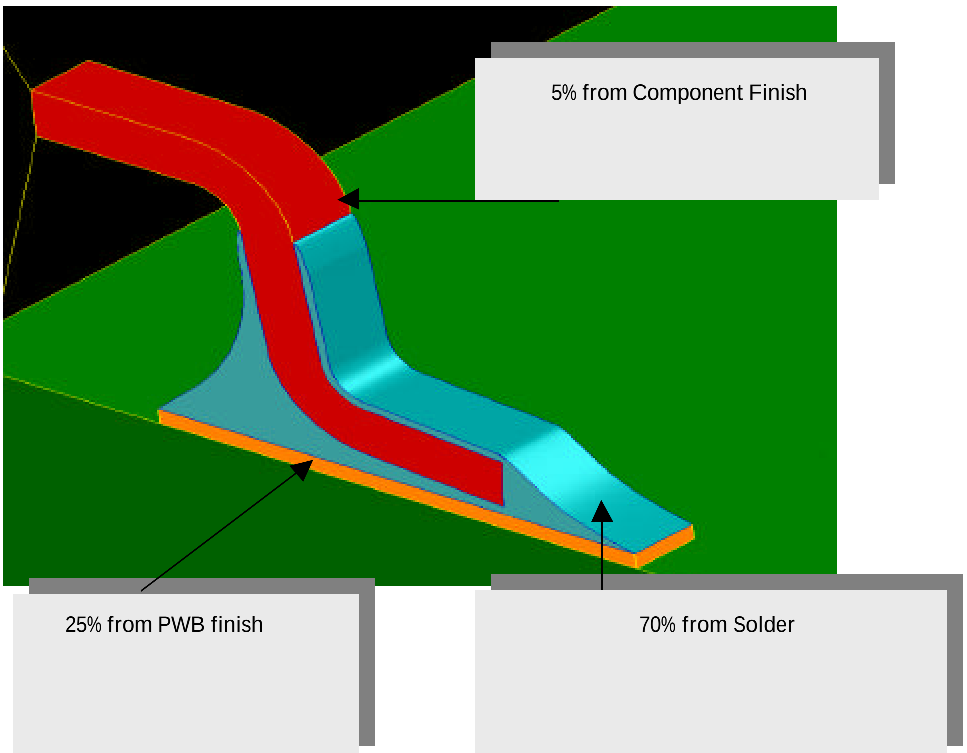

Figure:
Lead Composition.

We first compared gullwing joint with the 95Sn4.5Ag.5Cu solder compared to 60Sn40Pb eutectic solder. We took several boards with the eutectic solder and examined the images under the X-ray. Then the same process was done with five of the lead free solder boards. The following figures, no visual discrepancy between a lead free joint and a eutectic solder joint.

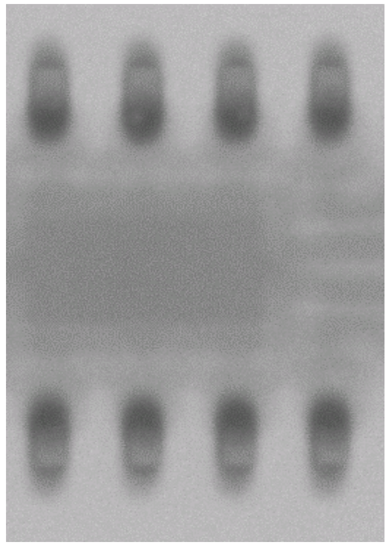

Figure:
Gullwing Joints with Eutectic Solder

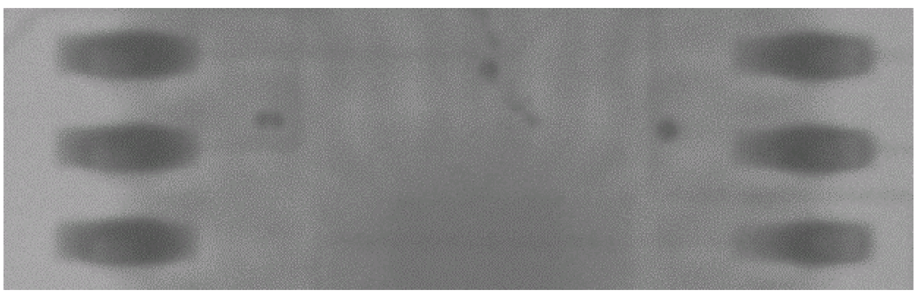

Figure:
Gullwing Joints with SnAgCu Solder

We also examined the profiles of these joints and found that the joint profiles were nearly identical. Once again we ran five lead free solder boards through and found little difference in the profiles. The following figures show the profiles of the eutectic solder and the profile of the lead free joint.

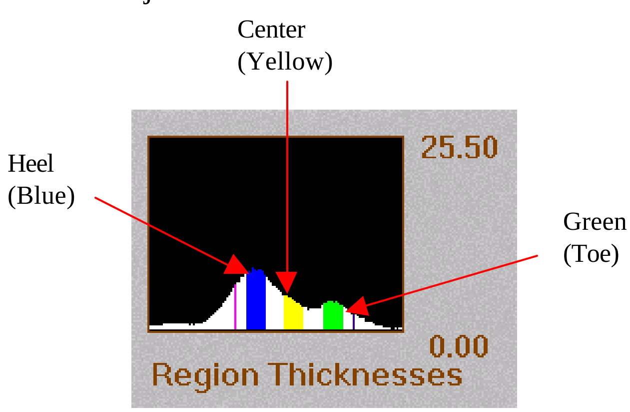

Figure:
Eutectic Solder Gullwing Joint

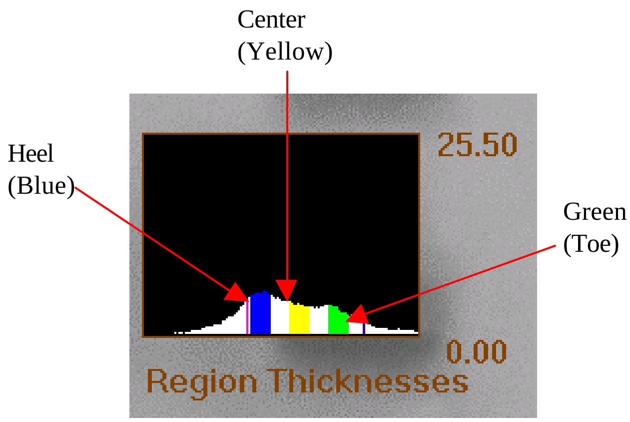

Figure:
SnAgCu Solder Gullwing Joint

Conclusion:

Through our initial study, we were able to analyze Tin, Silver, Copper solder alloy and conclude that X-ray imaging is a viable technique for testing these new solder alloys. This initial study looked at the gullwing solder joint and compared the eutectic solder to the lead free solder. We were able to examine both the X-ray profile and the image quality itself and saw no difference in image quality. We will continue the study and examine BGA, Jlead, and discrete packages and report these findings in the future.