The Study of the Hot Bar for Reflow Process in Interconnection of Head Stack Assembly

Joompondej Bamrungwongtaree[1], Pattaraweerin Woraratsoontorn[2]

[1] Department of Information Technology
Bangkok Suvarnabhumi University
Bangkok, Thailand
joompondej@gmail.com
[2]Department of Industrial Physics and Medical Instrumentation
King Mongkut's University of Technology North Bangkok
Bangkok, Thailand
oaw2520@hotmail.com

Abstract—The interconnection bonding process of hard disk drive, soldering process is normally used. However this process still found the defects and electrical short circuit, leads to parts rejection. The major problem caused parts rejection that is incomplete in soldering process. The aim of this study is to study and optimize the hot bar, improvement of heat transfer, using finite element method to control the hottest area and uniformity of the heat distribution at the hot bar on the reflow area. The reflow interconnection is a connection between the head gimbal assembly and the actuator arm in hard disk drive. The results from visual inspection, peel test and electrical test revealed that defects has been reduced from 1.2% to 0.3%. In conclusion, the optimization of the hottest area for the hot bar in reflow process must be done to reduce the defection after lap bonding reflow process.

Keywords-reflow; interconnection; finite element; hotbar

I. INTRODUCTION

Techniques for bonding the TGA (Trace Gimbal Assembly) tail to PCCA currently use lap bonding with the hot bar iron in reflow process. Current design of the hot bar is used for bonding one header at a time. The major problem caused parts rejection that is incomplete in reflow soldering process. After investigation found that the hottest area cannot control and is not uniform. The interconnection reflow process can be shown in figure 1.

The general defects after reflow process by using lap bonding are incomplete, burn pad and low peel strength. Incomplete resulted from insufficient heat transfer from the hot bar to TGA pad (flying lead) and solder pad even though attempt to adjust and optimization the reflow machine. Burn pad resulted from hot bar reflow touch with polyamide which leads to low peel strength value. The electrical current passed through the hot bar and then generated the number of heat at the small area where interconnection between TGA and arm actuator.

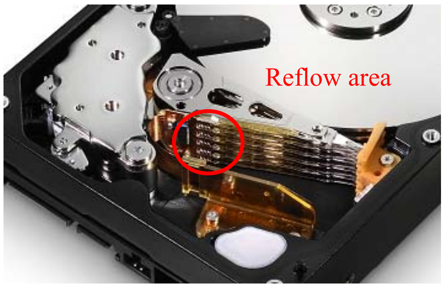

Figure 1. Reflow area

This paper focuses on lap bonding with planar reflow that not related to solder jetting in reflow process.

II. MATERIALS

The apparatus of the reflow process can be separated into 3 parts. The first is power supply (HTT1000) to control the high electrical current passed through the hot bar solder reflow soldering as shown in figure 2. The second is hot bar holding clamp that can be adjusted position in z-axis connect to the hot bar soldering by the nut and the screw, consisted of mechanism of automated movement of the hot bar soldering included the microscope (30x) connected on top of the clamp, operator is able to focus the part during solder reflow process. The last is the hot bar reflow soldering as shown in figure 3, after the electrical current passed through the hot bar then the electrical current will be changed to thermal energy following Joule's law. Figure 4 shows the reflow machine included tip holder. The solder pad has not lead in its component, the material the is selected to be solder for lap bonding reflow process following for green technology the solder material as shown in table 1. In the simulation model, the hot bar will be created by SolidWorks, included the Haynes230 and copper material. The dimension of copper on hot bar soldering will be controlled, Haynes230 will be varied which depend on the number of the reflow pad.

TABLE 1. COMPONENT OF SOLDER MATERIAL

Name	CAS No.	wt%
Tin	7440-31-5	95.5
Silver	7440-22-4	3.8
Copper	7440-50-8	0.7

Figure 2. Power Supply Unit (HTT1000)

The 3D model of the hot bar solder reflow will be imported into Ansys for finite element analysis to calculation the hottest area in lap bonding reflow soldering process.

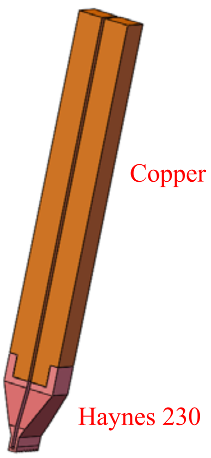

Figure 3. Hot bar solder reflow

Figure 4. Reflow machine included tip holder

III. METHODS

The old designs of the hot bar solder reflow have flat and bump at the tip. In the reflow process, the uniform of the temperature at the tip is necessary. The flat tip has a chance of solder bridging because the solder lead pitch is small (at 16 mil, 20 mil and 24 mil). As for the bump tip may occur burn pad that is polyamide was burnt due to hot bar touch to polyamide with high temperature.

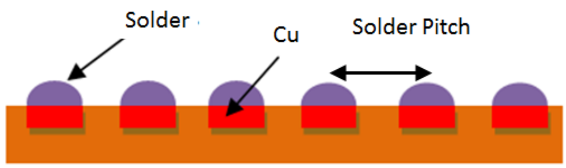

Figure 5. Solder lead pitch

The polyamide has not stainless steel cover in some area then if the hot test of the hot bar solder tip touch leads to defect. Thus, the 3D model of hot bar solder reflow tip will be created by SolidWorks. The tip of the hot bar is defind following the number of the solder lead pitch as shown in figure 5. The width of the hot bar is equal to flying lead width to make sure that the tip is superimposed by all flying lead. The 3D model is imported into Ansys Workbench for Thermo-Electric analysis in the temperature around reflow areas. Tetrahedron element is used for finite element analysis, the material properties of the copper and haynes 230 is put in the program that temperatures were varied as shown in table 2 and 3. Due to reflow process is in the clean room and reflow time is very short, heat convection will be not considered in this study. Following the Joule's law, the Joule heating equation gives the power per unit volume as equation (1)

$$\frac{dP}{dV} = \vec{J} \cdot \vec{E} \qquad (1)$$

Here, $\vec{J}$ is the current density, and $\vec{E}$ is the electric field. In a conductor of conductivity σ, $\vec{J} = \sigma\vec{E}$ and therefore

$$\frac{dP}{dV} = \vec{J} \cdot \vec{E} = \vec{J} \cdot \frac{\vec{J}}{\sigma} = \vec{J}^2 \rho \qquad (2)$$

Where $\rho = \frac{1}{\sigma}$ is the resistivity and vary with the different temperatures. This directly resembles the I^2R term of the macroscopic form.

TABLE 2. MATERIAL PROPERTIES OF THE COPPER

Properties	Copper 698A 801
Mass Density (kg/m^3)	8940.54
Thermal Conductivity (W/m*K)	4693.75
Specific Heat (J/kg*K)	380.99
Electrical Resistivity (Rho)	$1.68x10^{-6}$

TABLE 3. MATERIAL PROPERTIES OF HAYNES230

Temperature (˚C)	Thermal Conductivity (W/m*K)	Specific Heat (J/kg*K)
25	8.9	$3.97x10^8$
100	10.4	$4.19\ x10^8$
200	12.4	$4.35\ x10^8$
300	14.4	$4.48\ x10^8$
400	16.4	$4.65\ x10^8$
500	18.4	$4.73\ x10^8$
600	20.4	$4.86\ x10^8$
700	22.4	$5.74\ x10^8$
800	24.4	$5.95\ x10^8$
900	26.4	$6.09\ x10^8$
1000	28.4	$6.17\ x10^8$
Mass Density at 25 ˚C = 8.97 g/cm^3		

After simulated 3D model the prototype is made and testing.

IV. RESULTS

The results from analysis and changed some dimension of the reflow area the thermal distribution of hot bar solder reflow are shown in figure 6 and figure 7. It was found that if manufacturer is able to control the current density of the hot bar reflow solder tip, the heat distribution start from the center of the reflow area and spread to the both side of the reflow area. The rate of spread of the heat depends on the reflow time setting. Also, it was found that the old design had not control the current density, thus the heat distribution is not uniform leads to some area hotter than another area, root cause of burn pad and incomplete in reflow process.

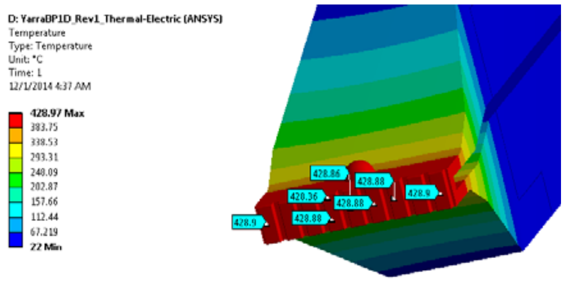

Figure 6. Temperature distribution on reflow solder tip

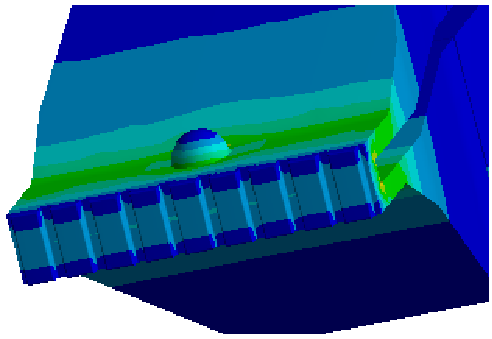

Figure 7. Uniform current density on reflow solder tip

After testing the prototype found that has much less solder bridging and solder incomplete when head stack assembly experienced lap bonding reflow process, solder bridging was reduced from 1.2 percent to 0.3 percent, solder incomplete was reduced from 0.25 percent to 0 percent and the last burn pad due to hot bar solder reflow tip is reduced from 0.2 percent to 0 percent, all through process use same reflow setting as the old design.

V. CONCLUSION AND DISCUSSION

The study for new design of hot bar solder reflow solder tip found that the heat distribution start from the center line of the reflow area and spread to the width of the solder reflow tip. Nevertheless, the current density is an important parameter for control the heat distribution of the hot bar solder reflow tip. Also found that the hot bar solder reflow bump type tip is quite better than flat type tip due to it has the space allow melted solder flow to cover the copper over hang. Actually, the current process reflow uses one time and one header, adding the dressing process for clamp the trace gimbal is able to make reflow as one time and two header.

REFERENCES

[1] M.R. Harrison, J.H. Vincent, H.A.H. Steen. 2001. Lead-free reflow soldering for electronics assembly. Soldering & Surface Mount Technology, Vol.13 Iss:3, 21-38J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[2] Reflow International. Solder Reflow Technology Handbook. Take June,09,2013, from http://www.conceptronic.com/products/solder-reflow-technology-handbook/

[3] R. Benjaporn, "Development of soldering process for joining of Head Gimbal Assembly and Actuator arm in Hard disk drive," King Mongkut's University of Technology Thon Buri, Agust 2013.