

Back Side Pad Bonding of Hard Disk Head Slider

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ABSTRACT

In the magnetic head of disk drive, the head slider is the major and lucrative part. Therefore, to increase the efficiency and serve an exponential growth of Hard Disk Drive industry, there is a need to continuously improve the slider. An approach to enhance the slider efficiency is to increase the number of sensors, leading to increase the number of bond pads.

To increase the number of bond pads, the location of bond pads must be relocated from the tail edge to the back side edge of the slider. At new location, a new bonding process by the 1064 nanometer Nd-YAG laser with pulse widths at 30 millisecond is applied to replace the solder jet bonding process. The result shows that the laser bonding process is feasible with 1 laser point, 60 milliJoule of laser energy, 550 micrometre of laser diameter and 3 Newton of holding force. With these parameters, the bonding process is investigated for flaw at the bonding joint by using Scanning Electron Microscopy. The result shows that the slider is bonded with flawless joint and acceptable effects as the intermetallic compound is occurred.

Keywords: hard disk head slider, bond pad, back side pad bonding process

INTRODUCTION

Nowadays, Hard Disk Drive (HDD) industry in Thailand has contributed a great deal to the Thai economy. As the top rank in the world more than 100,000 people are employed, and more than 400,000 million Baht worth for export values are earned. However, there are other concerning factors to maintain Thailand status as the world's number one HDD production base, for example, competing with other developing countries such as, China and Malaysia to gain a larger share of HDD manufacturers. In addition, Thailand needs more researches on advanced technologies in HDD production to make hard disk drives more efficient, more capacity or smaller size. This research will focus on how to make hard disk drives more efficient.

To make hard disk drives more efficient, there is a need to increase the efficiency of the hard disk read-write head (slider) by increasing a signal transmission (bond pad) in the slider, as a signal in the read-write process to control a flying height of the slider.

At the moment, there are 6 bond pads located on a tail edge of the slider. Therefore, if there is a need to increase a signal transmission, there is a need for more bond pads. For more bond pads, the tail edge does not provide enough space. As a result, the location of bond pads must be relocated to a back side edge as shown in Figure 1. Moreover the new bonding process must be discovered because the current bonding process, solder jet bonding (SJB) process, cannot be applied.

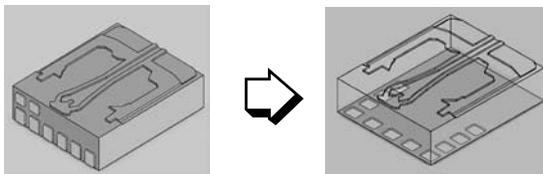


Figure 1. Original and new location of bond pads.

BONDING PROCESS IN HEAD GIMBALS ASSEMBLY PROCESS

A bonding process in a Head Gimbals Assembly (HGA) is the process that attached the slider with the suspension, which is a small arm that holds the slider in position above or beneath a disk, via bond pads. With the original location of bond pads, the SJB machine is used to load solder, aluminum alloy, to bond pads for connecting the signal from the slider to the suspension. The jetting device includes a crucible to contain molten solder and an orifice through which solder droplets are ejected. The ejection is mostly driven by piezoelectric actuators. Figure 2 shows the bonding process by the SJB machine at the tail edge of the slider.

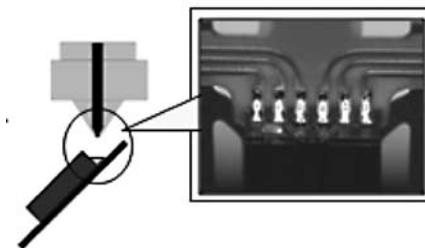
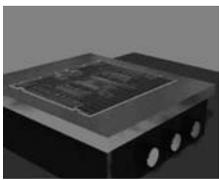


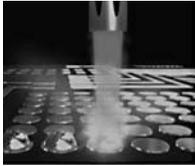
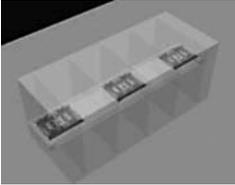
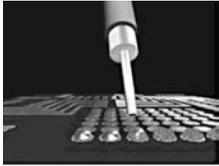
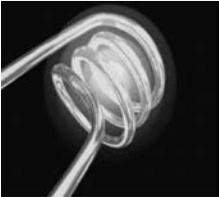
Figure 2. Solder jet bonding (SJB) process at the tail edge of the slider.

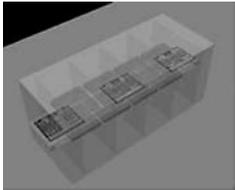
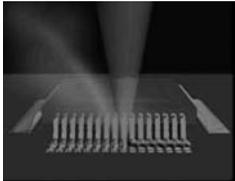
However, if the location of bond pads is relocated to the back side edge, the SJB process cannot be used. According to literature reviews, there are so many techniques that can be used for bonding process in HGA and an elec-

tronic print circuit board (PCB). From the study of HGA, there are 3 bonding methods which are Ultrasonic TAB bonding, Hot bar soldering interconnection, and Anisotropic conductive film bonding (Luk, C. F. et al., 2002). Furthermore, there are other studies such as Thermal Sonic Flip Chip Bonding to replace Anisotropic Conductive Adhesive Films (ACFs) (Cheah, L.K. et al., 2001). With these traditional techniques, the laser bonding is very interested. Vivari, J. et al., 2007 shows the comparison between the laser bonding and other heat bondings as shown in Table 1. After that, back side pads on PCB using the laser heating is discovered (Nagasawa, K. et al., 2008). For back side pads, a focused laser beam discovered (Nagasawa, K. et al., 2008). For back side pads, a focused laser beam melts the solder, bonding the chip that contains the vertical-cavity surface emitting laser (VCSEL) to the electrode on PCB. As a result, it shows that the laser bonding process can be used for bonding the slider and the suspension at the back side edge of the slider. Not only the study of bonding method but also the effect from the bonding is reviewed. Some will focus on the problem from the bonding process such as the study of mechanical heat of a plastic ball-grid-array (PBGA) characteristic using a laser and a hot air reflow by Finite Element Method (FEM) (Tian, Y. et al., 2002), the study of bonding joint in Flip-Chip process (Liu, Y. et al., 2008), and the thermal study in Flip-Chip process in LED by FEM (Fan, B. et al., 2008). These studies are about finding a new bonding method which gives more benefits and less effect.

Table 1. Thermal bonding process.

Equipment	Image	Area Heated	Key Features
Hot Bar Thermodes		<ul style="list-style-type: none"> • Area of contact and surrounding area through conduction 	<ul style="list-style-type: none"> • Contact heating • Heat transfer dependent on surface area of contact • Thermodes wear with use
Hot Plate		<ul style="list-style-type: none"> • Entire product through conduction from contact surface out to extremities 	<ul style="list-style-type: none"> • Contact heating • Heating rate dependant on contact surface area • Heats from the 'bottom' up
Resistance		<ul style="list-style-type: none"> • Conductive material between electrodes 	<ul style="list-style-type: none"> • Contact heating • Performance partly dependent on contact area between part and electrodes

Equipment	Image	Area Heated	Key Features
Soldering Iron		<ul style="list-style-type: none"> • Point touched and surrounding area through conduction 	<ul style="list-style-type: none"> • Contact heating • Heat transfer dependent on surface area of contact • Tips wear with use
Torch		<ul style="list-style-type: none"> • Area of flame focus and surrounding area through conduction 	<ul style="list-style-type: none"> • No physical contact; flame touches part • Available in very high energy capacity; with increased capacity comes increased flame size • Open flame ignites flammable materials
Convection Oven		<ul style="list-style-type: none"> • Whole product 	<ul style="list-style-type: none"> • Non-contact heating • Tight peak temperature control • Uniform heating across product • High throughput
Focused Hot Air		<ul style="list-style-type: none"> • Area defined by nozzle design, air dispersion, and conduction 	<ul style="list-style-type: none"> • Non-contact heating • More local than a convection oven • Tight temperature control
Induction		<ul style="list-style-type: none"> • All conductive materials within inductive field and surrounding area through conduction • Field strength decreases with the square of the distance 	<ul style="list-style-type: none"> • Non-contact heating • Available in very high energy capacity • Heats materials with higher electrical resistance faster (e.g. steel faster than copper) • Field shape is a function of coil shape

Equipment	Image	Area Heated	Key Features
Infra Red		<ul style="list-style-type: none"> • Area of IR exposure and surrounding area through conduction 	<ul style="list-style-type: none"> • Non-contact heating • Energy absorption is material dependant with metals being poor absorbers • Area of IR exposure can vary from as small as an 8mm spot to a theoretically unlimited area.
Diode Laser		<ul style="list-style-type: none"> • Area of laser focus and surrounding area through conduction 	<ul style="list-style-type: none"> • Non-contact heating • Area of focus can be as small as 0.6 mm • Precise energy output control • Energy absorption is material dependant

METHODOLOGY

To increase numbers of bond pads, the location of bond pads need to relocate first. Then, the new bonding process must be defined. Details are as follows.

Back side bond pads

Currently bond pads are located on the tail edge of the slider. At this location, the maximum number of bond pads could be only 8. Therefore, there is a need to relocate bond pads from the tail edge to the back side edge, which can increase the maximum number of bond pads from 8 to 18 as shown in Figure 3.

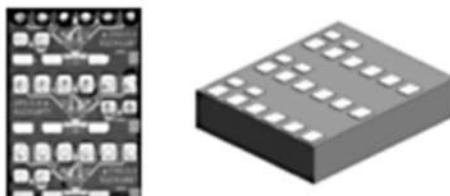


Figure 3. Bond pads on the back side edge of the slider.

Back side pads bonding process

With back side bond pads, the pre-solder slider will be aligned to the suspension that is reproduced with a slider on the lower side. After that the laser bonding process applies the convection to the slider to melt solder. While a laser is applied to the slider, the slider was also hold by vacuum head on upper side. This process is shown in Figure 4.

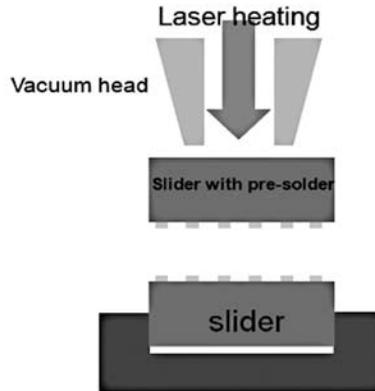


Figure 4. Laser bonding process for back side bond pads.

From the laser bonding process, the experiment as shown in Figure 5 is setup. The laser source which is a 1064 nanometer Nd-YAG laser with pulse widths at 30 millisecond is on the top. The pre-solder slider and the suspension are situated on a microstate that can be adjusted on x-y axis by using CCD camera.

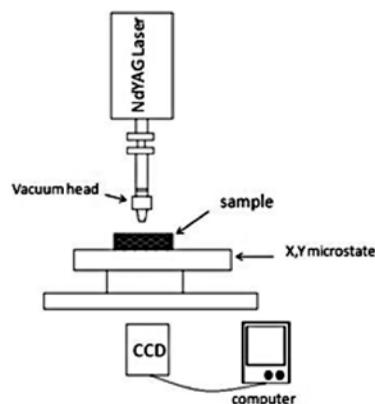


Figure 5. Laser bonding process experiment.

RESULTS AND DISCUSSIONS

From the experiment, four parameters which are numbers of laser point, laser energy, laser diameter and holding force are tested. All conditions are shown in Table 2. After the study with a constant bonding time of 10 seconds, the bonding process is succeeded by the following conditions:

- 1 laser point
- 60 milliJoule of laser energy
- 550 micrometre of laser diameter
- 3 Newton of holding force

With these appropriate conditions, the complete sample is brought to examine a bonded joint by using Scanning Electron Microscopy (SEM). The result shows that the joints are bonded as the intermetallic compound (IMC) is occurred. IMC layer is the reaction between a solder (Aluminum Alloy) and gold from bond pads, as shown in Figure 6.

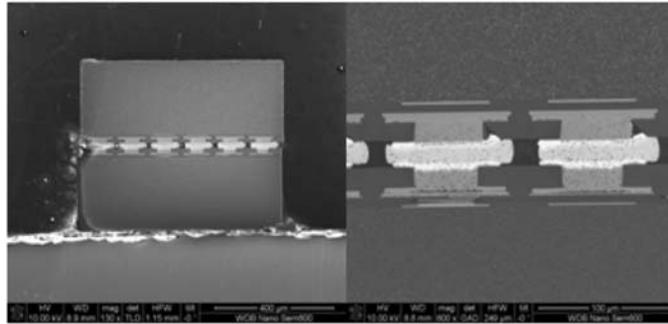
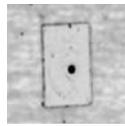
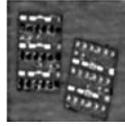
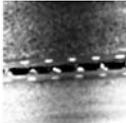


Figure 6. IMC layer of back side bond pads by SEM.

Table 2. Bonding experiment in different conditions.

Condition	Slider damage	bonded	picture
1 laser point 60 mJ of laser energy 0 N of holding force 550 μm of laser diameter	damage (slider burn)	bonded	
18 laser points 60 mJ of laser energy 0 N of holding force 100 μm of laser diameter	damage (slider burn)	bonded	
1 laser point 41 mJ of laser energy 0 N of force 100 μm of laser diameter	no damage	no bonded	

Condition	Slider damage	bonded	picture
18 laser points 41 mJ of laser energy 0 N of holding force 100 μm of laser diameter	no damage	bonded but only one side	
1 laser point 60 mJ of laser energy 3 N of holding force 550 μm of laser diameter	no damage	bonded	
18 laser points 60 mJ of laser energy 3 N of holding force 550 μm of laser diameter	can not bond in this condition		no picture
1 laser point 41 mJ of laser energy 3 N of holding force 550 μm of laser diameter	no damage	bonded	
18 laser points 60 mJ of laser energy 3 N of holding force 550 μm of laser diameter	can not bond in this condition		no picture

CONCLUSION

From the idea that needs to enhance the slider efficiency by increase the number of bond pads, it shows that the maximum number of bond pads could be 185 pads which are located at the back side edge of the slider. However, the original bonding process by solder jet bonding machine is not applicable. As a result, the back side pad bonding process by a laser is discovered. The experiment confirmed that the back side pad bonding process can be possible. This process allows the convection of heat via a laser to melt the alloy solder ball to create bond pads. The laser source is Nd-YAG 1064 nanometer of wave length and 30 millisecond of laser pulse width. The appropriate parameters that can create the bonding are 1 laser point, 60 milliJoule of laser energy, 550 micrometer of laser diameter, 3 Newton of holding force, and 10 seconds of bonding time. From the experiment, the result shows that the slider is bonded with flawless joint and acceptable effect.

ACKNOWLEDGEMENTS

This research is supported by Western Digital (Thailand) Co., Ltd. and funded by Industry/University Cooperative Research Center (I/UCRC) in HDD Component, the Faculty of Engineering, Khon Kaen University and National Electronics and Computer Technology Center, National Science and Technology Development Agency.

REFERENCES

- Cheah, L.K., Tan, Y.M., Wei, J., and Wong, C.K. Gold to gold thermosonic flip-chip bonding (2001) Proceedings of SPIE - The International Society for Optical Engineering, 4428; 165-170.
- Fan, B., Wu, H., Zhao, Y., Xian, Y., Zhang B., and Wang, G. Thermal study of high-power nitride-based flip-chip light-emitting diodes (2008) IEEE Transactions on Electron Devices, 55: 3375-3382.
- Liu, Y., Irving, S., and Luk, T. Thermosonic wire bonding process simulation and bond pad over active stress analysis (2008) IEEE Transactions on Electronics Packaging Manufacturing, 31: 61-71.
- Luk, C. F., Chan, Y. C. and Hung, K. C. Application of adhesive bonding techniques in hard disk drive head assembly (2002) Microelectronics Reliability, 42: 767-777.
- Nagasaka, K., Amako, J. and Fujii, E. Micro/Nano Lithography & Fabrication Micro-bonding laser chips using arrayed beams (2008) SPIE Newsroom, 24 July 2008.
- Tian, Y., Wang, C., and Liu, D. Thermomechanical behaviour of PBGA package during laser and hot air reflow soldering (2004) Modelling and Simulation in Materials Science and Engineering, 12: 235-243.
- Vivari, J. and Kasman, A. Laser Solder Reflow: A Process Solution Part 1, LEISTER Technology LLC.

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