Analysis of Automatic TDSON Bond Line Thickness (BLT) on the CyberSCAN CT-300 Machine with GR&R and T-Test

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Abstract*--Die Attach SON is the process of moving and placing the die from the wafer to the leadframe that has been applied with solder paste, then placing the clip on top of the die that has been bonded to the leadframe that has been applied with solder paste. Bond Line Thickness (BLT) is one of the important aspects that must be considered in the die mounting process. And the BLT value must be measured quickly and accurately using an automatic machine, namely by using the CyberSCAN CT-300 machine. However, the CyberSCAN CT-300 machine is the latest measurement machine at PT Infineon Technologies Batam, and is still in the development stage to determine the BLT value. So some testing and analysis of the measurement results of the CyberSCAN CT-300 machine was carried out. So the hypothesis arises how to measure and prove the results of the BLT sample measurement test carried out using the CyberSCAN CT-300 machine in accordance with its specifications. So the optimization of CyberSCAN CT-300 is done with the Gage Repeatability & Reproducibility (GR&R) method which aims to find out whether the CyberSCAN CT-300 machine can make measurements consistently or not. And After analysis, a %GR&R result of 7,16% was obtained, which is in an acceptable position, which means that the CyberSCAN CT-300 measurement system is acceptable and can measure the TDSON Bond Line Thickness (BLT) consistently.

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Keyword: CyberSCAN CT-300, GR&R, T-Test

I. INTRODUCTION

Background— *Die attach* is one of the important processes in the semiconductor world, especially ic packaging. *Die attach SON* is the process of moving and placing the good die from the *wafer* to the *leadframe* which has been given *solder paste* then given an *clip* on the *good die* that has been bonded on the *leadframe* and has also been given solder paste on the *good die*[1]. The purpose of this process is to connect the *die, clip* and *leadframe* using solder paste.so that *the electrical* can work properly[2].

In the *die attach SON* process, there is something known as *Bond Line Thickness. Bond Line Thickness (BLT)* is a *critical response* in the die attach process that is used to identify the height between the *solder paste* and the *leadframe* after the *die attach process*[3]. *Bond Line Thickness* is an important thing that must be considered and controlled considering that the height of the *die* from the *leadframe* is one of the factors that determine whether the unit meets the desired unit thickness specification criteria or not. And in the *die attach SON process* has an *e-clip* above the *good die* that has been bonded above the *leadframe*, and this will definitely affect the inconsistent results in the measurement process (BLT) because the product resulting from the *die attach SON* has an e-clip above the good die that has been bonded above the *leadframe.* Therefore, to measure thickness (BLT) using *CyberSCAN CT-300 machine* which has a compact high-resolution non-contact profilometer. If it is not in accordance with the specifications, it will have an impact on the stability of the next process, such as the wire bonding process which has an auto focus feature to detect the height of the die before bonding with the wire, and in the latest technology in the *die attach SON* process, the wire in the wire bonding process only uses 1 wire connectivity specifically for *die attach SON* products. And if the height of the *Bond Line Thickness (BLT)* is inconsistent then the machine will continuously be in an error condition and the process must stop.

However, the CyberSCAN CT-300 machine is the latest measurement machine available at PT Infineon Technologies Batam, and is still in the development stage to determine the value of BLT. Therefore, several tests and analysis of the measurement results of the CyberSCAN CT-300 machine were carried out in accordance with its specifications. The development of technology, especially in the world of semiconductor technology, the *CYBER TECHNOLOGIES company* which is one of the technology companies that focuses on the development of semiconductor metrology tool technology. Which has just launched the latest technology or invention of measurement tools such as the *CyberSCAN CT-300 machine*. And the *CyberSCAN CT-300 machine* is a machine that is used for measuring *die tilt, bond line thickness, fillet height, fillet weight* and *volume of glue/epoxy/solder*

paste[4]. The main components of the system are a laser or white light sensor and an X and Y motion system on a granite platform. Especially the combination of advanced sensor technology and X,Y motion system with high accuracy and high measurement speed enables high resolution 2D profiles and 3D rasters. The system can scan a maximum area of 300 mmx300mm.

***Problems*—** Based on the background described above, a problem can be formulated, namely how to test the *Automatic Bond Line Thickness* (BLT) analysis on the *CyberSCAN CT-300* machine using the *Gage Repeatability & Reproducibility (GR&R)* and T-*test* methods?

Objectives— Based on the details of the problem above, this final project was carried out with the aim of testing the *Automatic Bond Line Thickness* (BLT) analysis on the *CyberSCAN CT-300* machine the *Gage Repeatability & Reproducibility (GR&R) method* and *the* T-*test*.

Adventages— Hopefully, this final project can provide results that can be used in the future, so that the measurement of *Bond Line Thicknesses* (BLT) can be done automatically to simplify and shorten time.

II. METHOD

The first thing to do is to prepare *materials* such as *leadframe, solder paste, wafer* and *E-clip*. If all the *materials* are complete, we can set-up the *die attach SON* machine along with the *CyberSCAN CT-300 Machine*, if it is in accordance with the specifications then we can proceed to the next process, if it is not in accordance with the specifications then set-up again. The next process is to measure the BLT automatically using the *CyberSCAN CT-300 machine*. And BLT measurements are carried out twice which aims to obtain data that will be used to conduct a T-*test*. After that, an analysis is carried out to find out how *GR&R* optimization of the *CyberSCAN CT-300 machine* and conduct a comparative analysis between the 2 measurements and make conclusions based on the analysis.

***Die Attach SON Process*—** The following is the basic procedure for operating the die attach machine based on the PT Infineon Technologies Batam document Number Z8R00003858 :

1. Initialize the engine to return all parts to their initial position.
2. Input the recipe by clicking teach recipe recipe and browse.
3. The main process in die attach is input dispense pick and place out.
4. Set-up and teach all processes on the machine by clicking on the teach and set-up menu.
5. The input process means ensuring that all materials can be loaded properly such as leadframe, glue, and wafers.
6. For load wafers: set-up and load cassette menu pick and place and click all tools inserted.
7. For load magazine: menu strip output strip output optimize load magazine.
8. To replace the syringe and teach the dispense process: capillary and syringe flush high glue so that there are no bubbles during the bonding process toggle soft keys learn Z on rocker learn Z on leadframe.
9. To load wafers and teach pick and place: change tools optimize load wafer toggle soft keys learn pick Z touch height pick die insert leadframe with load blank strip learn bond Z touch height.
10. For Die Attach TDSON bond the *Die* to the *Leadframe* Bond the *E-clip* to the *Die top* Reflow to the HELLER.

After all teach processes are completed, the indicator menu will turn green and the machine is ready to use[13].

A. Gage Repeatability & Reproducibility (GR&R)

Gage Repeatability & Reproducibility (GR&R) is used when there is a new and different measurement system. Because the *CyberSCAN CT-300 Machine* has a new measurement from *Cyber Technologies Company*, it is necessary to carry out GR&R. To perform automatic measurements using the *CyberSCAN CT-300 Machine* and to collect data that will be used for GR&R, the procedure is carried out according to the PT Infineon Technologies Batam document Number Z8R00002195 as follows:

1. At least 10 samples are required.
2. It takes 3 operators or 3 raters to carry out the measurements.
3. Each operator or rater measures the same sample in the same way.
4. Measurements were repeated 3 times for each operator or rater.

The data obtained is inputted to the Minitab application which serves as a medium or application for doing GR&R.

The results obtained are analyzed and concluded based on the percentage of GR&R, whether the results are acceptable, acceptable with certain conditions or unacceptable and here I use the method of repeating measurements of 1 sample for 3 repetitions for same sample in the same way, to measure the height of the Bond Line Thikness (BLT) with units of microns.

B. Die Attach

Die Attach SON is to place the *die* onto the *leadframe* or *substrate* and then place the *clip* over the *good die* that has been bonded to the surface of the *leadframe* or *substrate*. The process starts with taking the *die* off the *wafer*. The usual method is to push the *die* off the *wafer* with the help of a *neddle ejector* and at the same time the *die* will be picked up by the pick up tool and placed on the *leadframe pad*[6].

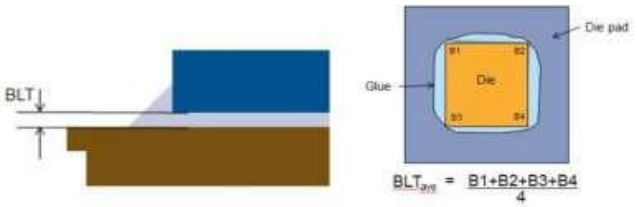
The *die attach process* consists of 3 main stages, namely *dispense, pick and place* and *bonding*. *Dispense* is the process of removing the *solder paste* through the *nozzle* to the *leadframe*. After that, the *good die* will be released with the help of an ejector *needle* and *pick up* tool and then placed or bonded to the *leadframe* that already has *solder paste*. After the *die attach process* is complete, it will then be cured at a certain temperature. The purpose of the cure process is to harden the *epoxy*, evaporate the solvent in the *epoxy*, and create a good cross-link to each molecule that moves[6].

C. Bond Line Thickness

Bond Line Thickness (BLT) is one of the *quality response outputs* during *set-up* and *processing*. *Bond Line Thickness* (BLT) is a critical response in the *die attach process* that is used

to identify the height of the *epoxy* between the *die* and the *leadframe* after the *die attach process*[3]. *Bond Line Thickness* (BLT) is an important thing that must be considered and controlled to stay in accordance with the specifications, because if it does not match the specifications it will have an impact on the next process. Like the *wire bonding process* which has an auto focus feature to detect the height of the die before bonding with the *wire*, if the height is inconsistent then the machine will often be in an error condition and the process must stop. *Bond Line Thickness* (BLT) also distributes heat from the *die* to the *die* paddle with the aim that the die does not overheat. The height of the *Bond Line Thickness* (BLT) also varies according to its specifications, the type of *epoxy* used and the type of *leadframe* used. The standard *Bond Line Thickness* (BLT) value commonly used is ≤10um. Here is how to get the BLT value by automatic measurement and the tools used:

Figure 4. Measurement *Bond Line Thickness*



D. Materials

Materials needed in the die attach process are as follows:

1. Leadframe
   Leadframe is a component made of copper that functions as the legs of the IC[11].
2. Solder Paste
   Solder Paste is an adhesive that aims to glue the chip to the leadframe pad so that the die does not come off easily[6]
3. Wafer
   Wafer is a large disk containing silicon chips that have been coated with glass. Glass aims to protect the wafer from foreign material or foreign material that can stick to the active metal on the wafer surface . This wafer contains hundreds or even thousands of brains from the IC to be assembled[12].

III. RESULT AND DISCUSSION

The number of samples used in this Final Project is 1 Leadframe type LL with 64 die type A. Measurements are carried out using 1 types of measuring instruments, namely CyberSCAN CT-300 with the aim that measurement data using CyberSCAN CT-300 will be used for GR&R.

A. BLT Measurement Result With CyberSCAN CT-300

Measurement and data collection using CyberSCAN CT-300 Machine were carried out by 3 operators and each operator carried out measurements and data collection 3 times [19]. In Table 4 below are BLT measurement data using CyberSCAN CT-300 Machine (um):

Table 1. Example of CyberCSAN CT-300 Data

NO	BLT CT-300 Operator A											
	Repetition 1				Repetition 2				Repetition 3			
	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
1	23,39	24,22	30,1	31,02	23,39	24,22	30,1	31,02	23,39	24,22	30,1	31,22
2	24,76	26,44	31,3	32,12	24,76	26,44	31,3	32,12	24,76	26,44	31,3	32,12
3	31,22	24,59	33,52	33,66	31,22	24,49	33,52	33,66	31,22	24,59	33,52	33,66
4	30,33	30,11	37,12	38,88	30,33	30,11	37,12	38,18	30,33	30,43	37,12	38,88
5	33,41	32,12	36,44	35,75	33,41	32,12	35,44	35,75	33,41	32,12	36,74	35,75
6	20,33	22,12	39,32	35,33	20,33	22,12	39,32	35,33	20,33	22,12	39,32	35,33
7	40,24	40,33	41,78	41,22	40,24	40,33	41,78	41,22	40,24	40,33	41,78	41,22
8	39,51	39,56	45,66	45,77	39,51	39,56	45,66	45,77	39,31	39,56	45,66	45,77
9	38,8	38,12	42,62	42,57	38,8	38,12	42,62	42,57	38,18	38,12	42,62	42,57
10	39,98	39,75	40,99	42,71	39,98	39,75	41,99	42,71	39,98	39,75	40,99	42,71

NO	BLT CT-300 Operator B											
	Repetition 1				Repetition 2				Repetition 3			
	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
1	22,39	24,22	30,32	31,02	23,39	24,22	30,32	31,02	22,39	24,22	30,32	31,02
2	24,03	26,44	31,4	32,12	24,03	26,44	32,4	32,12	24,03	26,44	31,4	32,12
3	31,22	24,59	33,52	33,66	31,22	24,59	33,52	33,66	31,22	25,59	33,52	33,66
4	30,33	30,11	37,12	38,88	30,33	30,11	32,12	38,88	30,33	30,11	37,12	38,88
5	33,41	32,12	36,44	35,75	32,41	32,12	36,44	35,75	33,21	32,12	36,64	35,75
6	20,23	22,12	39,3	35,33	21,33	22,12	39,3	35,33	20,13	22,12	39,3	35,33
7	40,14	40,6	41,18	41,22	40,24	40,6	41,18	41,22	40,24	40,6	41,8	41,22
8	39,51	39,56	45,16	45,77	39,11	40,56	45,66	45,77	39,51	39,46	45,66	45,77
9	38,88	39,1	42,32	42,57	38,88	39,12	42,32	42,57	38,88	39,12	42,32	42,57
10	39,28	39,25	40,99	42,71	39,98	39,75	40,29	42,71	39,98	39,75	40,99	42,71

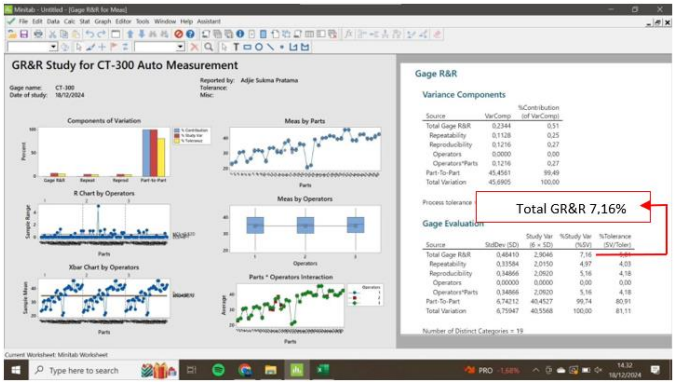
NO	BLT CT-300 Operator C											
	Repetition 1				Repetition 2				Repetition 3			
	P1	P2	P3	P4	P1	P2	P3	P4	P1	P2	P3	P4
1	23,39	24,22	30,82	31,02	23,39	24,22	30,82	31,02	23,39	24,22	30,82	31,02
2	24,76	26,44	31,5	32,12	24,76	26,24	31,54	32,12	24,76	26,44	31,5	32,12
3	31,22	24,59	33,52	33,66	31,22	24,59	33,52	33,66	31,22	24,59	33,52	33,66
4	31,33	31,11	37,12	37,88	31,33	31,11	37,12	37,88	32,33	31,81	37,12	37,88
5	30,41	32,92	36,44	35,75	30,41	32,12	36,44	35,75	30,41	32,92	36,44	35,75
6	20,33	22,12	39,32	35,33	20,33	22,12	39,32	35,33	21,43	22,12	39,32	35,33
7	40,24	40,33	41,78	41,22	40,24	40,33	41,78	41,22	40,24	40,33	41,78	41,22
8	39,51	39,56	45,66	45,77	39,51	39,36	45,66	45,77	39,51	39,56	45,66	45,77
9	38,88	38,12	42,62	42,57	38,88	38,12	42,62	42,57	38,88	38,12	42,62	42,57
10	39,98	39,75	40,99	42,71	39,98	39,75	40,99	42,71	39,98	39,15	40,89	42,71

We can see from table 4 above that operator B has 10 Die units in 1 leadframe to be measured. with the explanation that each 1 die unit is taken BLT measurement results on all four sides (square-shaped), with codes P1(left top), P2 (rigth top), P3 (left botttom), and P4 (rigth bottom) which each have four different measurement results in 1 die unit.

B. Gage Repeatability and Reproducibility (GR&R) Result

Gage Repeatability and Reproducibility is a method used to determine the amount of variance in measurement data caused by the measurement system. The system compares the measurement variation with the total observed variability, defining its capability. The two most important factors in measurement variation are repeatability and reproducibility. Repeatability is caused by equipment variation, and reproducibility by inspector or operator variations.The purpose of the GR&R method is to determine whether the CyberSCAN CT-300 can measure consistently and to determine whether or not the CyberSCAN CT-300 is an acceptable measurement system. Analysis of the CyberSCAN CT-300 using the Gage Repeatability & Reproducibility (GR&R) method was conducted using the Minitab application.

Figure 11. GR&R Report used Minitab application.



IV. Conclusion

After analysis, a %GR&R result of 7.16% was obtained, which is in an acceptable position, which means that the CyberSCAN CT-300 measurement system is acceptable and can measure the TDSON Bond Line Thickness (BLT) consistently.

Suggestions— For further research, the author can provide suggestions to improve the quality of CyberSCAN CT-300 measurements at PT Infineon Technologies Batam as follows:

1. Make sure that the CT-300 recipe is done properly before taking Bond Line Thickness (BLT) measurements.
2. Training the Appraiser in taking measurements using CyberSCAN CT-300 in order to improve the skills and abilities of the Appraiser.
3. Perform periodic maintenance and calibration to maintain the quality of the CyberSCAN CT-300 and the recipe.
4. Re-analyze recipes in case of measurement errors.

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