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Analysis of Lifted Metal Defect Improvement at Wire Bond Process for iMOTION Device

Final Project

By:

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Abstrak

Dalam proses pembuatan IC (Integrated Circuit) melalui banyak proses, salah satunya adalah proses wire bond. Kesempurnaan sebuah produk menjadi alasan besar untuk memenuhi keinginan pelanggan. Oleh karena itu, setiap produk harus dilihat kualitasnya agar produk tersebut sempurna dan tidak ada cacat produk di dalamnya. Proses wire bond memiliki banyak kecacatan, salah satunya adalah cacat logam terangkat. Pada tugas akhir ini, peneliti akan membahas mengenai perbaikan cacat lifted metal pada proses wire bond yang bertujuan untuk mengembangkan atau memperbaiki produk agar tidak terjadi cacat lagi. Selain itu, peneliti juga akan mencari analisa akar permasalahan terjadinya lifted metal melalui parameter-parameter yang digunakan pada proses wire bond dan mengetahui parameter yang tepat untuk mengurangi terjadinya cacat lifted metal. Dari analisa yang didapat, peneliti berharap dapat menemukan parameter yang tepat untuk mengembangkan atau memperbaiki terjadinya lifted metal.

Kata kunci: Integrated Circuit, Wire Bond, Cacat Logam Terangkat, Analisa Akar Permasalahan

Abstract

In the process of making IC (Integrated Circuit) through many processes, one of which is the wire bond process. The perfection of a product is a big reason to fulfill customer desires. Therefore, every product must be seen for its quality so that the product is perfect and there are no product defects in it. The wire bond process has many defects, one of which is the lifted metal defect. In this final project, researchers will discuss the improvement of lifted metal defects in the wire bond process which aims to develop or improve products so that defects do not occur again. In addition, researchers will also look for the root cause analysis of lifted metal through the parameters used in the wire bond process and find out the right parameters to reduce the occurrence of lifted metal defects. From the analysis obtained, researchers hope to find the right parameters to develop or improve the occurrence of lifted metal.

Keywords: Integrated Circuit, Wire Bond, Defect Lifted Metal, Root Cause Analysis

1. Introduction

PT Infineon Technologies Batam is a company engaged in the automotive sector with the main activity of making IC (Integrated Circuit). In the IC production process at Infineon Technologies there are 2 main production parts, namely the wafer fabrication process (Front End) and the assembly process (Back End). Infineon Technologies Batam located at Batamindo industrial Park lot. 317 is one of the factories owned by Infineon Technologies Batam which only operates in the IC assembly segment, namely Back end. In this era, more and more companies want their production to produce quality products. Today's increasingly sophisticated technology supports IC to be widely used in various fields, IC has a small size and light weight. The perfection of a product is one of the important things in a company in order to continue to satisfy customers.

IC which consists of several components in it has several stages or processes to produce products that are in accordance with production standards. Here the researcher will discuss one of the processes, namely the wire bond process. The wire bond process is the process of connecting electrical interconnections from the bond pad to the lead using wire. Wire Bonding is an important

stage in the assembly process, therefore the success of the next process is very important [1]. Briefly explaining the wire bond process, wire bond begins with an electric current called EFO which is useful for heating the wire in the capillary to form a ball shape called FAB (Free Air Ball). The wire that has formed a ball is then pressed into the bond pad, the process of connecting the FAB to the bond pad is called first bonding. Then the capillary lifts the wire and pulls the wire to continue the second connection on the lead called second bonding. In the second bonding circuit, the wire is touched and pressed on the lead to break the wire, resulting in an even shape.

In performing or connecting electrical interconnections from bond pads to leads, there is a possibility of errors during connection, these errors are called defects. Many defects that often occur in the wire bonding process are Weld Off, Bond Off, Ball Short to Ball, Cratering, Lifted Metal, and others.

Lifted metal is one of the defects that occur in the wire bond process. Lifted metal defect refers to the phenomenon that the bond pads peeled off in the first bonding process, resulting in the metallization in the bond pad being lifted but not yet reaching the silicon [2]. Lifted metal itself rarely occurs on some devices such as Dragon, Flex10, Sheri, Hammerhead. However, on iMOTION devices that are running at PT Infineon Technologies Batam lifted metal often occurs precisely on the High Voltage Integrated Circuit (HVIC) chip. HVIC are wafers specifically designed to handle high voltages in semiconductor applications. The basic requirements of HVIC integrated devices are high breakdown voltage, low specific resistance, and process compatibility with low voltage circuits [3]. This research uses a wire bond machine used in this iMOTION device product research is the UTC-5000NeoCu machine. This machine is capable of bonding on a tin substrate with a width of 100mm and a length of 300mm with a Y bond area of 92mm [4].

In this final project based on the problems that occur, the author has a goal to improve the lifted metal defect in the iMOTION device from the parameters used so that the product complies with production standards. The limitations of this final project are that this final project only discusses the lifted metal defect and how to improve the lifted metal defect, and find the right parameters to reduce the occurrence of this defect.

Looking at the raised metal defects that occur in iMOTION devices, it is necessary to know the causes that make the raised metal that often occurs in iMOTION devices. Raised metal can be caused by several abnormalities in the process, especially in the wire joining process. The author will look for the root cause of this defect using the 5W method. then find improved parameters to see the final results obtained.

2. Method

2.1 Design

To analyses a defect that occurs in a product, a flowchart is needed to support the workflow that will be carried out, and help in understanding, designing, and communicating work procedures clearly.

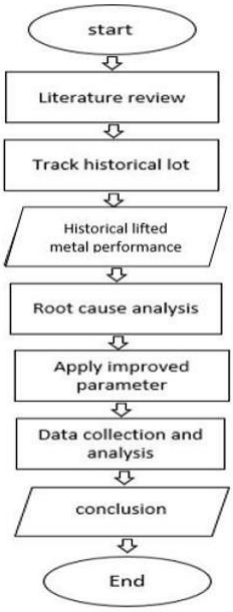

Figure 1 Workflow Method

2.1.1 Track historical lot & lifted metal performance.

In this process, the author will work with technicians to trace the history of metal defects that occur on the production line. The data in the table was obtained by studying the history of machine production time and the lot management system using STAREP software.

Table 1

Track Historical lot

lot number	NSOP	Tailing at Bump
VE149952B01	11	4
VE149952B02	16	10
VE149952B03	13	15
VE149952B04	14	35
VE149952B05	5	46
VE149952B06	9	96
VE149952B07	3	69
VE149952B08	2	33
Total	**73**	**308**

Source: STAREP

Preliminary testing was conducted, based on the historical lot tracing process in the table above, it was found that defects that could affect the raised metal occur in iMOTION devices, especially on the HVIC

chip. The following is the discussion.

a. NSOP (Non-Stick On Pad)

The main analysis found many NSOP (Non-Stick On Pad) on HVIC chips. Non-Stick On Pad in the context of wire bonding refers to the failure of wire bonds unable to bond the wire ball on the surface of the silicon chip bonding pad [5]. However, HVIC chips are susceptible to cracking of thinner bonds and in this final project discuss cratering instead of NSOP. Furthermore, another observation was made on NSOP by checking the bond force with a bond force calibration jig but lifted metal was still observed after bond force calibration. Therefore, this is not the main factor causing lifted metal.

b. Tailing at Bump

During the formation of the FAB (Free Air Ball) in the wire bonding process Cu wire encounters a problem where the condition of the wire end connected to the pad or chip has a long tail or protrudes this can be called asymmetrical FAB.

Figure 2 FAB Symmetrical and FAB Asymmetrical

Asymmetric FAB caused by long wire tails causes initial cracks in the bond pad. The crack propagates to the bonded ball surface and weakens the top metal layer of the pad. Therefore, the metal is lifted during loop formation. Due to the technical factors affecting this phenomenon, it is necessary to find the right process parameters.

2.1.2 Root cause analysis

In this process, the author will use the fishbone method and continue with the why-why method and discuss with wire bond experts and project team member.

a. Fishbone Diagram

Based on the results of the analysis using a fishbone diagram, it is used to identify the causes of decreased performance, namely Material, Man, Machine, Method. The usefulness of this diagram is to encourage approaches to problem solving from various factors. In addition, fishbone is also used in quality improvement initiatives to identify opportunities for process improvement.

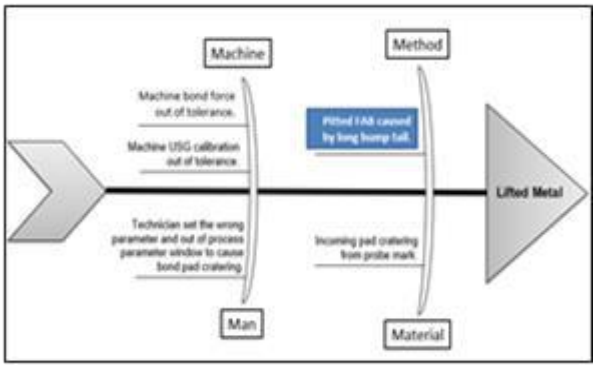

Figure 3 Fishbone Diagram

To find out the core problems in various factors of the fishbone diagram, the author uses the summary of the analysis in the table below.

Table 2

Root Cause Analysis on Fishbone

No	Factor	Reason	Verification Methode	Verification Result
1	Man	Technician set the wrong parameter and out of process parameter window to cause bond pad cratering.	Check parameter setting.	No different from the comparison
2	Machine	Machine bond force out of tolerance.	Check the bond force with bond force calibration jig.	Lifted metal remain after the calibration. It is not the root cause.
		Machine USG calibration out of tolerance.	Check the UCAC calibration value.	Within calibration spec limit for +/- 30%. It is not the root cause.
3	Method	Pitted FAB caused by long bump tail.	Repeat check with long bump tail condition with Hi-SC.	Lifted metal observed with long bump tail unit.
4	Material	Incoming pad cratering from probe mark.	Check bond pad probe mark. Submit the unbonded unit for FA check.	No cratering with 20units of inspection. It is not the root cause.

The raised metal is visible when there is an asymmetrical FAB that forms a long bump tail. The failure is an incomplete FAB, tailing at bump causes an initial crack in the bonding pad. The crack propagates to the pad surface and weakens the top metal layer of the pad. Hence, the metal lifted off during loop formation.

b. Why-why Analysis

The use of why-why analysis here is to analyze the root of the problem in the context of problem solving, i.e. looking for the root of a problem that has been observed. Here, the why-why analysis looks for the root cause of the tailing bump causing lifted metal.

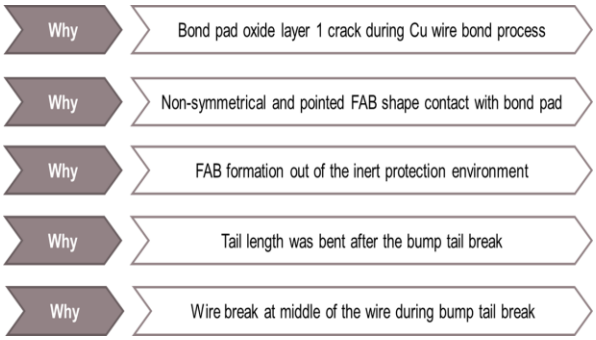

Figure 4 Why-why Analysis

From the why-why analysis on tailings bump, it is Optimized the bump tail break to improve the tailing at bump on lead.

2.2 Measurement Tools

Measuring tools help to provide an approach to defect analysis that can support the improvement of product quality. The following measurement tools are used:

a. SEM (Scanning Electron Microscope)

This measuring instrument serves to see and measure a defect or product that requires very high magnification of more than 100,000X. SEM also has the very important feature of being able to see the large depth of field required to create high resolution and three dimensional-like images of the sample surface [6].

b. Electron Microscope

The measuring instrument has the advantage of being able to see a high resolution of less than 1 nanometers. This helps to see the internal structure and surface of the sample in detail. And it helps to look at the bonding result from the side to see if the defect reaches the substrate or not. These two inspection tools have in common that they use electrons to form images, be it surface images for SEM or internal structural images for Electron Microscope.

2.3 Test

The methodology test used uses STAREP software, this software is useful for finding the identity of the lot number. Then the lot number will be exported to excel to see the defects and quantity of the lot number being searched. STAREP helps this research by producing the identity of the desired lot number.

3. Result and Discussion

Applying parameter improvements is an important step that refers to the action of using parameters that have been improved or optimized. After knowing the root cause of the problem, the following are control steps to optimize the bump tailing defect which causes lifted metal to occur on the iMOTION device.

Optimized bump tail to increase tailing on the bump. Contamination measures by optimizing the bump parameters by changing the parameters on the bump spark lead and neo cut. The bump spark parameter itself has the purpose of creating a strong bond between the pad and the wire. while the neo cut parameter refers to cutting the wire after the bonding process. The neo cut setting determines the length of the wire tail, which is the part of the wire that remains after the bonding process. This is important in ensuring the reliability and performance of the wire bond. Change the bump spark with time parameter from 0.350ms to 0.400ms then change the cut action parameter from down length 50um to 70um.

- Bump Spark Lead: 0.350ms → 0.400ms
- Neo Cut, Down length: 50um → 70um

Table 3

Validation Result

	Defect Tailing Bump	Improved
Before	157	96%
After	6	

Source: STAREP

an increased incidence in 3 lots of tailings plumes was observed when using the optimized recipe. From 157 defects to 6 defects resulted in an improvement of 96%.

Calculate percentage increase in excel:

$$= (Before - After) / Before \quad [7]$$

3.1 Result Measuring

The photo results obtained using the SEM inspection tool show that the metal is lifted from the top view of the pad at first bonding. Seen in the picture below in the left picture for good and the right for not good.

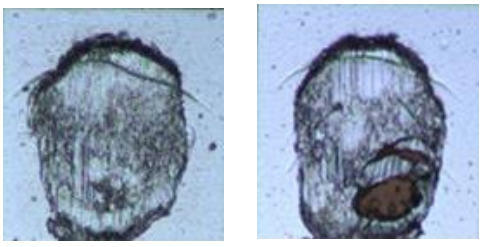

Figure 5 SEM Measuring Result

But the results of measuring instruments that are only seen from the top view are not enough to prove whether this defect is accepted or not to see the accept criteria on the chip, the results are needed to look inside. This is useful to see whether this lifted metal reaches metal layer 1 on the chip or not. To see the results of the inside view, an electron microscope inspection tool is needed.

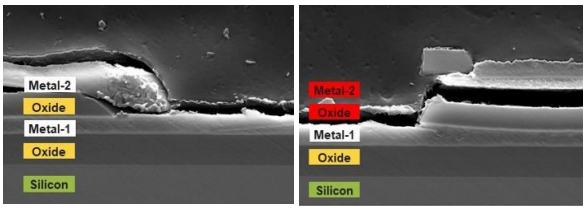

Figure 4 Electron Microscope Measuring Result

After being seen using an electron microscope measuring instrument, you can see the lifted metal on the chip. Lifted metal cannot only be seen from the top view only. because the condition of this lifted metal is that if the chip has not been chipped until it reaches silicon or metal 1 on the chip, it is still said to be acceptable. However, if it has been exposed to metal 1 and has reached the silicon, it is said to be defective. Inspection of the inside of the chip is needed to see the success of this defect whether the chip meets the criteria or not.

3.2 Data Collection and Analysis

The following is the data collection process to see before and after improved parameters from 600 lot samples. Where 300 lot samples for before and 300 lots for after. At the time of production for 300 lots itself does not take long, it only takes one month. For 300 lots before starting on January 6, 2024 and ending on January 27, 2024. As for 300 lots after starting from February 10, 2024 and ending February 28, 2024.

Table 4

Data Collection

Tailing at Bump	Overall Defect	Improved
Before Improve	3898	**99%**
After Improve	34	

Source: STAREP

The results of the data collection above with the same sample found defects tailing at bump before and after improve with different comparisons. With a total defect before improve amounted to 3898 units and after improve amounted to 34 units. With a 99% improvement success rate.

4. Conclusion

The conclusions obtained in this final project based on the results of the analysis of lifted metal defects in iMOTION devices at PT Infineon Technologies Batam. Based on the root cause analysis, the lifted metal defect on the HVIC chip is caused by improper machine parameters. This improper parameter causes the FAB (Free Air Ball) in the wire bond process to be asymmetrical. This unsymmetrical FAB has a long tail bump and causes an initial crack in the pad, hence the raised metal in loop formation. After improving the parameters by optimizing the spark and neo cutting parameters on the machine. Reduction of defects in tailing at bump also occurred in the 3 lot test from 157 defective units to 6 defective units in tailing at bump with an improved success of 96%. Furthermore, data collection was carried out on 600 lots with the same comparison before and after with the improvement of parameters, a decrease in defects also occurred in data collection with an improvement in success of 99%.

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Attachment

No	lot number	Qty	Tailing at Bump
1	ZA251029B28	7680	0
2	RU248004B02	7680	0
3	ZA251029B24	7680	0
4	RU242002B04	7680	0
5	1E248710B02	6459	0
6	RU236087B17	7680	0
7	RU242002B05	7680	0
8	ZA251029B28	7680	0
9	RU236087B24	2466	0
10	6A301000B13	4800	0
11	RU248004B03	7680	0
12	VA249887B08	4800	0
13	ZA251029B29	5760	1
14	RU236087B20	5760	0
15	6A301000B14	5582	0
16	RU242002B06	7680	0
17	ZA251029B25	7680	2
18	ZA251029B30	3677	0
19	1E250828B02	4800	0
20	VA249887B09	4800	0
21	RU236087B23	7680	0
22	RU248004B04	7680	0
23	RU236087B21	2603	0
24	ZA251029B24	7680	1
25	RU236087B21	2603	0
26	RU242002B07	2716	0
27	RU236087B24	2466	0
28	ZA251029B26	7680	0
29	VA249887B10	4800	0
30	RU242002B08	4245	0
31	ZA251029B30	3677	0
32	ZA251029B37	7680	0
33	RU248004B05	7680	0
34	ZA251029B29	5760	1
35	RU248004B06	2967	0
36	RU242065B01	7680	0
37	RU242005B01	7680	0
38	1E250828B03	2963	0
39	VA249887B11	4800	0
40	ZA251029B25	7680	2
41	ZA251029B27	3510	0
42	RU242065B02	7680	0
43	RU251097B04	7680	0
44	ZA251029B26	7680	0
45	RU242065B03	7680	0
46	RU242005B02	7680	0
47	ZA251029B38	7680	2
48	VA249887B12	4800	0
49	ZA251029B32	7680	0
50	RU251097B05	7616	0
51	ZA251029B37	7680	0
52	VA249887B17	4800	0
53	RU251097B06	2573	0
54	RU242005B03	7680	0
55	ZA251029B27	3510	0
56	ZA251029B39	7680	4
57	RU242065B01	7680	0
58	ZA251029B33	7680	0
59	ZA251029B33	7680	0
60	ZA251029B40	5233	0
61	RU242005B04	7680	0
62	RU242065B02	7680	0
63	1E250828B05	4800	0
64	VA249887B13	3000	0
65	RU201379B10	7680	0
66	ZA251029B34	7680	0
67	RU201379B11	2215	0
68	VA249887B14	4800	0
69	RU242005B05	7680	0
70	RU242065B04	7680	0
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72	RU242277B10	3335	0
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76	RU242065B05	7680	0
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80	RU242005B06	7680	0
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86	ZA251029B33	7680	0
87	VA250150B10	7680	0
88	RU242065B05	7680	0
89	RU242005B07	7887	0
90	RU242065B06	7680	0
91	ZA251029B40	5233	0
92	RU242065B05	7680	0
93	ZA251029B45	7712	0
94	RU250336B02	7680	0
95	1E250828B06	4546	0
96	RU242065B07	6488	0
97	ZA251029B43	7680	0
98	RU250336B03	5060	0
99	RU243102B01	7680	0
100	VA250150B11	4800	0

No	lot number	Qty	Tailing at Bump
101	RU242065B06	7680	0
102	VA250150B12	4800	0
103	RU243102B02	7680	0
104	RU242065B08	7680	0
105	ZA251029B34	7680	0
106	RU250336B05	7680	0
107	VA250150B13	4800	0
108	ZA251029B35	7680	0
109	ZA251029B53	7680	1
110	ZA251029B48	7680	0
111	RU243102B03	7916	0
112	RU242065B07	6488	0
113	VA250150B14	4800	0
114	ZA251029B35	7680	0
115	RU250336B06	6862	0
116	1E250829B01	4800	0
117	RU242065B08	7680	0
118	ZA251029B36	3500	2
119	ZA251029B54	5760	0
120	RU242065B09	7680	0
121	VA250150B15	4800	0
122	RU242065B08	7680	0
123	RU243102B04	7680	0
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173	ZA251029B52	3514	0
174	VA249887B26	4800	0
175	VA244348B09	4800	0
176	ZA251029B56	7680	0
177	RU241134B03	7680	0
178	VA249887B27	4800	0
179	RU239156B24	5455	0
180	1E250829B05	6261	0
181	ZA251029B50	7680	7
182	VA249887B28	4800	0
183	VA244348B10	4800	0
184	RU225178B22	7680	0
185	RU241134B04	7680	0
186	VA249887B29	2933	0
187	ZA251029B58	7680	0
188	VC306983B01	7200	0
189	ZA249216B03	7680	0
190	ZA251029B57	7680	0
191	ZA251029B59	7680	0
192	ZA249216B04	5760	0
193	VA244348B11	4800	0
194	ZA251029B60	3510	0
195	RU239156B23	5632	0
196	ZA249216B05	3678	0
197	ZA251029B51	7680	0
198	1E248710B03	4800	0
199	VA244348B12	4800	0
200	VC306983B02	6152	0

No	lot number	Qty	Tailing at Bump
201	RU225178B22	7680	0
202	RU225178B23	7680	0
203	ZA251029B52	3514	0
204	RU241134B05	7680	0
205	VA244348B13	4800	0
206	6A300877B31	4800	0
207	VC306983B03	6215	0
208	ZA249216B12	7680	0
209	RU225178B24	4800	0
210	RU241134B06	7680	0
211	ZA251029B58	7680	0
212	ZA249216B06	7680	0
213	6A300877B32	7680	0
214	RU225178B23	4800	0
215	RU241134B07	7680	0
216	ZA251029B59	7680	0
217	VA244348B14	7916	0
218	ZA249216B13	6488	0
219	RU219260B27	4800	0
220	VC305746B03	7680	0
221	1E248710B04	6862	0
222	ZA251029B59	4800	0
223	RU241134B08	4760	0
224	ZA249216B07	7680	0
225	RU225178B24	4800	0
226	6A300877B33	4800	0
227	ZA240017B10	3674	0
228	ZA249216B03	7680	0
229	ZA240017B10	7147	0
230	6A300877B34	3514	0
231	RU219260B28	4800	0
232	VC305746B04	4800	0
233	ZA249216B04	7680	0
234	ZA240017B11	7680	0
235	RU243106B01	4800	0
236	1E238876B01	5455	0
237	ZA249216B14	6261	0
238	6A300877B35	7680	0
239	ZA240017B11	7680	0
240	VC305746B05	7680	0
241	ZA251029B60	7680	0
242	RU219260B29	4800	0
243	RU219260B30	7680	0
244	ZA249216B05	4023	0
245	6A300877B37	2849	0
246	RU219260B27	4800	0
247	RU219260B27	8399	0
248	RU243106B02	7680	0
249	ZA249216B15	5577	0
250	ZA249216B09	4024	0
251	1E238876B06	5760	0
252	RU229197B25	2846	0
253	ZA249216B16	4800	0
254	ZA249216B12	7500	0
255	6A300877B39	7680	0
256	RU243106B03	7680	0
257	RU219260B28	4800	0
258	6A300877B40	4800	0
259	ZA249216B10	3296	0
260	1E238876B05	7680	0
261	RU229197B26	5760	0
262	VE248817B13	2112	0
263	RU243106B04	6472	0
264	ZA249216B06	4800	0
265	RU219260B29	7680	0
266	6A300877B41	2730	0
267	RU229197B27	7680	0
268	RU219260B30	4035	0
269	ZA249216B13	7680	0
270	6A300877B42	4800	0
271	RU243106B05	4982	0
272	1E238876B07	4800	0
273	ZA249216B11	7680	0
274	ZA249216B07	4800	0
275	6A300877B43	7680	0
276	RU229197B25	7680	0
277	RU229197B28	2882	0
278	RU229197B25	4760	0
279	1E238876B08	7680	0
280	RU241135B02	3728	0
281	VE248817B14	5760	0
282	ZA249216B18	3040	0
283	ZA249216B14	7680	0
284	6A300877B44	7200	0
285	RU229197B26	7680	0
286	RU232321B22	7680	0
287	RU241135B03	7680	0
288	6A300877B36	5760	0
289	RU229197B27	4800	0
290	ZA249216B09	3510	0
291	RU232321B23	5632	0
292	ZA249216B19	3678	0
293	1E238876B02	7680	0
294	6A300877B38	4800	0
295	VE248817B15	4800	0
296	RU229197B28	6152	0
297	ZA247106B94	6488	0
298	6A300877B45	7680	0
299	RU241135B04	5060	0
300	RU232321B24	7680	0

FORMULIR LOOGBOOK BIMBINGAN DAN PENGAJUAN
SEMINAR PROPOSAL/SIDANG TUGAS AKHIR*

Nama : Nada Rindiani
NIM 3222101012
Pembimbing I : Nanta Fakih Prebianto, S.ST., M.Sc.
Judul : Analysis of Lifted Metal Improvement at Wire Bond Process for iMOTION Device

No	Hari/Tgl	Rincian Kegiatan	TTD Pembimbing I & II	
1	Kamis, 16 Mei 2024	Pembahasan jurnal, dan bab3		
2	Selasa, 28 Mei 2024	Pembahasan fishbone, serta mejelaskan hasil penyebab masalah pada penelitian		
3	Selasa, 25 Juni 2024	Pembahasan hasil jurnal, dan hasil data pada penelitian		
4	Jumat, 28 Juni 2024	Perbaikan jurnal pada fishbone, table data, persentase data		
5				
6				
7				
8				
9				
10				

Berdasarkan hasil bimbingan yang telah dilaksanakan selama 2 bulan dan telah disetujui oleh dosen pembimbing, maka dengan ini saya mengajukan diri sebagai peserta ~~Seminar Proposal~~ /Sidang Tugas Akhir*.

Batam, 28 Juni 2024
Peserta

NIM: 3222101012