Scrap Analysis on Econo Pim 3 Module

Final Project

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Abstrak

Modul Econo pim 3 adalah salah satu produk manufaktur yang memiliki ringkasan fitur yang baik sep- erti kepadatan daya tinggi, tersedia sensor suhu terintegrasi dan modul yang sesuai dengan RoHS. Modul econo pim 3 juga memiliki keunggulan berupa konsep modul yang ringkas, waktu dan biaya siklus pengembangan pelanggan yang optimal, fleksibilitas konfigurasi, dan modul econo pim 3 dapat diterapkan pada kontrol dan penggerak motor, pemanas dan pengelasan industri, serta AC ruangan. Namun dengan semua kelebihan tersebut modul econo pim 3 harus melalui proses yang panjang, pada saat proses pembuatan modul ditemukan scrap atau tidak layak pakai, dari sekian banyak pros- es pembuatan sistem proses penyolderan ditemukan bottle neck scrap. Tujuan dari penelitian ini ada- lah untuk mengetahui penyebab utama terjadinya cacat pada modul econo pim 3 pada saat proses penyolderan sistem dan menganalisis cacat yang terjadi. Penelitian ini menggunakan metode fish- bone, yang mana fishbone ini tentunya sangat membantu dalam mengetahui penyebab dari cacat yang terjadi. Diagram tulang ikan, disebut juga diagram „sebab-akibat", adalah alat yang digunakan untuk mengidentifikasi akar penyebab suatu masalah yang mewakili akibat dan faktor-faktor atau sebab-sebab yang mempengaruhinya. [1]

Kata Kunci : *Cacat, Modul Pim 3, Proses Penyolderan Sistem, Diagram Tulang Ikan*

Abstract

Econo pim 3 module is one of the manufactured products that has a good summary of features as highs power density, integrated temperature sensor available and RoHS- compliant module. Econo pim 3 module also has advantages as compact module concept, optimized customers development cycle time and cost, configuration flexibility and econo pim 3 module can be applied to motor control and drives, industrial heating and welding and room air conditioners. But with all that advantages econo pim 3 module must go through a long process, during the manufacturing process the module is found scrap or not suitable to use, from many manufacturing process system soldering process is bottle neck of scrap found. The purpose of this research is to find the root cause of econo pim 3 module defects during system soldering process and to analysis defects that occur. This research uses the fishbone diagram method, which fishbone diagram is certainly carried help full in knowing the cause of the defects occurs. Fishbone diagram, also called as 'cause-and-effect' diagram, is a tool used to identify the root cause of problems which represents the effect and the factors or causes influencing it. [1]

Keywords: *Defects, Pim 3 Module, System Soldering Process, Fishbone diagram*

Introduction

Infineon cegled hungary is a company that produces many products, which one of its products is econo pim 3 module. Integrated Power Module (IPM) is a power electronics packaging strategy which extends the concept of multichip modules (MCMs) to high power electronics assemblies, with the idea being that the control and power circuitry components are integrated together into a single compact power module [2]. Econo pim 3 module is usually applied to motor control and drives, heating ventilation and air conditioning, industrial heating and welding [3].

System soldering itself is a process to installation dcb with solder pad to baseplate which will become a module, based on author experience during the system soldering process found several defects modules were found, the author's findings state that not all defects that occur are categorised as scrap.

Author used fishbone diagram method to find the main cause of the defect. Fishbone diagram is a common tool used for a cause and effect analysis to identify a complex interplay of causes for a specific problem or event. The fishbone diagram can be a comprehensive theoretical framework to represent and analyse the sources of innovation [4].

Literature Review

1. Sytem Soldering Process

One of the processes at Infineon Cegled is the system soldering process. This process has a purpose to combine a DCB, solder pad and baseplate in a jig, after finishing combining we insert in to vadu machine, but before we insert to vadu machine, we need to carrying out the process of installation must same with drawing module. Module checking criteria in the soldering process:

1. DCB is firmly attached to the baseplate

2. No scratches on the baseplate

3. The existing wire to the DCB is not bent

4. Uneven soldering can cause damage to the baseplate

5. No broken parts on the edge of DCB

In Infineon use VADU 300XL for combine all material, VADU 300XL is equipped with three separate process chambers and internal substrate handling with inline carrier transfer for highly efficient series production. The system enables void-free solder connections with preforms and / or pastes in a continuous process. The reproducibility of the soldering processes is guaranteed by permanent process control. [5]

2. Econo Pim 3 Module

EconoPIM modules are characterized by a high integration of different functionalities. For example, each contains a three-phase rectifier, a brake chopper, a three-phase inverter and a NTC thermistor for temperature measurement. With a blocking voltage of 1200 V, the new EconoPIM 3 reaches a maximum current rating of 150 A – the highest current in the market for this design.[6] Each EconoPIM™ module integrates a rectifier bridge, a brake chopper and an inverter stage. The Econo housing features a copper base plate for optimized heat spread and includes a thermistor (NTC).[7]

3. Pareto Chart

The concept of the Pareto principle was developed in the 19th century by the economist Vilfredo Pareto. who noticed that 80% of the land in Italy was owned by just 20% of the population.Moreover, he found that 80% of production usually came from only 20% of the companies. This led him to a general hypothesis that 80% of the results are originated from 20% of the factors or causes that influence the results. The Pareto principle, which is also known as the rule of 20/80, has become an important quality tool, recognized by the American Society for Quality (ASQ) as one of seven basic quality tools for process improvement.[8] A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant.[9]

4. Check Sheet

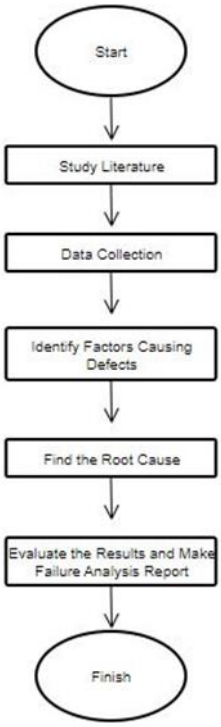
A Check Sheet is an important tool for effective data collection and analysis. It is a form used to collect required data in a systematic and organized manner.[10] These are usually associated with menial tasks of recording defect events; it can be beneficial for recording expected items in the process, displaying the performance of the process, identifying causes of the defect event, and revealing trends or patterns in the defect events.11]

5. Fishbone Diagram

A fishbone diagram, also known as an Ishikawa diagram or a cause-and-effect diagram, is a visualization tool for categorizing the potential causes of a problem.[12] A fishbone diagram is a cause-and-effect discovery tool that helps figure out the reason(s) for defects, variations or failures within a process.[13] To create the diagram, the effect (symptom) is written at the head of the arrow. Potential causes (theories) are then added to complete the diagram. A common set of major categories of causes consists of personnel, work methods, materials, and equipment.[14]

Methods

1. Design



the first step taken by the author is to conduct a study literature, after conducting a study literature the author collects the necessary data to find out what defects occur during the system soldering process. After finding the defects that often occur, the author looks for the root cause of defects that often occur using fishbone diagrams, after the root causes are found the author takes the last step is make a failure analysis report.

1. Pass Criteria

Error Type	Description	Criteria
Solder Splash	Solder splash on DCB	Solder splash in DCB trenches is not allowed.
Voids in module soldering	Voids in system soldering	The void under chip, which is lighter than DCB color, is a system soldering void. If the system soldering void exceeds the accepted size, the module shall be scrapped. Decision criteria: The width tolerance of voids is 2,4 mm.
Lifted DCB	Unmelted soldering plate	The soldering plate is not melted if a definite contour (sharp contrast) is visible at the edge of the substrate. We have to check the module with the naked eye too to make sure of defect. In such cases, other modules from the affected soldering form shall be checked 100% by naked eyes Decision criteria: The angular tolerance is less than 10 degree and the distance of the DCB is not adjacent
DCB mechanical damaged	Broken or cracked DCB	Broken or cracked DCB are not allowed
Damage or dent / imprint	Scratch on baseplate	One piece scratch is accepted on the bottom of the baseplate. If its length is max 30mm (measure by control template) and its convexity is not higher than 20 Micron. Visible copper in scratches is not allowed. Control template 20 Micron straightedge shall be used to the

		evaluation.
Burn Module	Burn module	Burn module are not allowed
Damaged wires	Damaged wires	Damaged wires are not allowed

3. Tool and Material

a. Vadu 300XL

Parameter Profile	Temperature	Pressure	Time
Chamber 1	240 ˚C	225 mbar	230 s
Chamber 2	330 ˚C	950 mbar	230 s
Chamber 3	45 ˚C	1000 mbar	230 s

b. X-ray 2.5

The X#-platform series is an inline automated X-ray system which covers a wide range of AXI applications. It is a flexible platform with very versatile fields of use depending on the application requirements. The inspectable applications range from component level inspection for wire bonds, large SMT boards, high-power electronic modules up to fully assembled modules. [15]

c. Direct Copper Bond (DCB)

DBC (Direct Bonded Copper) substrates have been proved over many years to be the most cost effective and reliable solution for circuits in power electronics. The bases of these substrates are ceramics, either alumina or aluminium nitride.[16] The DBC process takes advantage of the copper – oxygen eutectic where the melting point is lower than that of pure copper or oxide ceramic. At the melting temperature the eutectic is the only liquid present, it wets and bonds to both surfaces. At 1065°C – a liquid copper-oxygen eutectic will form on the surface of the copper.[20]

d. Baseplate

Baseplate is one of the main materials used to make the Econo Pim 3 Module. One of the main functions of the baseplate is to provide mechanical support for the electric components and the DBC substrate. At the same time, it must propagate the heat generated by the semiconductor chips to the external heat sink effectively. A high degree of surface smoothness is also required to guarantee no voids between the baseplate and the DBC substrate, because voids can cause hot spots that will eventually lead to cracking and poor reliability.[17]

e. Solder Sheet

SnAgCu (SAC) solder is being offered as a lead-free termination finish. SAC finish is obtained by dipping the terminals of components into molten SAC solder. However, the reliability of solder joints formed with SAC solder refinished components needs to be determined in order to evaluate the effects of the SAC solder refinishing process. [18]

Solder sheet is an important component in making modules because the solder sheet functions to unite between the DCB and the Baseplate. the solder sheet used by pim 3 module is 2A006/SnAg3,5Cup RE38,5x31,9x0,3mm.[19]

f. Jig

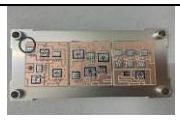
Jig is one of the important Component in making econo pim 3 module because the jig is used to combine all components to become a module. The jig itself has many Size, so every time want to use the jig, it must be in accordance with the module author want to make. If it is not appropriate it can create defects.

Result and Discussion

1. Result

a. Table of Defects

No	Type of Defects	Defect Image	Category of Defects	Next Action
1	Hollow Soldering DCB		Minor	If the void is still in accordance with the pass criteria, do re-soldering
2	Lifted DCB		Minor	If the lifted part is still in accordance

				with the pass criteria, do re-solder-ing
3	Solder Splash		Major	This defect cannot be re-paired refer to pass criteria
4	DCB Mechanical Damage		Major	This defect cannot be re-paired refer to pass criteria
5	Damage Wires		Major	This defect cannot be re-paired refer to pass criteria
6	Scratch Baseplate		Minor	Using a special sponge we can rub the part of the baseplat e that has scratch to re-move the scratch
7	Burn Module		Major	This defect cannot be re-paired refer to pass criteria

After we find defects that occur during the system soldering process, we can categorize the module can still be re-soldered referring to chapter 3 sub chapter 3.2 Pass Criteria.

b. Check Sheet

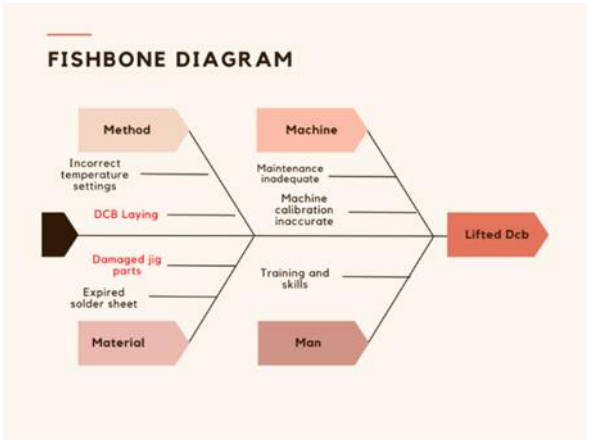
Based on the observation results, it was found that the defect configuration was not only 1, further observations were needed to categorize, so that the most frequent defects were found during the system soldering process, the data in the table is taken from July – December, the data is presented as follows:

Project Name: Analysis of the Defect's
Name of Data Recorder: Stephen
Location: Infineon Technologies AG Cegléd kft
Data Collection Dates: 23-12-2023

Defect Types/ Event Occurrence	Month						TOTAL
	July	August	September	October	November	Desember	
Hollow Soldering DCB	4	5	7	6	7	2	31
Lifted DCB	9	14	11	8	7	11	60
Solder splash	3	6	6	3	7	5	30
DCB Mechanical Damage	1	2	1	0	1	3	8
Damage Wires	0	1	2	1	0	1	5
Scratch Baseplate	1	0	3	2	0	5	11
Burn Module	0	0	1	1	0	3	5
TOTAL	18	28	31	21	22	30	150

It was found that the total of defect data was 60 types of defects lifted DCB. This defect is the most common defect during the production process. next we use the pareto chart to determine how much influence a defect has during the system soldering process.

c. Fishbone Diagram



Factor	Problem	Verification	Remark	Occurrence Per-

				cent
Ma-chine	Mainte-nance inade-quate	Insufficient and irregu-lar ma-chine mainte-nance.	Schedule machine checks and re-pair ma-chines according to proce-dures.	1
	Machine calibration inaccurate	Inaccurate calibration of the vadu 300XL machine, leading to inappropri-ate tem-peratures.	Calibrate the vadu 300Xl machine regularly.	1
Man	Training and skills	Lack of operator training and skills in the DCB laying process and ma-chine op-eration	Provide regular training to operators	4
Meth-od	Incorrect tempera-ture set-tings	Improper tempera-ture profile settings, tempera-ture that are too high or tempera-ture that are too low	Deter-mine the right tem-pera- ture pro- file.	2
	DCB Lay-ing	DCB placement that doesn"t match to jig.	Do the checking after put-ting the DCB.	7
Mate-rial	Dam-aged jigs part	There are broken parts of the jig.	Perform periodic checks on jig.	7
	Expired solder sheet	Quality of an expired solder sheet af-fects its melting point.	Always check the expired date be-fore using solder sheet.	1

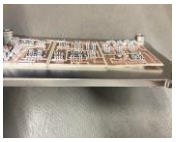
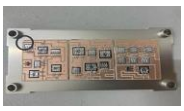
After analyzing using the fishbone diagram, 2 factors were found to influence the occurrence of lifted DCB, that is from material and method, for the method factor is DCB laying and for the mate-rial factor is a damaged jig.

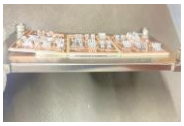
2. Failure Analysis Report

2.1 Description

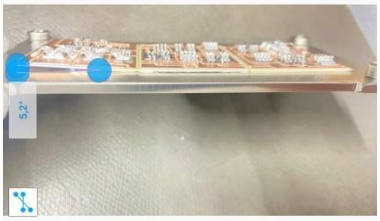
The soldering system Vadu 300XL is equipped with three separate process chambers and internal substrate handling with inline carrier transfer for highly efficient series production. DCB are crucial components that provide electrical insulation and thermal management in power modules. A lifted DCB can result in compromised electrical performance, overheating, and potential system failure.

2.2 Analysis data that was found

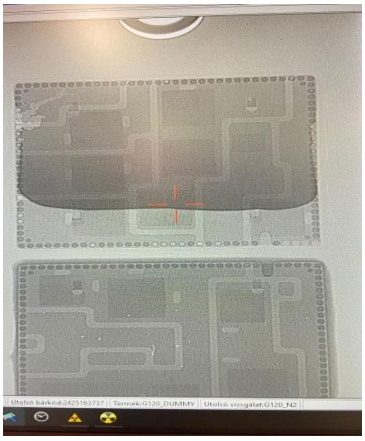
No	Type of Lifted DCB	Picture of De-fects	Explanation of Defects
1	DCB too close with another DCB		Lifted DCB are found with the characteristics of the DCB are close together, lifted like this cannot be re-soldered be-cause the dis-tance between DCB is too close.
2	Lifted DCB with dam-aged ce-ramic parts		Lifted DCB like this cannot be re-soldered because refer-ring to sub chap-ter 3.2 pass crite-ria explains that DCB with dam-aged ce- ramic is catego- rized as scrap

3	The usu- al Lifted DCB		Lifted DCB like this can still be re- paired but re- ferring to the pass criteria its lifted not ex- ceeding 10 de- grees.

2.3 Lifted DCB with Degrees

No	Picture of Lifted DCB	Description of Lifted DCB
1		The de- gree angle on the lifted dcb is 6°, which means that the lifted can still be re- soldered.
2		The de- gree angle on the lifted dcb is 2,7°, which means that the lifted can still be re- soldered
3		The de- gree angle on the lifted dcb is 5,2°, which means that the lifted can still be re- soldered.
4		The de- gree angle on the lifted dcb is 4,2°, which means that the lifted can still be re- soldered.

2.4 Results X-ray



The picture in the result of the lifted dcb module being x-ray. Darker colours indicate better solder- ing results while lighter colours indicate less good soldering results

2.5 Root causes

After analysing using fishbone diagram author found 2 root causes that affect the Lifted DCB, as described below:

1. Material

The damaged part of the jig is the root causes from material, usually there is a small part of the jig that is damaged so that the operator doesn't realise when placing the DCB on the jig, which results in the Lifted DCB.

2. Method

In the method section related to placing the DCB, during the process of placing the DCB into the jig operator doesn't follow the method or procedure that applies in the company. Operators often place the DCB carelessly which results in a Lifted DCB.

Conclusion

After analysis it was found that Lifted DCB is a Defects that often occurs in system soldering process, and after further analysis it was found that the lifted DCB have 3 different types namely lifted DCB which is close to each other, lifted DCB whose ceramic breaks, and only lifted DCB. After re-analysis, it turns out that the first and second types of defects are declared scrap according to pass criteria and the third type can be replicated if the lift is <10 degrees. After analysis using fishbone diagram the root causes come from material (Damaged jig parts) and method (DCB Laying).

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FORMULIR LOOGBOOK BIMBINGAN DAN PENGAJUAN SIDANG TUGAS AKHIR*

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Judul : scrap analysis on econo pim 3 module

No	Hari/Tgl	Rincian Kegiatan	TTD Pembimbing I
1	Friday, 22 March 2024	Brainstorming about the title	
2	Friday, 29 March 2024	Review progress after first mentoring -Add journals in abstract and change keywords	
3	Friday, 05 April 2024	Review progress. - collect data related to the title - change problem, objectives and limitations	
4	Friday, 12 April 2024	Review progress. - make fishbone diagram - make check sheet	
5	Friday, 19 April 2024	Review Progress. - Improved fishbone diagram and added a table explaining fishbone diagram	

6	Friday, 26 April 2024	Review progress. - Change flowchart	
7	Friday, 03 May 2024	Review chapter 4 and review citation	
8	Friday, 10 May 2024	Review chapter 4 and review citation	
9	Friday, 24 May 2024	Review root cause, corrective action, Failure analysis Report and chapter 5	

10	Friday, 31 May 2024	Final review, review bibliography.	

Berdasarkan hasil bimbingan yang telah dilaksanakan selama 3 bulan dan telah disetujui oleh dosen pembimbing, maka dengan ini saya mengajukan diri sebagai peserta Sidang Tugas Akhir*.

Batam, 3 Juni 2024
Peserta

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