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Improvement of Manufacturing Yield through Gemba Approach: A Case Study in an Integrated Circuit Package Assembler Company

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Abstract

Technology is improving every day, and digitalization is one of the key items that can be used to innovate products with advanced technology. This has also increased the demand for IC packages. OSAT companies struggle to achieve high manufacturing yields as this is one of their KPIs to get more business and improve their reputation. Moreover, the COVID-19 pandemic has brought consequences to the market and caused a shortage of IC packages. Therefore, OSAT companies need to work on improving their manufacturing yield. In this qualitative research, an OSAT company was selected as the research target to find out the main contributors causing manufacturing yield loss and the contribution of Gemba approach in improving manufacturing yield. A series of interviews was carried out and all the data was analysed using NVivo 12 plus analysis software. Four themes have been identified as the main contributors to manufacturing yield loss: Environment, Man, Machine and Method. On the other hand, three themes have been identified on the contribution of Gemba approach in improving manufacturing yield. Using NVivo 12 plus analysis software, both the main contributors of manufacturing yield loss and the contribution of Gemba approach in improving manufacturing yield were able to link together, as shown by framework metrics.

Keywords: Outsourced Semiconductor Assembly and Test (OSAT), Gemba Approach, Integrated Circuit (IC), IC Packaging, Manufacturing Yield

Introduction

The semiconductor industry is a critical component of modern technology, providing the building blocks for a wide range of electronic devices. This industry is highly competitive as companies constantly seek ways to improve product quality, efficiency, and manufacturing yields. One of the key players in the semiconductor industry is the Outsourced Semiconductor Assembly and Test (OSAT) industry, which provides services such as packaging and testing of semiconductor devices. The OSAT industry faces several challenges in improving

manufacturing yield, including increasing demand for high-performance devices, more complex packaging requirements and product quality.

An integrated circuit (IC) is the fundamental building block of all modern electronic devices. It is an integrated system of multiple miniaturized and interconnected components such as capacitors, resistors, transistors and diodes which are embedded into a thin substrate of semiconductor material, usually silicon. They are commonly used as amplifiers, oscillators, timers, counters, logic gates, computer memory, microcontrollers or microprocessors (Awati, 2021). Physically, an IC comprises a thin film layer of electronic components with interconnecting wires forming on s silicon substrate's surface. Functionally, ICs can be designed as either digital devices such as logic gates, microcontrollers or microprocessors, or analogue devices, including audio or instrumentation amplifiers as well as mixed-signal devices which combine both analogue and digital functionality (Charig, 2022). Examples of daily products that use IC include automotive products such as cars and motorcycles, computers, smartphones, televisions and other products that involve electronic parts. Integrated circuits are typically fragile and do not have any connectors or pins to connect to a circuit board. Therefore, in IC Packaging processes, chip carriers will be used to protect the delicate structure of the integrated circuit and thus provide pin connectors (Ayodele, 2022). The IC market has a value of USD 37.76 billion in 2019 and is expected to increase from USD 40.94 billion in 2023 to USD 77.89 billion by 2031, with a compound annual growth rate (CAGR) of 8.37% over the forecast period (2024-2031) (IC Packaging Market Size, Growth & Trends Report 2031, 2024). The Integrated Circuit Packaging Market Share by Region for 2019 through 2031 reveals a persistent rise across global regions, with North America consistently atop others throughout. Noteworthy in its ascent comes Asia Pacific closely behind the incumbent. Generally, the integrated circuit packaging industry appears destined for extensive proliferation, propelled by technological strides and heavy requirements across diverse fields. Asia Pacific stood proudly at the forefront of bold innovation and popularization (Raje, 2024). The IC packaging will either be processed by the Original Equipment Manufacturer (OEM) company or an Outsourced Assembly and test (OSAT) company, including outsourcing companies and contract manufacturing companies that provide assembly and electrical test services.

Manufacturing yield is a critical metric for the semiconductor industry as it measures the percentage of goods produced from raw materials. It determines the semiconductor industry's profitability and competitiveness, especially for OSAT companies. This is because the manufacturing yield of OSAT companies will affect their business when their customers are looking for OSAT companies to provide assemble and test services for IC packages. A higher manufacturing yield indicates that the manufacturing line is more stable, less waste is produced, and higher quality will attract more customers. The manufacturing yield in OSAT is affected by various factors, such as process variation, equipment reliability, and operator skills, which affect the quality of the products. Improving the manufacturing yield in OSAT is essential to ensure the quality and reliability of semiconductor products and to meet the growing demand for electronic devices.

One of the ways to improve manufacturing yield is by applying the Gemba approach. The Gemba approach is a lean management tool developed by Toyota and has been widely used in the manufacturing industry to improve efficiency and product quality, reduce waste, and

increase manufacturing yields. It is defined as going to the actual location where the work is being done, observing the processes, and identifying areas for improvement, for example, the production floor in manufacturing, the job site on a construction project, the operating room in a hospital and the kitchen of a restaurant. This approach is based on the principle that the best way to improve a process is to observe it in action and identify areas where waste and inefficiencies can be eliminated, and areas that need further improvement. Gemba's approach has several benefits, including identifying process and procedure gaps, promoting continuous improvement, and improving efficiency. The Gemba approach also promotes a culture of continuous improvement whereby employees are encouraged to identify inefficiencies and waste and develop solutions to address them. This can lead to sustained improvements in efficiency and productivity over time. In manufacturing industries, the Gemba approach is a popular approach to denote the action of seeing the actual process, understanding the work, asking questions, and learning from those who do the work. It is an opportunity for the management and support staff to take a break from their daily office-tasks and walk to the floor of their workplace to identify the problems or process gaps that caused the manufacturing yield loss. Once the management and support staff identify the problems or process gaps during the Gemba approach, they can develop improvement actions to solve the problems or process gaps to improve manufacturing yield.

Based on the analysis report shown in Figure 1.1, the trend and forecast for the advanced IC packaging market are increasing globally. A few reasons lead to this increasing demand for IC packages. First, the rise of technologies. Nowadays, things have become more advanced as technologies, especially electronics, have developed. There are more products that plug electronic components and IC packages into their design to gain more advanced functions. For example, autonomous driving in Tesla vehicles, safety features in cars, and additional or stronger functions of smartphones and laptops. All these technologies required IC packages such as microcontrollers and microprocessors to run. Therefore, as the types and numbers of technologically advanced products keep increasing, the demand of IC packages will also increase rapidly. Next is the pandemic of Covid-19. As mentioned above, the pandemic of Covid-19 had caused many factories to shut down, especially in 2020 when they stopped the production line. This led to a shortage of IC packages, and this IC shortages issue continues until today.

Figure 1.1: Trends and forecasts for global advanced IC packaging market (Source: Advanced IC Packaging Market Trends and Forecast, 2022)

The company that was selected for this research is a contract manufacturing OSAT company located in Penang, Malaysia, which was given the name Company A due to confidentiality issues. Company A provides IC Packaging services to their customer in the field of assembly as well as electrical testing. Manufacturing yield is one of the company's primary KPIs, as this is one of the considerations when the customer chooses a subcontractor to provide assembly and electrical test services. In general, manufacturing yield will be affected by product quality. If the product does not meet the quality standard stated in ISO 26262, the products need to be rejected and, thus causing manufacturing yield loss. Therefore, improving manufacturing yield and product quality is the team's main task, including manufacturing, engineering, and quality assurance, and this activity needs to be carried out continuously. In this research, the assembly side of this company will be on the study target as most of the manufacturing yield loss is caused by assembly processes.

Figure 1.2 shows the overall assembly processes in Company A. Company A provide assemble services to three main types of IC packages namely Leaded, QFN and BGA. The assembly processes for Company A are divided into two parts which is Front-Of-Line (FOL) and End-Of-Line (EOL). FOL processes started from Wafer Taping Process until 3rd Optical Gate whereas EOL processes started from Mold Plasma until Final Visual Inspection (FVI). From Figure 3.2, all the IC packages undergo the same processes in FOL. However, when reaching EOL, all three types of packages had split into different EOL processes
due to package design. Overall, the assembly processes had been categorized into two types: fully automatic and semi-automatic. Key assembly processes of this company are Die Attach, Wire Bond, Mold, Forming, Package Saw and Ball Mount as these processes are considered critical which the chance of creating waste and causing manufacturing yield loss is high.

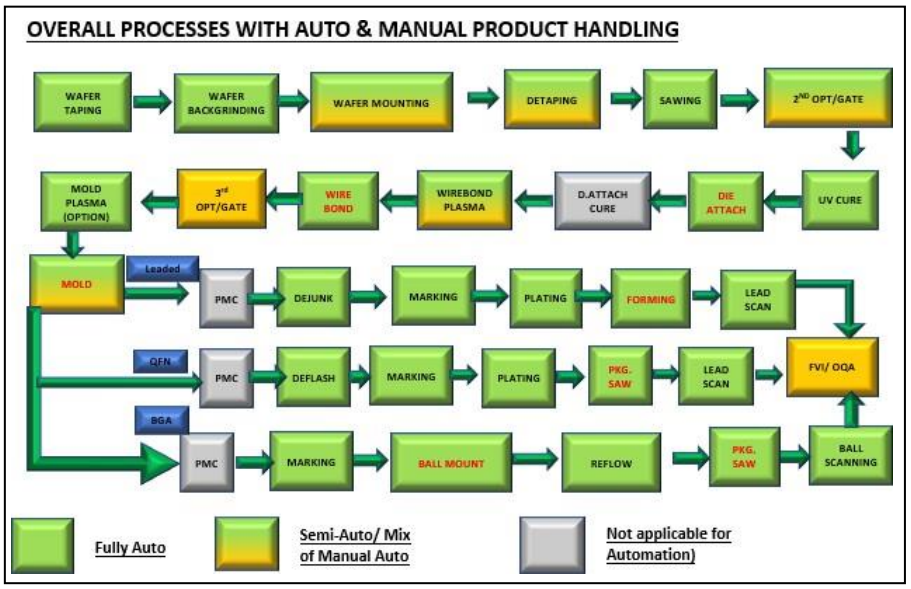

Figure 1.2: Overall Assembly Processes in Company A.

Figure 1.3 shows the manufacturing yield of the research target company which is Company A in 2022 by months. From the figure, the manufacturing yield of Company A in year 2022 is fluctuating with a maximum of 99.84% of manufacturing yield in May and August and minimum of 99.76% of manufacturing yield loss in January 2022. From the data above, the manufacturing yield of Company A still got a lot to go to achieve the target of 99.85%.

Therefore, Company A needs to improve its manufacturing yield so that it can achieve its manufacturing yield target.

Figure 1.3: Manufacturing Yield of Company A in 2022 by Month

Therefore, this research aims to investigate and understand how the Gemba approach can improve the manufacturing yield of OSAT. By addressing this problem, this research can provide valuable insights into applying lean management methodologies in the OSAT industry and contribute to improving the manufacturing yield in OSAT. Based on the above discussion, the research objectives (RO) are as follows:

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RO 1: To identify the main contributors that affect manufacturing yield in OSAT

RO 2: To understand how the Gemba approach improves manufacturing yield in OSAT company.

This study will contribute to the existing knowledge on applying the Gemba approach in the semiconductor industry and provide valuable insights into the factors that affect manufacturing yield in OSAT. Theoretically, this research contributes to the growing body of knowledge on lean manufacturing methodologies and their application in the semiconductor industry. Gemba's approach which emphasizes continuous improvement and waste reduction through a focus on the shop floor is an important tool in lean manufacturing. On the other hand, this research can contribute to developing the Lean Six Sigma framework, which aims to reduce variability and defects in the manufacturing processes. This research is able to show how the Gemba approach can be integrated into Lean Six Sigma framework to enhance the effectiveness of process improvement efforts.

On the other hand, this research can also provide insights into how the DMAIC (Define, Measure, Analyze, Improve, Control) process of Lean Six Sigma can be applied in conjunction with the Gemba approach to improve manufacturing yield in OSAT. By applying DMAIC, OSATs can define the problems, measure the extent of the issues, analyze the root cause, implement solutions and control the processes to provide real-time insights into the manufacturing processes and identify opportunities for improvement. By conducting this research and demonstrating the effectiveness of the Gemba approach, it can provide insights on how the Gemba approach can be integrated into the Lean Six Sigma framework to improve manufacturing yield at OSAT.

Literature Review

Inline with the chosen topic, some articles related to quality management approach have been reviewed, including lean management, six sigma, DMAIC approach, and Kaizen.

Lean Management

Lean management was originated in the Toyota Production System (TPS) Toyota developed. Ohno (1998), defined lean management as "the complete elimination of waste so that all activities create value for the customers.". While lean management aims to reduce waste and optimize efficiency, its focus on sustainability makes it far more than a cost-saving technique (Wittine et. al., 2024). According to Al-Rifai (2024), the production lead time was dramatically decreased from 18.22 days to only 68.2 minutes, and the production throughput was increased from 40 to 77 units per shift. These improvements not only alleviated overtime expenses but also called for and reduced work-in-process inventory and space requirements leading to improved productivity with significant cost benefits.

A study by Chen et al (2015), examined the application of lean management to the packaging process in an OSAT company by using the Gemba approach to identify areas for improvement in the packaging process. The outcome of this study shows that lean management principles led to a significant improvement in manufacturing yield from 92.5% to 95.5%. Another study conducted by Chen et al (2018), examined the application of lean management to the backend assembly process in an OSAT company. In this study, the Gemba approach is used to identify the areas for improvement in the assembly processes. This study had found that implementing lean management principles improved manufacturing yield from 96.5% to 97.5%.

Additionally, Hu et al (2016), examined the application of lead management to the wire bonding process in an OSAT company. This study used the Gemba approach to identify areas for improvement in the wire bonding process. As a result, the researchers found that implementing lean management principles significantly improved manufacturing yield from 96.8% to 98.3%. Another study conducted by Lin et al. (2017), examined the application of lean management to the wafer sort process in an OSAT company. This study uses the Gemba approach to identify areas for improvement in the wafer sort process. It shows that implementing lean management improved the manufacturing yield from 97.8% to 98.6%.

The application of lean management to the semiconductor industry has significantly improved manufacturing yield. The Gemba approach, which involves going to the place where the work is done and observing the work processes to identify areas for improvement, has been a key element in the success of lean management in the semiconductor industry. The studies reviewed in this literature review provided evidence that applying lean management principles to specific processes within an OSAT company can lead to significant results.

Six Sigma

Six Sigma is a data-driven approach to process improvement that seeks to reduce defects and process variations. The semiconductor industry has adopted Six Sigma to improve quality and reduce costs. It has been applied to various aspects of the semiconductor manufacturing process, including wafer fabrication, assembly and testing (Kumar et al., 2016).

A study by Chai et al (2011), found that Six Sigma could be used to identify and reduce the root cause of yield losses in the OSAT industry. Next, another study by Huang et al (2015) explored the integration of Six Sigma and Lean Principles in the OSAT industry. The study found that integrating Six Sigma and Lean principles could help OSAT companies improve their quality, reduce cycle time, and increase efficiency. In a study by Huang et al. (2017), Six Sigma was used to improve the yield of a semiconductor packaging process in an OSAT company. By applying DMAIC framework, they identified the root causes of manufacturing yield losses. They implemented solutions to address them, resulting in a significant improvement in yield and a reduction in defects after implementing Six Sigma. The Six Sigma DMAIC approach was implemented by Tsarouhas and Sidiropoulou (2024) in a packaging production system, which resulted in an 8.24% increase in the production process, yield.

In conclusion, Six Sigma is a quality management methodology that seeks to improve the quality of processes, products and services by reducing the occurrence of defects or errors. Six Sigma has been used in OSAT to improve manufacturing yield by identifying and addressing the root cause of defects. Using DMAIC framework and statistical tools, OSAT companies able to identify the root causes of manufacturing yield losses and implement effective solutions to address them. The application of Six Sigma and Lean Principles, along with Gemba approach can further enhance the effectiveness of the improvement process. The studies reviewed in this literature review highlight the potential of Six Sigma and Gemba approach in improving manufacturing yield in the OSAT industry and demonstrate its successful application in various contexts.

DMAIC Approach

DMAIC is an acronym for Define, Measure, Analyze, Improve and Control. It is a process improvement methodology used in Six Sigma, which is a data-driven approach to quality improvement that aims to eliminate defects and reduce variability.

In 2018, Li et al (2018), conducted a study and found that the DMAIC process effectively identified the root cause of defects and implemented solutions that led to a significant improvement in manufacturing yield. Another study by Goh et al (2019), on improving the manufacturing yield of a semiconductor testing process in an OSAT company also concluded that DMAIC effectively improved the manufacturing yield by identifying the root cause of defects and implementing solutions on the root causes. A similar study had done by Tan et al. (2020), on the application of the DMAIC process in improving the yield rate of a semiconductor assembly process in an OSAT company. This study showed that DMAIC is an effective process to identify the root cause of manufacturing yield losses and implement solutions that improve the company's manufacturing yield. A study by Reddy Gangidi (2019), concluded that the DMAIC methodology, properly executed under an experienced Six Sigma project team with the support of management, is a powerful tool that can reduce process variations and improve product yields, eliminating waste and improving customer satisfaction.

In conclusion, the DMAIC process is an effective problem-solving methodology that has been widely applied in the OSAT industry to improve manufacturing yield. In the OSAT industry, improving manufacturing yield is essential to the company's success. Previous studies have

shown that the DMAIC process effectively identifies the root cause of defects and implements solutions that lead to significant improvements in manufacturing yield.

Kaizen

Kaizen is a Japanese term that translates to "continuous improvement" or "change for the better". It is a philosophy and management approach that focuses on making incremental improvements in processes and operations to enhance efficiency, productivity and quality. Over time, Kaizen has gained popularity in various industries, including manufacturing, whereby it is employed to improve manufacturing yield and overall performance. Moreover, Kaizen is a management strategy that is designed to achieve a competitive edge by continuously learning (Samadhiya et al., 2023) and incrementally improving processes in every organisation (Chwist & Ingald, 2024).

Several studies have explored the application of Kaizen in OSAT companies to enhance manufacturing yield and overall performance. For example, Lin et al. (2017) investigated the implementation of Kaizen activities in a semiconductor packaging company. The study found that by involving employees in Kaizen initiatives and adopting the Gemba approach, the company achieved a significant reduction in defects and improved manufacturing yield. Another study conducted by Lim et al (2019), had examined the impact of Kaizen on the yield of microelectronics manufacturing process in an OSAT company. This study had revealed that continuous improvement efforts through Kaizen resulted in reduced cycle times, increased process efficiency and improved manufacturing yield.

Gemba Approach

In Japanese Gemba means "true places" (Desenvolvimento, 2021), in other words, it refers to where the real action occurs. Gemba can be summarized by the words of Toyota Chairman Fujio Cho which is "Go see, ask why, show respect" (Shook, 2021). Management and support staff team need to observe what is happening at the work places while showing respect to the people that involved, especially those doing the real value-creating work of the business (Shook, 2021).

In 2014, Manuel F. Suarez-Barraza performed research on applying the Gemba-Kaizen approach in a multinational food company (Suarez-Barraza et al., 2014). They had concluded that there are various benefits in using methodological approaches such as Gemba-Kaizen for process innovation which is shown by the experience of the multinational food company in this research. They also found out that the Kaizen improvement team had yielded greater benefits because it was based in the workplace and could directly observe all the activities representing waste in the manufacturing processes.

In summary, Gemba approach is the fundamental improvement approach before any organization move on to implement other improvement approaches such as Kaizen and DMAIC. To implement improvements approaches in manufacturing industry and solve problems such as product quality or manufacturing yield, first the root cause of causing the problems need to be identified. Gemba approach is one of the most effective ways to identify the root cause of problems as it involves observation in the manufacturing processes as well as receive feedbacks from operators who perform hands on activity to the machines and they are the first gate to detect any problems or abnormality in the production line. Therefore, the

company had started to use Gemba approach in the initial stage of improving manufacturing yield.

Methodology

In qualitative research, the processes involved are in the sequence of identifying research topic and research questions, selection of sampling and site, data collection, data analysis and write up. In this research, the topic that had been decided was Improvement of Manufacturing Yield Through Gemba Approach: A Case Study in An Integrated Circuit Package Assembler Company. During selection of sampling and site, since this is qualitative research, therefore only a small sampling of interviewees is needed for data collection. Interviews were carried out to the selected interviewees for data collection purpose. Then, all the interview scripts will be analyzed by using NVivo 12 Plus software and proceed to write up process.

This research employed a case study qualitative approach. This is because this research will focus on one company whereby the data collection sample will be in small samples through interviews with related persons in the company. The objectives of this research are to study the main contributors that cause manufacturing yield loss in an outsourced semiconductor assembly and test company as well as to improve manufacturing yield in the company. Both objectives show that this research will examine a phenomenon that complied to the purpose of conducting qualitative research. On the other hand, while performing this research, the researcher will be the primary data collection tool by conducting interviews to related persons. All these above characteristics had shown that this research is qualitative instead of quantitative.

Case Study Strategy

A case study is an empirical in-depth inquiry about an individual, family, group or organization. It is mainly used to explain causal links in real-life intervention that are too complex for either the survey or experimental strategies. In case study strategy, it includes questions or propositions, units of analysis, logic linking the data to the questions or propositions as well as the interpretations of the outcome. A case study can be reported as a single case or as a compilation of a series of cases.

In this qualitative research, case study strategy will be used. By definition, case study strategy is used to explain real-life intervention. In this research, the researcher will perform data collection by interviewing related person in the company on the real-life issue. The interview will mainly focus on the topic of manufacturing yield such as what is the manufacturing yield, what causes manufacturing yield loss and what is the action will be implemented to overcome this issue. At the end, after implement Gemba approach, the manufacturing yield will become a monitoring data to monitor the effectiveness of the improvement plans.

Data Collection

This research was conducted by using the Interpretivism research philosophy with total duration of six months. In the first month, an online study was conducted on the current trend of global demand on semiconductor devices as well as the challenges they faced, which is manufacturing yield. In the second

month, employees of Company A were invited to participate in this research. The employees responded and agreed to participate in this research. In third month, a literature review was conducted and methodology of this research was identified. In the fourth and fifth months, visits to Company A for interviews and participating in Gemba walk organized by the company were carried out. In the sixth month, data analysis and theme analysis of the data was carried out to determine the main contributor of manufacturing yield loss in Company A as well as to understand how Gemba approach can improve manufacturing yield in Company A.

Sampling Technique

The main focus of this research paper is on the main contributor of manufacturing yield loss and improvement of manufacturing yield in the company through Gemba approach. Therefore, the sampling method used in selecting interviewees is a purposive sample. The inclusion criteria applied while identifying interviewees for this research are company employees which directly or indirectly involved in the performance of manufacturing yield. In Company A, there are three main functional area that are directly or indirectly involved in the performance of manufacturing yield: manufacturing, engineering and quality assurance. The manufacturing department is responsible for producing output for the company and monitoring manufacturing yield. Next is the engineering department, which is always working on process and machine-related issues to reduce the quantity of rejects produced by their process or machine, contributing to the manufacturing yield. Lastly is the quality assurance department. Manufacturing yield and quality are interrelated, whereby quality of products will affect manufacturing yield. Therefore, the quality assurance department is important as a third party to monitor the process and machine performance in terms of quality, which indirectly contribute to manufacturing yield. For each functional area, we will select Managers, Managers, Engineers and Executive to perform interviews, depending on the allocation of positions in the department, as shown below list:

Table 3.1
List of Interviewees

Functional Area	Position	Number of interviewees
Manufacturing	Manager Executive	1 1
Process Engineering	Manager Engineer	3 4
Quality Assurance	Manager Engineer	1 2

Interview

A semi-structured interview is a combination of structured and unstructured interviews. In a semi- structured interview, the interviewer has a general plan for what they want to ask and what data is needed. However, the questions do not have to follow a particular phrasing or order. This type of interview is often open-ended, allowing for flexibility but following a predetermined thematic framework. Semi-structured interviews will be a good fit for the research if the researchers have prior interview experience and the research questions are exploratory.

In this research, semi-structured interviews were carried out through face-to-face and phone interviews so that the researcher could obtain trustworthy data and information to the interviewees with direct access to information sources. As mentioned above, the semi-structured interview questions are exploratory, and the answers can help guide researchers in future research, which is what this research needed. By conducting interviews, the researcher will be able to understand how the manufacturing yield affects the company and what will happen if this issue continues. On the other hand, by interviewing experts in the industry, the researcher can gain information and details on this industry which will further help in this research activity.
Interview questions for this research are defined to ensure the research objectives will be achieved and are tabulated in Table 3.2

Table 3.2
Interview Questions

Research Objective	Interview Questions
RO1: To determine the main contributor on the manufacturing yield loss in an outsourced semiconductor assembly and test (OSAT) company	Could you define manufacturing yield loss from your perspective in your company? What are your perceptions of the importance of yield loss on the company's operations performance? How does yield loss affect the company's operations performance? Could you explain your experience where you have observed or dealt with the company's yield loss? What is the main contributor to the manufacturing yield loss in an outsourced semiconductor assembly and test (OSAT) company? What is the improvement action or approach did you have taken to eliminate the main contributor you detected? Is the improvement action you had implemented able to help improve manufacturing yield?
RO2: To understand how Gemba approach can improve manufacturing yield in an outsourced semiconductor assembly and test (OSAT) company	Could you define the Gemba approach from your perspective? Do you think Gemba approach is able to help improve the manufacturing yield? In your opinion, how to improve manufacturing yield in an outsourced semiconductor assembly and test (OSAT) company through Gemba approach? Had you applied Gemba approach in your process before? If yes, does it help in reducing defects and improve manufacturing yield? What is the process gap that you had encounter during Gemba approach which will affect manufacturing yield? What had you done for the process gap that you identified through Gemba approach? Is the manufacturing yield improved after applying Gemba approach?

Data Analysis

In this research, data collection will be performed in real environment whereby the collect data is most often verbal and not numerical, which is in words form. In this research, thematic analysis will be used as the foundational method of data analysis. It is a qualitative data analysis method that involves reading through data set such as transcripts from in interviews or focus groups, and identifying patterns in meaning across the data to derive themes (Braun and Clarke, 2006). Thematic analysis involves an active process of reflexivity whereby a researcher's subjective experience plays a central role in meaning making from data. It is a flexible approach to qualitative analysis that enables researchers to generate new insights and concepts derived from the collected data and information. Basically, there are six steps to perform thematic analysis:

Familiarize the data
Create initial codes
Collate codes with supporting data
Group codes into themes
Review and revise theme
Write narrative

In this research, the NVivo 12 plus analysis package was selected and used to perform data analysis through coding process. It is a qualitative data analysis software that can be used to collect, organize, analyse and visualize unstructured or semi-structured data. NVivo able to help researchers to import data in a range of file format, organize demographic data, code sources, capture ideas, run queries and visualize project items. All of this will reduce the complexity and simplifies the arduous tasks in coding process and make the thematic analysis bearable.

The data analysis of this research started with familiarize and transfer all the interview scripts into NVivo 12 plus software. Then, all the data was encoded. In this phase, all the data with similar meaning is classified by standardized codes for further analysis. After this process, a theme will be created which used to classify the codes that created earlier. Then, all the themes will be further analyzed so that to see whether any theme able to be further combined into subtheme. These processes will be continuous until a thematic web with the main themes was obtained to determine the main contributors of manufacturing yield loss in OSAT companies.

Findings and Discussion

Demographic Profile of Participants

To conduct this research, three key departments had been selected to perform interview as discussed in Section 3 Methodology under subtopic Sampling Technique.

Manufacturing

In manufacturing department, one manager and one executive were selected. Their role in the company is to produce output by planning of machine and operator allocation based from loading forecast.

Manufacturing Manager in Company A is a forty-two years old man who had work in this company for twenty years whereby he has experience in this field for twenty-two years. He in-charge of the entire process in the company and two executives reported to him who in charge of FOL and EOL respectively. A twenty-minute interview was conducted with him to collect data for this research. Next is Manufacturing Executive who has twelve years of experience in this field and worked for eight years in this company, aged thirty-six. The interview was conducted with a duration of fifteen minutes.

Engineering

A total of seven interviewees was interviewed in engineering department which consists of three Senior Managers and three Senior Engineers, covering entire manufacturing processes including FOL and EOL, with two Managers and two Engineers from FOL and the rest from EOL. The role of engineering department is to work on process and machine related issues to reduce the quantity of rejects produced by their process or machine which in turns contributing to the manufacturing yield.

First interviewee for engineering department is the Senior Manager who is responsible for two of the key processes in FOL, aged forty-nine with an experience of twenty-seven years of experience in this field whereby eight of them are from Company A. The engineer from same process had selected for interview as well, which is a thirty-two years old Senior Engineer with five years of experience in this field which are all gain from Company A. The interview session for both were conducted in parallel and it took a total of 25 minutes.

Next is Senior Manager from another key process at FOL, a thirty-night years old Filipino with seventeen years old experience in semiconductor industry and had served Company A for twelve years. Several engineers reported to him in this company and one of the them was selected to involved in this study as well. She is a thirty-eight years old Senior Engineer that had served for thirteen years in Company A which is her first working company. The interview session for both were conducted in parallel and it took a total of 30 minutes.

Lastly is from EOL processes whereby a Senior Manager and a Senior Engineer was selected. The Senior Manager is a forty-six years old man with experience of twenty-two years in this field and worked in Company A for six years. The Senior Engineer reported to him, a thirty years old man with seven years experiences in semiconductor field which gain from this company. The entire interview session for this group was around 40 minutes.

Quality Assurance

The role of quality assurance in Company A is to monitor the process and machine performance in terms of quality which indirectly contribute to manufacturing yield as well. In this department, two person was selected whereby one is Senior Manager and another one is Engineer who reported to him.

The quality assurance Senior Manager is a fifty-two years old man with twenty-eight years of experience and worked in Company A for three years whereas the engineer that reported to him is a twenty-seven years old engineer with an experience of 3 years in semiconductor company and had worked in Company A for three years since graduated from university. It took twenty-five minutes for interview with both of them.

Main Contributors of Manufacturing Yield Loss in Company A
In this research, two key items are the focus which is the main contributors of manufacturing yield loss in Company A as well as to understand how Gemba approach can improve manufacturing yield in Company A.

"Manufacturing yield is important for us as it will increase our reputation in global market, attract more customers and produce revenue. Therefore, our team always working on solving issues that will impact on the manufacturing yield and this activity is continuously carried out." (EOL Engineering Manager)

Through interviews and data analysis using NVivo 12 plus software, four main themes had been identified after careful consideration. These main themes were identified through 4M1E analysis which represent machine, man, method, material and environment. These themes represent the categories of factors which affect manufacturing yield loss in Company A. In this research, the four themes that able to identified are environment, man, machine and method, as shown in figure below:

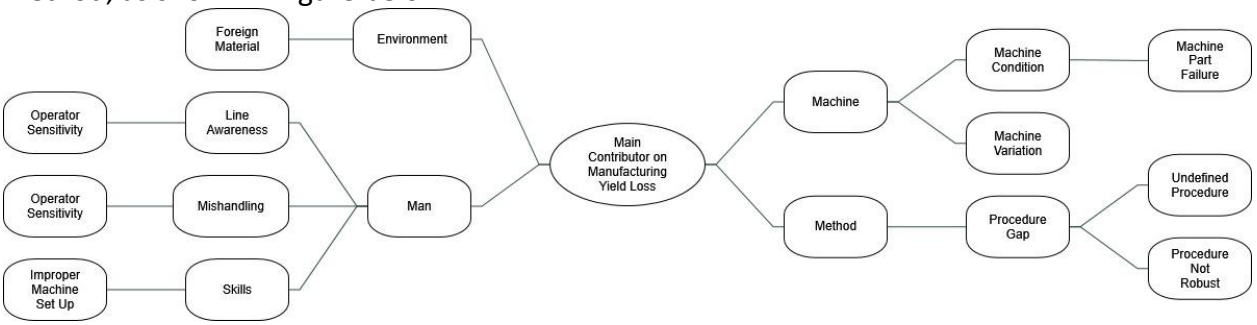

Figure 4.1: Nodes Diagram on Main Contributor of Manufacturing Yield Loss in Company A (NVivo Output)

Theme 1: Environment
Based on the finding and interview outcome, the environment is one of the contributors that causes manufacturing yield loss. The environment can be defined as the surrounding condition in the production line where the IC packaging process is carried out. Based on the interview outcome, there is one key process whereby environment is causing most of the manufacturing yield loss: Wire bond process. During the wire bond process, gold or copper wire will be bonded between lead and IC areas. This is to link up a connection between IC area and the substrate area as the preparation of Printed Circuit Board (PCB) mounting process.
"Foreign material is the main contributor of manufacturing yield loss in the wire bond process. This is because foreign material will lead to a lot of quality issues such as non- stick on pad (NSOP) and non-stick on lead (NSOL)." (FOL Engineering Manager)

FOL Process Engineer also commented on this:
"Not only NSOP and NSOL, if the foreign material is attached after the wire bond process, it will cause wire shorting at the IC packages as well."

Based on above comments by the Wire bond team in Company A, before wire bond process started, any foreign material that is attached to lead or die will cause the wire not to be bonded at either side. When this happens, there will be no connection built between IC and the substrate, and this will lead to an open circuit and electrical cannot be connected

(Michael, 2019). This will cause the IC package to fail as an Open in Open & Short (OS) electrical test and thus causing manufacturing yield loss. On the other hand, any foreign material is attached to the wire during or after wire bonding, and if the material is conductive, it will create a short circuit which will fail as Short in OS electrical test (Michael, 2019). This also will lead to quality issues and thus affecting manufacturing yield.

In fact, foreign material always exists in the environment, which cannot be prevented. Therefore, Company A monitors on the foreign material by performing particle count check every shift to ensure the amount of foreign material is still within control.
"We perform particle count check every shift and make sure the particle count does not exceed our specification limits. If the particle count reading exceeds the specification limit, we will shut down our line to perform 5S activities." (Quality Assurance Engineer)

However, it doesn't mean that foreign material cannot be reduced. If there are proper control and improvement actions, there are still possibilities to ensure the foreign material amount still within control. Besides monitoring, the team also perform Gemba in the production line so that they are able to brainstorm and provide improvement actions to reduce the foreign material.

"Through Gemba walk in the line, we had identified several opportunities for improvement to reduce foreign material. We had implemented off-shoe control, install double air shower and material air shower to reduce foreign material. In fact, after implementation of these improvement actions, data shows that the manufacturing yield had improved in my process." (FOL Process Engineer)

The above statement shows that by performing Gemba approach in production line, the team identified opportunities for improvement on their main contributor of manufacturing yield loss, which is foreign material. Through a series of improvement actions, the particle count reading was reduced, and less quality issues happened due to foreign material, which caused an improvement in manufacturing yield.
"My next plan is to build and install clean room with more advanced technology which able to further reduce foreign material brought from outside into the production line." (FOL Engineering Manager)

Although the manufacturing yield in the wire bond process had been improved through a series of improvement activities, a series of improvement plans will still be ongoing as long as there are any opportunities for improvement found through Gemba approach.

Theme 2: Man

The next theme that able to be identified in this research is Man. Man or human is the key resource in the manufacturing industry as they are needed to operate the machine, fix the machine, perform machine set up, perform inspection, perform machine buyoff and other roles. As all these activities are performed manually, there is high chance for humans to make mistakes, leading to manufacturing yield loss. Three subthemes had been identified through this main theme: line awareness, mishandling and skills.

Line awareness refers to how sensitive the operators and technicians on detecting abnormality in the production line. Through Gemba walk in the production line, the team had identified that some of the operators are having low sensitivity on the quality awareness and this will lead to non-detection on any quality issue, thus the affected machine or procedure will still continue runs and end up causing a lot of losses in manufacturing yield.
"Operators in the line are lack of quality awareness. Some of them who lack in quality awareness will be not sensitive enough to report any abnormality to their supervisors, thus causing quality issues and lead to manufacturing yield loss especially excursion case." (Quality Assurance Manager)

When any abnormality happens, for example, abnormality in the machine, the first gate of detection will be the one who operates it, which is the operator. Therefore, the operator is the first gate of detection when any abnormality happens and stop the bleeding by shutting down the affected machine. Therefore, if the operator's sensitivity is high, he or she will be able to detect abnormalities easily and have a high chance of preventing manufacturing yield loss. Therefore, briefing on quality awareness is important as a refresher training for operators to increase their line awareness and reduce manufacturing yield loss.

"Monthly quality awareness briefing will be carried out and all the operators need to perform test to evaluate their quality awareness." (Quality Assurance Manager)
The next subtheme that was identified is mishandling. While operators are performing the manual activity as mentioned above, there is a risk for them to have mishandling issue as observed through Gemba walk by team members in Company A. Operator mishandling will leads to many types of quality defects which the affected IC package need to be yielded off and thus affecting manufacturing yield.

"The main contributor on the manufacturing yield loss in my process is human mishandling. During operator performing inspection on wire-bonded IC packages which haven't been moulded, there are risks for operators to accidentally touch the unprotected wire and causing wire defects which need to be yielded off." (FOL Process Engineer)

EOL Manufacturing Manager also commented this:
"On the other hand, operator handling issue will cause manufacturing yield loss as well. This is because there are a lot of possibilities when the products are handled manually as this is human dependent." (EOL Manufacturing Manager)

From the interview, team members of Company A identified many areas with risk for their operator to encounter mishandling issues. Drop magazine, drop strips, units drop, touching wire on unmoulded IC packages and scratches on packages are examples of mishandling issue that happened in Company A which able to observed through Gemba approach. Therefore, improvement actions have been come out to resolve mishandling issues. Apart from performing monthly quality awareness briefing, the team also conducted a CCTV audit to monitor operator performance and make sure they did not repeat similar mishandling issues in the production line.

"I performed CCTV Audit on human mishandling, issue finding to operators who fail to follow procedure." (Quality Assurance Engineer)

However, the above action done by Quality Assurance team is considered a lagging indicator, which means that when any finding was found during the audit, it was too late as the affected product might be run in process days or even weeks ago. Therefore, improvement action that can prevent mishandling issues must be in place. Through Gemba approach and internal discussion outcome, automation will be the best solution eliminating, if not reducing, the frequency of manual handling and reducing the chance of mishandling.

"…changing from manual to automated process so that able to reduce manual handling." (Quality Assurance Engineer)

The next subtheme that related to Man is the skills, especially on technicians' skills. In a manufacturing production line, each process will have several numbers of machines, from four machines to hundreds of machines per process. To fully utilize the machine capacity, each machine will be qualified to run several types of products from several customers. When there is a need to change the type of products run in certain machine, technicians need to perform machine conversion as different types of products might use different tooling and parameters even if the process is the same. EOL Manufacturing Manager stated:

"Machine performance is the main contributor of manufacturing yield loss. Machine with no proper set up and buyoff will create rejects and cause manufacturing yield loss."

EOL Engineering Manager further explain on the machine conversion as below:
"High machine and equipment conversions will contribute to the manufacturing yield loss. This is because during machine conversion, technician will need to perform mechanical changes to the machine and might leads to accuracy problem"

Above statements are the observation from the team members when they performed Gemba walk in the line by monitoring technician performance and audit on the machine set up as well as machine buyoff data. On the other hand, EOL Engineering Manager also have found that high turnover and insufficient technical training also contribute to weak machine set up and leads to manufacturing yield loss:

"High turnover and insufficient technical training to technician will leads to improper machine set up which causing machine to product rejects and decrease the manufacturing yield." (EOL Engineering Manager)

Through this observation on the root cause of weak machine performance, the team had developed improvement actions to solve the above issue. Manufacturing teams revise their manufacturing plan to minimize machine conversion to ensure process stability and reduce the chance of improper machine set up and buyoff.

"I had dedicated machine to run specific products, therefore able to reduce conversion frequency." (EOL Manufacturing Manager)

On the other hand, EOL Manufacturing Manager also work with engineering to develop Recipe Management System (RMS) to prevent improper machine set up. In short, RMS is a system that will automatically identify the type of products that will run in the machine and

will auto select the recipe or parameter for that particular type of product. This system able to prevent wrong recipe or parameter selection when technician performing machine set up.

“I had worked with engineering team to implement Recipe Management System (RMS) to prevent improper machine set up as well as on the auto-selection of machine recipe for different products.” (EOL Manufacturing Manager)

However, when the loading is high, the manufacturing team must perform multiple machine conversions to clear the loading and thus will have a high frequency of machine conversion. To resolve this, the Engineering team has come out with an improvement action to improve technician skills:

“I had developed a Guru Program to enhance the new technician setup skill whereby there will be an experienced technician to teach and monitor the skills of new technician when they performing machine set up.” (FOL Process Engineer)

Through Guru Program, technicians’ skill can improve as they are granted with an experience technician to teach them all the skills and monitor their performance by performing on-job examination. However, the in-line technicians are not from the machine maker, therefore, their skills are still limit which is based from their experience and the training provided by machine maker. Therefore, technical training from machine maker also will helps in improving technician skills:

“Besides that, I always request equipment vendor to provide more technical training to my engineers and technician so that they will have more understanding on the machine.” (FOL Engineering Manager)

Based on the interview outcome, all the team members including engineering, manufacturing and quality assurance team agreed that Man is one of the main contributors that causing manufacturing yield loss. However, through Gemba approach, the team able to figure out the specific root cause as per stated in the subtheme and they are able to implement improvement actions based on their observation to improve manufacturing yield.

Theme 3: Machine

Next, the theme that had been identified through the interview is on Machine. Machine is the key tool in the manufacturing process whereby all the processes in the manufacturing production line is done by machine. For example, die attach, wire bond, mould, laser mark, ball attach and package saw. Therefore, machine performance is important to ensure the output of the machine which is the product, meets internal and customer expectations. Any failure in machine part as well as input variation will cause quality issue on the product.

Generally, machines are built up of different parts which namely machine parts. Therefore, through this research, a subtheme was able to be identified which is machine part. Machine part mechanical part is made up of various types of material, mostly wear and tear. Since the price of machines is expensive and the number of machines is a huge number, therefore, that is unlikely for the company to replace new machine in a certain period of time as long as the machine still able to produce output and will not cause any safety issue. Some machines even

run twenty-four hours daily for more than twenty years and are still functioning. However, there are chances for machine part failure especially those old machines and will cause quality issues to the products.

“In my opinion, the main contributor of manufacturing yield loss is machine parts malfunction. When machine parts malfunction, machine cannot run smoothly and will product rejects which causing manufacturing yield loss.” (EOL Process Engineer)

From above statement, machine part failure will cause the machine not able to run smoothly as expected and will produce defect product. Furthermore, if the machine is old, there will be more parts having risk of failure due to wear and tear which having higher risk to create defect product and affecting manufacturing yield.

“In my opinion, machine is the main contributor for manufacturing yield loss in my process, especially old machines which their function and performance had reduced over the time.” (FOL Engineering Manager)

By performing Gemba approach, engineers and the management team will have a chance to interview operators especially on machine performance. Operators operate the machines and will know if any machine always encounter machine part failure and causing automatic shutdown. Therefore, through interview, the team members able to identify the list of machines which always causing problem and perform tighter monitoring to the machine performance. Then, the team members able to brainstorm on the improvement actions that can be applied to prevent if not reduce the frequency of machine part failure, which is early detection before excursion happens. Based on the discussion outcome, one of the improvement actions will be review on preventive maintenance frequency especially for old machine and quality assurance department need to perform audit on the machine to ensure all the preventive maintenance activities is completed in time.

“Preventive Maintenance schedule plan with tighter control need to be applied to old machine especially those having high downtime. This can be done by reviewing the preventive maintenance frequency of machine parts and monitor their performance. If necessary, increase the frequency of preventive maintenance.” (EOL Process Engineer) “I perform audit in machine part preventive maintenance, issue finding to those machine owner who did not perform preventive maintenance on time.” (Quality Assurance Engineer)

However, above improvement action only able to capture abnormality when performing preventive maintenance activity especially those part without alarm triggering. There are still risk of undetected machine part failure which will cause excursion to the manufacturing yield. Therefore, another improvement plan had been proposed by the team which is on the real time signal capturing so that able to monitor the critical machine part performance in real time.

“To quantify input signal by collect data / signal motor phase current with real time monitoring. With real time monitoring of machine performance, any abnormality on the machine will be detected in real time and prevent the machine to produce more rejects.” (EOL Process Engineer)

Next, through this research, another subtheme was able to be identified is machine variation. As mentioned above, there are many manufacturing processes in the production line of Company A, and the number of machines for every process can be vary from four machine per process to hundreds of machines per process. Among such a huge quantity of machines in every process, all the machines will have different characteristics, even the same model of machine also will encounter slight variation between each other. Variation of machine input such as parameters, tools, and mechanical parts will product different output. Since the same type of products will be process at different machine even though same process, every machine needs to be tuned separately so that the output of all the machine will be same, preventing quality issue and manufacturing yield loss.

Through Gemba walk, the team will be able to monitor or inspect themselves on the output of the machine which is the product and find out whether there is any difference between the products produced by different machine and also to check whether they encounter any quality issues. At the same time, the team members also able to interview operators, especially those in charge of multiple machines in their own process.

“I had found machine to machine input variation as the gap when performing Gemba approach” (FOL Process Engineer)

Following up on the finding of machine variation, improvement actions was implemented to identify machine variation and link it to different types of products. This will able to avoid manufacturing yield loss which caused by machine variation.

“To regroup problematic device and perform DOE to solve quality issue. Every type of product required different machine parameter to process and those products are processed in different machine. By performing DOE, we able to identify machine variation and link to different types of products.” (FOL Process Engineer)

Based on the discussion above, we can conclude that machine is one of the major contributors that result in manufacturing yield loss. At the same time, we also can conclude that through Gemba approach, the team members able to identify the root cause of manufacturing yield loss and implement improvement actions to improve the manufacturing yield.

Theme 4: Method

The last theme that was identified through this research is Method. Method is referring to the particular procedure for accomplishing or approaching something. In Company A, every activity that have defined procedure will fall under method. However, all those defined procedures were set by human, so it might not be perfect. Therefore, all the procedure gaps need to be identified and close to reduce the risk of manufacturing yield loss caused by method.

Through Gemba approach, several procedure gaps had been identified by the team members. This is because the team members will go to production line and witness by themselves how the operators performed all in-line activities and also get feedback from operator if they found any procedure gap. Most of the findings are related to procedure gap on operator handling activities. Below is the comment from FOL team:

"The process gap that I found during Gemba approach was operator handling procedure during inspection of the product. Since the product is unmoulded, their inspection on the product and handling needs to be more careful" (FOL Engineering Manager)

The same goes to EOL portion whereby the comment from EOL Manufacturing Manager as below:

"During Gemba approach, operator inspection method and tooling use for inspection are the gaps that will leads to quality issues as well as excursion cases."

From above statements, it can be concluded that there are procedure gaps along the manufacturing process including FOL and EOL.

One example provided by one interviewee is that operator was instructed to perform inspection on the product, however there is no procedure on how to perform inspection as well as the tool that need to be used for this inspection. Therefore, instead of performing inspection using jig, operator will just take the product using their hand to perform inspection. In this case, there will be risk for operator whereby their hand might touch the product especially unmoulded product and causing wire damage. If the operator use jig to perform inspection, then their hand will not be touching the product and thus the risk of causing damage wire will be much lower.

Through this finding on the procedure gap, the team members had performed internal discussion with operators to come out with a solution to close the procedure gap. From the outcome of the discussion, the best solution will be removing all the non-value-added activity so that able to eliminate the risk of inducing defects.

"I had discussed with my team as well as manufacturing team and quality assurance team to remove non-value-added flow to eliminate the risk of inducing defects." (EOL Engineering Manager)

However, not every activity is non-value-added and most of the activity is still critical and needs to be practiced continuously, such as performing product inspection as part of the machine performance monitoring. Therefore, for these kinds of unavoidable activities, there are solutions to close the gap which is properly defined the procedure and prepare any tools that required to perform that particular activity.
"To design jig or tools which more suitable for the inspection activity and able to reduce handling issues." (FOL Engineering Manager)

In summary, manufacturing yield loss can be caused by procedure gaps not properly defined by the previous person-in-charge or whoever defined the procedure. All these procedure gaps need to be solved as these procedures mostly defined for operator. If the procedure is not detail or still have gaps, there will be risk for operator to make mistake and impact the manufacturing yield.

Improvement of Manufacturing Yield in Company A through Gemba Approach

Figure 4.2 shows the nodes diagram of the research on the contribution of Gemba approach in improving manufacturing yield. Based on interview outcome and data analysis using NVivo software, three themes can be defined: Observation, Teaming and Value Added.

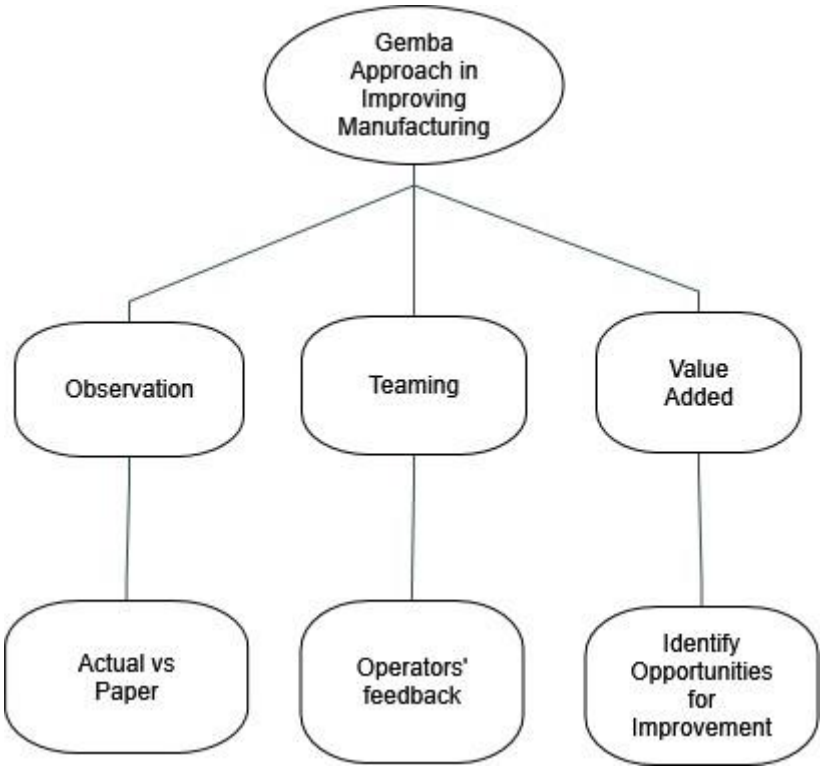

Figure 4.2: Nodes Diagram of the research (NVivo Output)

Theme 1: Observation

The first theme that was identified through this research is Observation. The key concept of Gemba approach is going to the actual location where the work is being done, observing the processes, and identifying areas for improvement. This can be further elaborate as comparing what actual happen in the manufacturing production line with what was written in documents, and thus a subtheme of Actual vs Paper was identified.

Below are some of the comments of the interviewees on their thought of how Gemba able to contribute in improving manufacturing yield.

“Gemba involve in-line observations whereby we are able to found out real issue in line rather than discussing in meeting without any real observation.” (Manufacturing Executive)

“Gemba approach able to help in understanding the actual vs paper or document, and the team able to validate the procedure or process set up by them in the line” (FOL Engineering Manager)

“Engineers need to be personally attended the issue rather than based on paper analysis and Gemba walk will build more experience and collect more evidence based on actual facts, help in instead brainstorming on solution and improvement ideas” (EOL Engineering Manager)

"Instead of brainstorming with the team in the meeting, Gemba approach able to give overview on actual line scenario and can get the feedback from the line people." (EOL Process Engineer)

By referring to above interview statements, the interviewees agree that Gemba approach is a suitable approach for them to perform analysis on the root cause that causing manufacturing yield loss as well as to brainstorm on the improvement actions that can be done to improve manufacturing yield. This is because instead of talking and discussing in meeting at the office, hands-on will be more effective as the team members able to do, observe and explore themselves on the main contributors of manufacturing yield loss as well as improvement action that can be done.

Theme 2: Teaming

The next theme that was identified by this research is Teaming. Gemba approach is not only limited to going to production line and observe, it also created a chance for the team members to talk with the operators and receive their feedback as a team. Operators are the one always stays in production line, operating machines and perform product inspection as well as creating revenue to the company. Therefore, they are the one having deepest understanding on everything that happen in the production line. By talking or interview operators, the team member will able to have a lot of findings and suggestion which they never think off. Through this, a subtheme of Operators' feedback was identified.

"Gemba approach involve operators to contribute on providing suggestion and problem in line whereby they are the one that do the process and they might more understand the gap." (FOL Process Engineer)

In summary, the team members are able to get a lot of information from the operators as they always stay in production line and they know everything that happen inside. Therefore, Gemba approach needed to further extend to interview with operator instead of limiting it to observation.

Theme 3: Value Added

The last theme that was able to be identified is Value Added. As mentioned above, Gemba approach able to help the team members to identify the main contributors that causing manufacturing yield loss. Through brainstorming during Gemba, the team members will come out with new ideas or new opinion which they never thought before. After the team member identify the main contributors, improvement actions can be done to eliminate if not reduce the risk. On the other hand, instead of improvement actions based on main contributor of manufacturing yield loss, the team members will able to identify any OFI that they think needed to be improved in production line as well.

"Gemba approach able to identify opportunity for improvement in the production line, then the team able to perform corrective actions or improvement activities." (FOL Process Engineer)

In summary, Gemba approach not only able to help identify root cause of any issue, it also able to help the team members to identify any OFI that can be implemented to further increase the manufacturing yield.

Summary of Finding

As summary, the management of Company A shall understand factors that will contribute to manufacturing loss by applying Gemba approach, including Man, Machine, Method and Environment.

Through observation, four types of main contributors of manufacturing yield loss in Company A were identified: Man, Machine, Method and Environment. In Man, several subthemes were identified, including mishandling, operator awareness and technician skills. All these subthemes represented the root cause of manufacturing yield loss in Company A which able to be observed through Gemba activity in Company A by the team members. In Machine part, machine condition and machine variation contributed to the manufacturing yield loss in Company A. On the other hand, Method was contributed by handling procedure whereas foreign material contributed to Environment.

The next Gemba concept was Teaming. four types of main contributors of manufacturing yield loss in Company A were identified: Man, Machine, Method and Environment. In Man, several subthemes were identified, including mishandling, operator awareness and technician skills. All these subthemes represented the root cause of manufacturing yield loss in Company A which able to be observed through Gemba activity in Company A by the team members. In Machine part, machine condition and machine variation contributed to the manufacturing yield loss in Company A. On the other hand, Method was contributed by handling procedure whereas foreign material contributed to Environment.

Figure 4.3 shows the framework metrics that able to be plotted out as the outcome of this research. Based on the framework metrics and the research outcome, three Gemba concepts had been identified: Observation, Teaming and Value Added. Through these concepts, the main contributors of manufacturing yield loss in Company A were identified, including Environment, Man, Machine and Method. The outcome of this research shows that Gemba approach can help identify the main contributors of manufacturing yield loss. Upon identifying the main contributors, the team members could brainstorm and implement improvement actions to eliminate if not reduce the identified root causes on the manufacturing yield. As for interview outcome, all the interviewees agreed that Gemba approach can help in improving manufacturing yield.

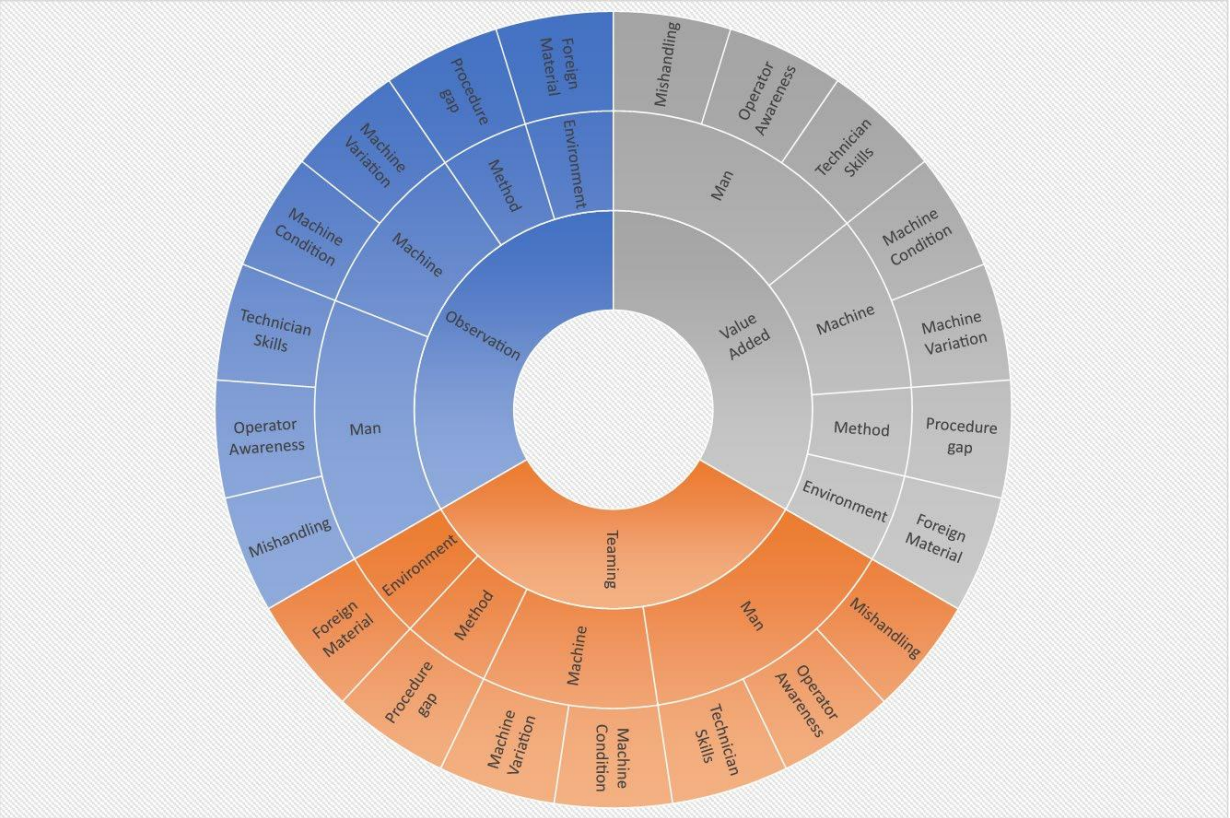

Figure 4.3: Framework Metrics of the Research

Conclusion

The demand of semiconductor devices is increasing from time to time as technology improves. Therefore, in order to stay competitive in the semiconductor industry, besides using advanced machine in the manufacturing process, the other key items are on the manufacturing yield and product quality. By achieving high manufacturing yield and providing high quality products, the company will increase their ability to compete in the global market. In order to achieve high manufacturing yield, Gemba approach is one of the choices that can be applied.

From the research and interview outcomes, the main contributors that lead to manufacturing yield loss were identified. On the other hand, through Gemba approach, other than identifying the main contributors causing manufacturing yield loss, the team members also identify opportunities for improvement which will benefit the company. In conclusion, this research shows that Gemba approach is a suitable approach to be applied at OSAT companies in order to increase manufacturing yield.

Contribution of the Study

The global semiconductor industry has experienced rapid growth and innovation, driving the demand for advanced packaging solutions. OSAT companies play a crucial role in ensuring the successful packaging and testing of IC packages. One of the key challenges faced by OSATs is achieving high manufacturing yield, as this will directly impact the cost, product quality and time-to-market of semiconductor products. This research aims to determine the main

contributor to the manufacturing yield loss in OSAT company and to understand how Gemba approach can contribute in improving manufacturing yield in OSAT company.

Gemba emphasizes the importance of observing and improving processes at the actual work place. By implementing Gemba principles and techniques, OSATs can identify and eliminate the main contributors of manufacturing yield loss and implement improvement actions to reduce product quality issues and thus improve manufacturing yield. This research will contribute to the existing body of knowledge on the application of the Gemba approach in the semiconductor industry and provide valuable insights into the factors that affect manufacturing yield in OSAT. Theoretically, this research contributes to the growing body of knowledge on lean manufacturing methodologies and their application in the semiconductor industry. Gemba approach which emphasizes continuous improvement and waste reduction through a focus on the shop floor is an important tool in lean manufacturing. It is one of the ways to improve efficiency, reduce waste, and increase production yields.

This research able to contribute to the development of Lean Six Sigma framework which focus on minimizing waste and variability in manufacturing processes in order to improve quality and efficiency. The Lean Six Sigma framework is an approach that combined both the principles of Lean manufacturing and Six Sigma methodologies. Lean manufacturing focuses on the elimination of waste and the optimization of resources whereas Six Sigma aims to reduce variability and defects in the manufacturing processes. This research show how the Gemba approach can be integrated into Lean Six Sigma framework to enhance the effectiveness of process improvement efforts. Through Gemba approach, Lean Six Sigma can leverage the knowledge and expertise of frontline employees to identify and eliminate waste and defects in the manufacturing processes, and results in improving manufacturing yield.

On the other hand, this research also can provide insights onto how the DMAIC (Define, Measure, Analyse, Improve, Control) process of Lean Six Sigma can be applied in conjunction with the Gemba approach to improve manufacturing yield in OSAT. By applying Gemba approach in manufacturing processes, it can help to define the main contributors of manufacturing yield loss, measure the rate of yield loss caused by each contributor and perform data analysis. Furthermore, through Gemba approach, improvement actions also can be implemented to improve manufacturing yield as well as implement certain control to the process to prevent any manufacturing yield loss. By applying DMAIC, OSATs are able to define the problems, measure the extent of the issues, analyze the root cause, implement solutions and control the processes to provide real-time insights into the manufacturing processes and also identify opportunities for improvement. By conducting this research and demonstrating the effectiveness of Gemba approach, it can provide insights on how Gemba approach can be integrated into Lean Six Sigma framework to improve manufacturing yield at OSAT.

Limitation and Future Study

There are several limitations in this study. First of all, only a small sample size was involved in this study. This is because this study only limits to assembly area of the company and only key persons were selected to participate in this research, whereby some of the non-key persons might have different opinion on Gemba approach. Secondly, this study only focuses on the target company's assembly area whereby the Company provide assembly and electrical testing services. Manufacturing yield only covers for assembly area and did not cover

electrical test area whereby the final output of the company should involve electrical test as well. As the research only focus on assembly, this research can be further replicated to cover the entire IC packaging process from assembly until electrical test. Moreover, it can also be further replicated by involving more respondent in the data collection to gather more information with different opinion.

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