IDENTIFICATION OF CAUSES OF VARIATION IN THE SEMICONDUCTOR MANUFACTURING PROCESSES BY GRAPHICAL ANALYSIS: A SIX SIXMA APPROACH

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BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	IDENTIFICATION OF CAUSES OF VARIATION IN THE SEMICONDUCTOR MANUFACTURING PROCESSES BY GRAPHICAL ANALYSIS: A SIX SIGMA APPROACH
Sesi Pengajian	:	2008/2009

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Dedicated to my beloved family especially my parents, supervisor, FKEKK lecture and also to all my friends.

ACKNOWLEDGEMENT

I have just completed my Final Year Project (PSM) and thesis in sufficient time. First of all, I would like to take this opportunity to express my appreciation to some organizations and individuals who have kindly contributed for my final year project in UTeM. With the Cooperation and contribution from all parties, the objectives of the project; soft skills, knowledge and experience were gained accordingly even this is just part of the whole project. Furthermore, I would like thank to me supervisor. Miss. Farah Shahnaz Feroz for the proper guidance, cooperation and involvement throughout my Final Year Project. Her effort to ensure the successful and comfort ability of student under her responsibility was simply not doubtful. Moreover, I would like to extend my sincere acknowledgement to my parents and family members who have been very supportive for the past six months. Their understandings and support in term of moral financial were entirely significance towards the project completion. Last but not list, my appreciation goes to my fellow students in UTeM, especially for who are from KEKK. Their willingness to help, opinions and suggestions on some matters, advices and technical knowledge are simply precious while doing upon completion of my final year project.

ABSTRACT

Six Sigma is an improvement process, developed by Motorola in 1985. Its use in reducing variation in the production processes could not be denied. Increasing product output without maintaining quality would lead to an increase in the process variation. The objective of this project is to detect and find possible ways to reduce the variation in semiconductor manufacturing production of IC (Integrated Circuit). Sample production data from the industry (an IC manufacturing company) was analyzed graphically to check on the stability of the production process. Possible causes for instability were proposed, based on out-of-control points and threats detected. The process capability was measured to determine if products produced meet customer's specification. Based on graphical and numerical analyses performed, production process for X1, Y1 and Y2 were out of control, and X2 was stable and capable to meet customer specification, after the elimination of an outlier. All in all, immediate actions should be taken to improve the stability of the production processes so that the output is predictable. This would ensure the best quality of products delivered to customers. Once process has been stabilized, a continuous quality improvement system should be planned and implemented to improvise current process.

ABSTRAK

‘Six Sigma’ adalah satu proses penambahbaikan yang dibangunkan oleh Motorola pada 1985. Memang tidak dapat dinafikan, ianya digunakan untuk mengurangkan variasi didalam proses pengeluaran. Meningkatnya keluaran produk tanpa menjaga kualiti akan mendorong kepada peningkatan variasi terhadap proses itu. Objektif projek ini adalah mengesan dan mencari punca-punca yang mungkin untuk mengurangkan variasi di dalam pengeluaran pembuatan semikonduktor IC (Litar Bersepadu). Data-data yang diambil dari industri, dianalisis secara grafik bagi memeriksa tahap kestabilan proses pengeluaran. Berpandukan data-data yang tidak menentu dari taburan graf, punca-punca untuk ketidakstabilan telah dikemukakan. Bagi menentukan produk yang dihasilkan memenuhi kehendak pelangan, kecekapan proses telah dilakukan terhadap produk. Berpandukan graf dan analisis berangka, proses pengeluaran untuk X1, Y1 dan Y2 adalah tidak menepati kehendak pelangan, manakala X2 stabil dan memenuhi kehendak pelangan, selepas dikeluarkan satu data luaran. Secara keseluruhanya, tindakan segera harus diambil bagi memperbaiki tahap kestabilan proses pengeluran. Ini penting, supaya jangkaan pengeluaran dapat diramalkan. Maka dengan ini, apabila proses dalam keadaan stabil peningkatan produk dan kualiti secara beterusan dapat dilaksanakan terhadap pengeluaran produk.

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DPMO	*defects per million opportunities*
IC	Integrated Circuit
Cp	Process Capability
PSM	Projek Sarjana Muda
SPSS	Self-Propelled Semi-Submersible
Std. Dev	Standard Deviation
SPC	Statistical Process Control
DFSS	Design for Six Sigma
DMAIC	define, measure, analyze, improve, and control
TQM	Total Quality management
NNs	Neural Networks
USL	Upper Specification Limit
LSL	Lower Specification Limit
UCL	Upper Control Limit
LCL	Lower Control Limit
Cpk	Critical Process index
Pp	Process Performance
Ppk	Process Performance Index
PPM	parts per million
NP	No plating
R&D	Research and Development

CHAPTERR 1

INTRODUCTION

Six sigma is basically, a quality objective. It is an organization-wide, leadership-driven, process-oriented initiative, designed so that the processes produce no more than 3.4 *defects per million opportunities* (DPMO). To achieve this, a relentless pursuit of variation reduction in all critical processes needs to be carried out. Processes are required to operate so that the engineering specification is at least plus or minus Six Sigma (sigma stands for standard deviation) from the process target. Six sigma is a management philosophy based on objectives to reducing variation. A disciplined data-driven methodology for decision making and process improvement, to increase process performance, needed to decrease variation of the system.

1.0 Project background

The six sigma initiative has contributed to a change in the discussion of quality from one where defects were measured in percentages to a discussion of defects per million. It emphasizes setting extremely high objectives. Goals are stretched to focus people on process improvement. With the knowledge that more than 200 process steps are usually necessary to manufacture a chip, old ideas about satisfactory quality levels are no longer

acceptable. With shrinking dimensions, semiconductors yields become increasingly sensitive to manufacturing variations.

In semiconductor industry, the output of the production is important. Increasing the output without maintaining the quality would lead to the increase in variation in the process. By reducing this variation, it will improve the quality of the product. However, not all company will do the maintaining continuously, this always happens to the company that wants to achieve a higher output of production by neglecting the quality of the product. This leads to the product outcome that is sold customers are not the best among the best.

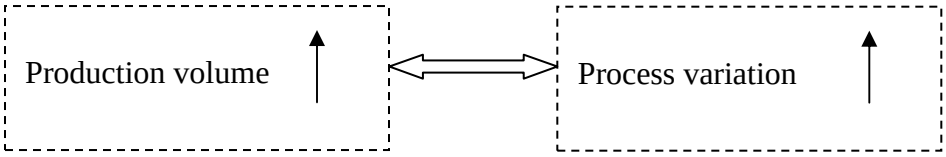

Figure 1.1 Industry production theories

One of the objectives of this project is to identify and find a possible ways to reduce the variation in semiconductor manufacturing production of IC (Integrated Circuit). This project focuses on the 'End Line' production, which are the last steps for producing an IC. This part is calling the sawing process, where the chip on strip is sawed to small sizes of IC.

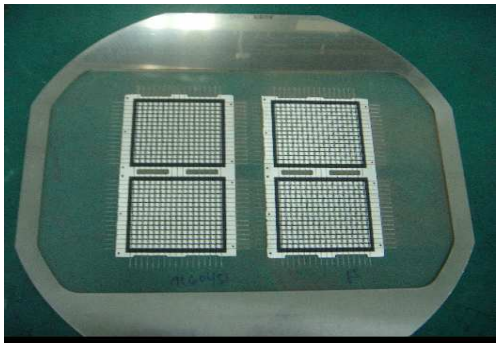

Figure 1.2 Strips on ring

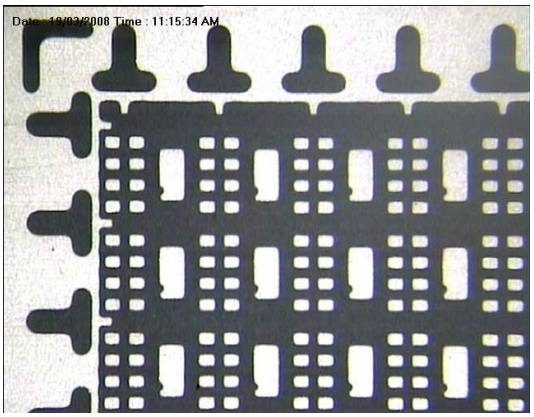

Figure 1.3 Close view of chip on strip

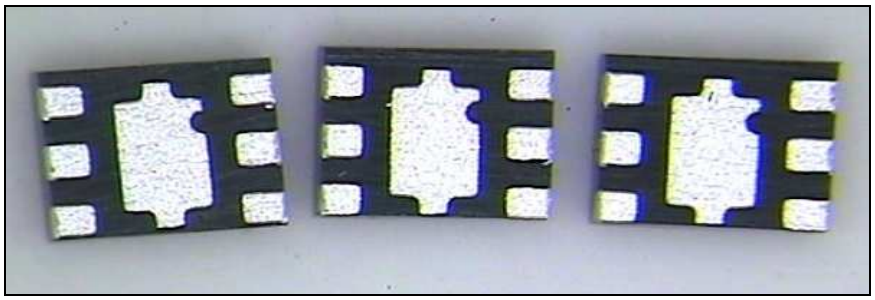

Figure 1.4 a chip of an IC after sawing process

Figure 1.2 to figure 1.4 shown an example of processes that happen in 'End Line' of production. A strip of an IC is loaded into a machine and will be sawed to a smaller size like the ones in figure 1.4. After sawing process IC (Integrated Circuit) has been measure to detect if have any saw offset to the package size. It's important to company to make sure the product that has produce meet the customer's specification . However, variations do occur in this process, production data from the industry will be analyzed to detect data variation. After the problem-solving methodology is done, a possible solution will be proposed to the industry.

Causes of variation can be classified as common and special causes. In this case, special causes of variation are taken as subject to do the analysis. Examples of special variation that can take in producing an IC are wrong setting of alignment to sawing

process, untrained operators who not serious to do their job, machine condition that run out of limit also give an effect to the root cause of variation and the time of working that influence the mood of operators when do their job. Effects from these special causes will lead to an increase in variation. At the same time, it may lead to a chip defect and damaged. To observed and analysis the variations of the data, that is the Process Capability (Cp) method is use. Process capability is a method by compares the output of an in-control process to the specification limits by using capability indices.

The target to achieve in this analysis is to detect and find possible ways to reduce the special cause variation in the manufacturing of IC (Integrated Circuit). All products and services are a result of some process. Six Sigma benefits others besides the customers. Six Sigma not only treats manufacturing as parts of a larger system, it removes the narrow, inward focus of the traditional approach. A through literature study on Six Sigma, Statistical process Control tools and the implementation of Six Sigma in the semiconductor industry will be performed.

1.1 Project Objectives

The aims of doing this project are stated below;

1. To study and explain the benefits of the implementation of Six Sigma in the semiconductor industry to gain competitive advantage.
2. To identify production problems related to shifts and variations through control charts and Process Capability (Cp) analysis.
3. To propose a method using Six Sigma approach to reduce variation in the production process. This would thus eliminate rework and customer callbacks caused by defects, leading to lower production costs and improve customers' satisfaction.

1.2 Problem statement

The semiconductor industry is highly innovative. The rate of innovation forces companies to proceed with high volume production before their process reach maturity. This is important for the company to maintain their status and compete with other semiconductor industry. Producing high volume of products while ignoring quality would lead to process variations.

Increasing output will influence the defects and process variation to output process. Process variations would cause products failing to meet customers' requirement. When the quality of products does not follow customers' spec, it will affect other processes. An increase in variation will lead to an increase in production cost. Time spent for rework for problematic products causes a lot of problem in the production line.

Customer products must be in good condition - quality and quantity wise. All of these requirements should be fulfilled by companies that care about their reputations. Furthermore it gives advantages for both, industry and customers. This would ensure the best quality products delivered to customers by decreasing variation in process that leads to cost reduction when there is less scrap in producing products. In production, less rework = improvement in productivity = employee satisfaction. When products meet customers' specification, they would promote good feedback from customers and at the same time will increase sales.

1.3 Scope

In this project, three assumptions are made for the data collected:

- Independence of the data.
- Normal-Gaussian distribution also called the Gaussian distribution is an important family of continuous probability distributions, applicable in many

fields. Each member of the family may be defined by two parameters, location and scale: the mean ("average", μ) and variance (standard deviation squared) σ^2, respectively.

- The data is randomly distributed.

The most common motto for Six Sigma is "**Perfection is Possible**". The subtitle would be "Even when things go wrong, the product is still good". There are two major qualifiers to the concept of perfection. The major concept is that the perfection specially means that the product meets the customer's accurately determined specification.

The rest of Six Sigma process understands the statistic behind the charts and controls, learning the methods to determine what are working properly, and how to identify and fix problems that do occur.

In this project, it has two limitation levels that cannot be avoided. Firstly, to get the zero-defects of the variation of producing an IC. As known, each process has its variation. From here, possible ways to reduce process variation will be studied. Secondly, data collection is handled by the company staff. I have no control as to when the data is collected and how data collection is handled. Human error that occurs when taking the data also affects the analysis.

To analyze the data, Six Sigma method has been used. Statistical Software like SPSS and MINITAB are applied to industry data.

1.4 Methodology project

I will also perform a thorough literature study and review on Six Sigma, Statistical Process Control tools, Implementation of Six Sigma in the semiconductor industry, A study on control pattern recognition system, Control Chart Analysis, Trend Analysis in Manufacturing for Quality Improvement and Probability Plot for normal distribution. The

technique of statistical process control, control charts and Process Capability Index (Cp) can be used to identify productions problems related to shifts and variation.

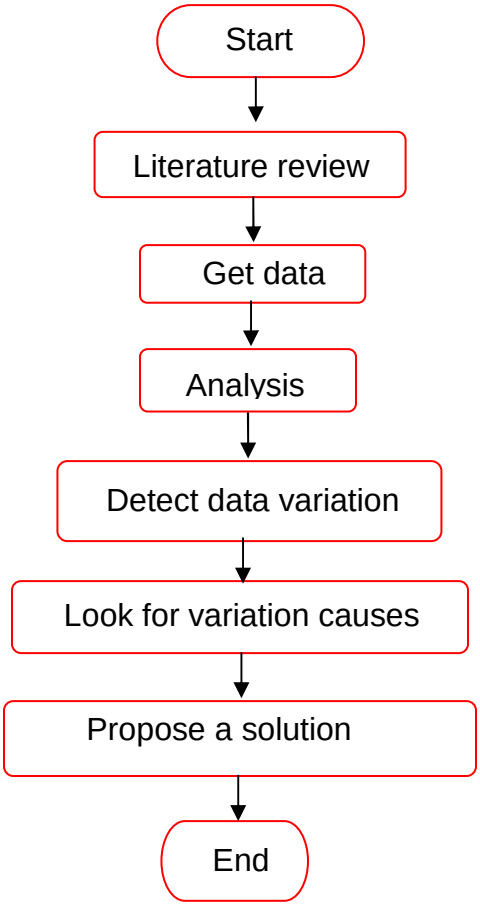

Figure 1.5 Project flowchart

In this project, I propose a method using Six Sigma approach to reduce variation in the production process. The most common comparison between Six Sigma and Three Sigma, Six Sigma was applied to whole an important process while Three Sigma only specific at certain process. This would thus eliminate rework and customer callbacks caused by defects, leading to lower production costs and improve customer's satisfaction.

1.5 Outline of PSM report

This PSM report consists of five chapters. The first chapter discusses about background, objectives, problem statement, scope and methodology of this project. Chapter two discusses more on theory and includes literature reviews that have been done. It also will discuss on components of the analysis and software used in this project. Chapter three discusses on the methodology to solve the variation and graphical analysis development of this project. Chapter four will discuss about project's analysis and results. Finally in chapter five it will discuss about conclusion and future work proposal for the project.