

IDENTIFICATION OF CAUSES OF VARIATION IN THE SEMICONDUCTOR
MANUFACTURING PROCESSES BY STATISTICAL ANALYSIS: A SIX SIGMA
APPROACH

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Specially dedicated...

To supervisors

To my beloved parents

To my kind brothers and sisters

And to all friends

For their

Support, Encouragement, and Best Wishes

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ABSTRACT

The purpose of this thesis is to solve the problem of variation in the semiconductor processes by statistical analysis, using the six sigma approach. The current yield loss due to this defect had contributed to the increased production cost due to higher material scrap and rework time. Project objectives were set in Define phase in six sigma approach to detect variation and find possible ways to reduce the variation in the semiconductor manufacturing. The information for the six sigma approach was gathered and the data was collected from a company in the measure phase. A literature review on the six sigma approach will be carried out. The analyze phase results reveal the relationship of vital few causes of variation issue, which led to the defects' root cause of production of integrated chip (IC). Variation was associated with the environmental and physical factors. Therefore, the relationship between these factors and the functionality and rework ability yield was developed. In Improve phase, the solution was proposed to reduce the variation considering factors such as physical dimension. Process capability (Cp) method is used to observe and analysis the variations of the data. In final Control phase, all the changes and implementation were properly documented, analyzed and planned for the possible solutions. Control chart is drawn using appropriate software such as Minitab to use for analysis of the variation. The result from the project has provided an insight on actual successful deployment of Six Sigma approach with application of its various statistical tools and techniques, and as the systematic problem solving framework on solving actual industrial issues.

ABSTRAK

Tujuan thesis ini adalah untuk menyelesaikan masalah variasi dalam proses semikonduktor dengan menggunakan analisis statistik iaitu pendekatan six sigma. Kemerosotan hasil daripada masalah ini telah menyumbang kepada kenaikan kos pengeluaran akibat kenaikan bahan sekerap and masa pembaikan. Objektif projek telah ditetapkan di fasa tetapan untuk mencari variasi dan mengeluarkan segala cara yang boleh digunakan untuk mengurangkan variasi di dalam proses semikonduktor. Informasi untuk pendekatan six sigma dikutip dan data juga diambil daripada syarikat dalam fasa mengukur. Tinjauan pustaka untuk pendekatan sig sigma juga akan dijalankan. Keputusan fasa analisis telah menunjukkan hubungan antara beberapa kemungkinan punca penting untuk masalah variasi yang akan mengganggu proses pengeluaran IC. Masalah variasi yang berkait rapat dengan faktor persekitaran dan faktor fizikal. Oleh itu, perhubungan faktor-faktor tersebut dengan kefungsiian dan pembaikpulihan telah diwujudkan. Dalam fasa peningkatan, cara mengatasi akan dicadangkan untuk mengurangkan variasi dengan mengambil kira faktor-faktor seperti dimensi fizikal. Kaedah keupayaan process akan digunakan untuk pemerhatian dan analisis terhadap variasi untuk data. Dalam fasa kawalan, kesemua perubahan and implementasi akan dimasukkan dalam dokumen, dianalisis dan cara-cara mengatasi akan dimasukkan dalam satu pelan. Peta berpandu dilukis dengan menggunakan perisian seperti Minitab untuk menganalisis variasi. Hasil kajian projek ini telah memberikan satu pengertian yang mendalam untuk pendekatan six sigma dengan pelbagai alat statistik dan aplikasi sebagai satu kaedah penyelesaian masalah yang sistematik untuk penyelesaian masalah industri.

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LIST OF ABBREVIATIONS

Cp	Process Capability
DMAIC	define-measure-analyze-improve-control
IC	Integrated Circuit
PCB	printed circuit board
DPMO	defects per million opportunities
ISO	International Organization for Standardization
SPC	Statistical Process Control
DFSS	design for six sigma
DMADDD	Define, Measure, Analyze, Design, Digitize, and Draw Down
DMADV	Define-Measure-Analyze-Design-Verify
X bar R	Average and Range Control Chart
X bar S	Average and Standard Deviation Control Chart
X Median R	Median and Range Control Chart
I-MR-R	Individuals, Moving Range (between) and Range(within)

CHAPTER I

INTRODUCTION

Semiconductor industries are always on the ways to improve their productivity as well as maintain their high quality control for the products. Business improvement methodology has been developing for the last century [1]. In statistics and probability theory, standard deviation of a data set or a probability distribution is the square root of its variance. Standard deviation is widely used for measuring the variability or dispersion. The standard deviation is a value which indicated that the total number of individual data deviated from the mean value. This means that an estimation value of the variation in a set of data measurement provides by the standard deviation. Recently, sigma levels from one to six have been applied in different industries all over the world. The latest approach for improving the quality of products is Six Sigma. This approach is actually modified from the previous approach where there are new concepts, methods and tools added to remove the limitations that had been identified. Six Sigma is an approach that increases the process performance as well as enhances customers' satisfaction. Six Sigma is needed

for improvement and problem solving for the products of semiconductor industry. Processes do not get better by themselves. So, if there is no improvement for them, it might be become worsen over time. A good approach is needed to improve the performances that measured by cost, quality and customer satisfaction.

1.0 Project Background

Six sigma was first established in the mid-1980s by Motorola under the leadership of Robert W. Galvin who is the initial developer of six sigma [2]. Six Sigma originated in the manufacturing world and grew out of the science of quality engineering. It makes heavy use of statistical process control rather than a simply statistical technique. Furthermore, it is a methodology for solving quality problems and it has applicability far beyond the area of manufacturing in which it was developed. Six sigma is a management to the bottom line results. It is a disciplined way to deliver more money to the bottom line through process improvement. Six sigma approach aim to create near-perfect processes, products and services that aligned to deliver what the customer wants.

In the manufacturing semiconductor industries, these companies view six sigma in two ways which are as a power tools for improving processes and products as well as an approach for improving both the processes. So, the number of quality outputs for the production lines are very important. The variation of the process may be increased if the production lines increase the outputs regardless to maintain the quality of products. Maintaining the quality of products is an effective way to reduce the variations in the processes. The relation of output production and the process variation is clearly shown in Figure 1.1 below.

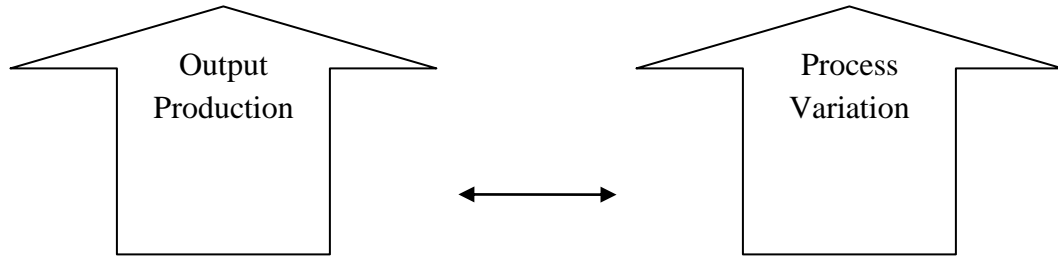


Figure 1.1: Production theory for industry

The main objective of this project is to identify and find a possible solution to reduce the variation in the semiconductor manufacturing that producing integrated circuit (IC). The problem can be solved efficiently once the variation is identified.

1.1 Objectives

The objectives in this project are as shown below.

1.1.1 To study and explain the benefits of the implementation of Six Sigma in the semiconductor industry to gain competitive advantage.

1.1.2 To identify and analysis variation by using control chart and process capability (Cp).

1.1.3 To apply the Six Sigma approach to reduce the variation in the production process. This can eliminate the rework process and thus saving the cost.

1.1.4 To improve the quality control and product management for a company.

1.1.5 To identify the solution for reducing the variation that occurs in a semiconductor company.

1.2 Problem statement

A semiconductor industry is highly concerned with the quality of the products as well as to come out with a product that is low cost and high quality which can meet the customer's needs or requirements. The volumes for the products may be increased due to the high demand from the customers. However, there might be variation occurred during the process since some of the products have to be come out in a shorted or in the committed time to the customers. High process variation is not only will cause the product be rejected by customers but also will increase the cost for manufacturing the product. This is because the rework process is needed and will cause the cost and time is needed to be spent to find the solution. This will cause loss to a company since more time and modal have to be spent to overcome the problems of variation.

1.3 Scope

In this project, three assumptions are made for the data collected which are Independence of the data, means that the data is normally distributed, 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, and the data is randomly distributed.

The limitations in the project are there is impossible to get a zero defects in the variation of producing a product and no idea on how the data is collected and handled since the collection of data is handled by company staffs. Zero defects mean reaching a level of infinity sigma, which is nearly impossible. This is because there is always a chance of some errors or defect occurring. Unless conditions are perfect, the objective of zero defects is not possible. Data collections are handled by company staffs. So, human errors that occurred for the data collections may have some effect to the analysis.

1.4 Project Methodology

The project methodology will be followed a flowchart which is shown as Figure 1.2 below.

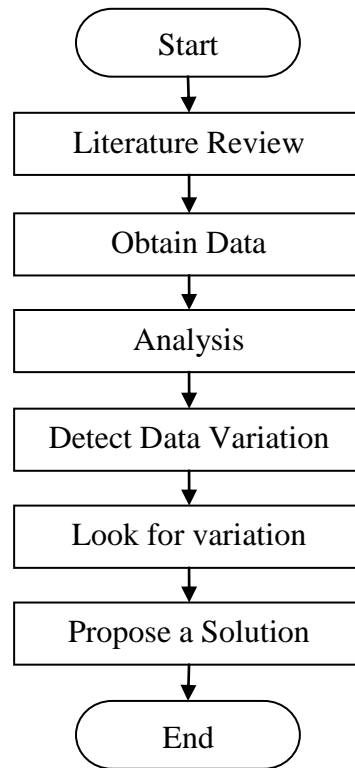


Figure 1.2: Flowchart for the project methodology

A literature review about the Six Sigma is done where information and ideas is gather to understand the concept of the approach. Besides that, this project will also perform the Statistical Process Control method and implementation of Six Sigma approach to a semiconductor company. Control chart and capability analysis are used to identify and find possible solutions for the cause of variation in the semiconductor manufacturing process. Then, sample data is collected from a company. Finally, a Six Sigma approach is used to reduce the variation of the manufacturing process. Thus, this will eliminate the rework process and fulfill the customer's requirements as well as the production costs.

CHAPTER II

LITERATURE REVIEW

2.0 Introduction

The main purpose of this chapter is to give the overview information about the title of this research. This chapter also explored and summarized the related literature about this title. This chapter will give the details explanations about the Six Sigma application in industry, the methodology of Six Sigma in order to increase productivity, process capability, quality control, control chart and others.

2.1 Six Sigma

Six Sigma originally gained acceptance as a measure of product design for manufacturing, especially in process intensive industries such as Integrated Circuit (IC)

and printed circuit board (PCB) fabrication and assembly. The word Sigma is a statistical term that measures how far a given process deviates from perfection. Six sigma is a methodology that can be used to improve the output quality of a process. Six Sigma not only can be used in manufacturing processes but also can be applied to other business such as marketing plans and designing of products. Recently, there is a significant increase in the use of Six Sigma methodology in manufacturing industry and others. Sigma is standard deviations from the mean of a data set or a measure of variation. Six sigma refers to six standard deviations from the mean. Six Sigma's aim is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting. Statistical tools can be used to reduce the amount of variation for a process by removing the cause of variations. This can increase the output quality of a process. Six Sigma is a data driven methodology, and requires accurate data collection for the processes being analyzed. Six sigma approaches is used for eliminating the defects in any process where the defects refer to anything that outside the customer's specification. Basically, Six sigma is an approach for improving processes, lowering defects, reducing process variability, reducing costs, increasing customers' satisfactions and increasing profits for company. Six sigma is focus on communication between the design, development and manufacturing parts of an organization.

2.2 Comparison of six sigma with other sigma level

In simple terms Six Sigma is a disciplined program or methodology for improving quality in all aspects of a company's products and services. The traditional quality model of process capability differed from Six Sigma in two fundamental respects. Other sigma level was applied only to manufacturing processes, while Six Sigma is applied to all important business processes [3]. For three sigma level, a capable process was one that had a process standard deviation of no more than one-sixth of the total allowable spread, where Six Sigma requires the process standard deviation be no more than one-twelfth of the total allowable spread. By addressing all business processes, Six Sigma not only treats manufacturing as part of a larger system, it removes the narrow as well as more