UNIVERSITI PUTRA MALAYSIA

APPLICATION OF FOCUS IMPROVEMENT TO REDUCE NON-STICK ON PAD PROBLEM IN IC PACKAGING

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia
in Fulfilment of the Requirements for the
Degree of Master of Science

February 2004

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This work is dedicated to my beloved
Parents, brother, sister and niece

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of requirements for the degree of Master of Science

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Chairman : Associate Professor Napsiah Ismail, Ph.D.

Faculty : Engineering

Total Productive Maintenance (TPM) methodologies are used to eliminate profit loss or waste due to equipment failure or defect. TPM is designed to get maximum efficiency from the equipment while creating a satisfactory working environment. In Motorola, Selangor yield improvement had been an important agenda. One of the TPM pillar which is Focus Improvement activity is designed to minimize targeted losses that had been carefully measured and evaluated, was employed to improve yield in front-end assembly. The top three yield lost in parts per million (ppm) were contributed by the following defects in descending order: Non Stick on Pad (2715 ppm), chip and crack (782 ppm) and missing wire (687 ppm). The team focused on Non Stick on Pad (NSOP), which was the top yield lost contributor. NSOP was due to: floating die, bonded ball small in size, foreign matter on pad and glassifications to say a few. Floating die contributed 48% of the NSOP defect. In this project detailed

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explanation on how one of TPM tools, which is Focus Improvement activity used to reduce Non Stick on Pad due to floating die is shown. Upon identifying the root cause of die floating which was due to no support and weakness in the vacuum system actions were taken to eliminate and to control the identified causes. As a result NSOP due to floating die had been reduced from 1300 parts per million (ppm) to 650 ppm a reduction of 50% within one year.

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PERPUSTAKAAN SULTAN ABDUL SAMAD
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Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENGGUNAAN KAEDAH PENINGKATAN PENUMPUAN UNTUK MENGURANGKAN MASALAH NON-STICK ON PAD DALAM PEMBUNGKUSAN LITAR SEPARA ALIR

Oleh

SIVAKUMAR A/L DHAR MALINGAM

Februari 2004

Pengerusi : Profesor Madya Napsiah Ismail, Ph.D.

Fakulti : Kejuruteraan

Senggaraan Produktif Menyeluruh atau ringkasanya TPM adalah untuk menghapuskan kerugian atau pembaziran yang disebabkan oleh kegagalan dan kecacatan peralatan. TPM bertujuan untuk memperolehi kecekapan maksimum pada peralatan di samping mempertingkatkan kejayaan syarikat dan menjadikan tempat pekerjaan satu tempat yang dapat memuaskan hati pekerja. Motorola, Selangor telah mula menumpukan sepenuh perhatian dalam meningkatkan kualiti. Kaedah Peningkatan Penumpuan atau ringkasannya FI yang merupakan salah satu tunggak TPM bertujuan untuk mengurangkan kemerosotan kualiti yang dikenal pasti dan telah diukur dengan teliti digunakan untuk meningkatkan kualiti barangan di pemasangan "front-end". Tiga punca tertinggi kemerosotan kualiti dalam unit per juta (ppm) adalah disebabkan oleh: "Non Stick On Pad" (2715 ppm), "chip dan crack" (782 ppm) dan "missing wire" (687 ppm). Penumpuan diberikan kepada "Non Stick On

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Pad" (NSOP) memandangkan ia adalah punca kemerosotan kualiti yang tertinggi. Beberapa contoh punca NSOP adalah : unit terapung, saiz bola yang kecil, bendasing pada pad dan kaca pada pad. 48% NSOP adalah disebabkan oleh unit terapung. Projek ini menunjukkan bagaimana FI digunakan untuk mengurangkan NSOP disebabkan oleh unit terapung. Setelah mengenalpasti punca unit terapung yang disebabkan ketiadaan asas penahan dan kelemahan sistem vakum langkah-langkah telah diambil untuk menghapuskan dan mengawalselia punca tersebut. Hasilnya kaedah ini berjaya meningkatkan kualiti dengan mengurangkan NSOP pada unit terapung daripada 1300 unit per juta (ppm) kepada 650 ppm; pengurangan sebanyak 50% dalam tempoh masa setahun.

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LIST OF ABBREVIATIONS

AM	-	Autonomous Maintenance
AITPM	-	American Institute of Total Productive Maintenance
DOE	-	Design of Experiment
EFO	-	Electronic Flame Off
FAB	-	Free Air Ball
FEA	-	Finite Element Analysis
FI	-	Focus Improvement
FMEA	-	Failure mode and effects analysis
IC	-	Integrated Circuit
I/O	-	Input /Output
JIPM	-	Japan Institute of Plant Maintenance
JIT	-	Just in time
MLI	-	Maverick Lot Initiative
MTBF	-	Mean Time between Failures
MTBA	-	Mean Time between Assist
MP	-	Maintenance Prevention
MOS	-	Metal Oxidize Silica
NG	-	No Good
NSOP	-	Non-Stick on Pad
NPI	-	New Product Introduction
OEE	-	Overall Equipment Effectiveness
OPL	-	One Point Lesson

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PM	-	Productive Maintenance
PPM	-	Planned Preventive Maintenance
ppm	-	parts per million
PQFP	-	Plastic Quad Flat Package
QA	-	Quality Assurance
QFD	-	Quality Function Deployment
QM	-	Quality Maintenance
QFP	-	Quad Flat Package
RCM	-	Reliability Centered Maintenance
SPC	-	Statistical Process Control
SMART	-	Specific Measurable Achievable Rewarding Time based
TPM	-	Total Productive Maintenance
TI	-	Texas Instrument
TQC	-	Total Quality Control
TQM	-	Total Quality Management
USG	-	Ultrasonic Generator
UK	-	United Kingdom
XQFP	-	X-Quad Flat Package

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CHAPTER 1

INTRODUCTION

1.1 Introduction

For the past several years' industry has been bombarded with a surplus of quality improvement philosophies, tools and techniques, which are often not fully explained or synthesized in a way that clearly depicts the "Big Picture". It seems like there has been a constant push to generate more and more pieces for the quality improvement puzzle without sufficient knowledge on how to put them all together properly (Berdine et al., 1998).

Some of the popular quality improvement tools and philosophies are Total Quality Management (TQM), ISO 9000, Baldrige Criteria, Statistical Process Control (SPC), Design of Experiment (DOE), Deming, Juran, Re-Engineering and Quality Function Deployment (QFD). These tools or philosophies create pieces of quality improvement puzzle. The questions are whether the pieces fit together or a set of disjointed pieces. The generation of this puzzle frustrates many people, managers in particular, who may lead 'he quality improvement efforts unsuccessful (Berdine et al., 1998).

The results of this puzzle can be seen in a manufacturing environment. Management will impose one idea after another without clearly explaining how to solve the problems in an effective and systematic manner. The people who are working for the company or department are forced to follow the ideas or methods from the management, which sometimes created a lot of confusion, tension and stress. This

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environment stimulates fire fighting among the people and usually ends up with and increased in quality defect level.

In order to improve quality and be profitable in the challenging Semiconductor Business Motorola, Selangor had started to use Total Productive Maintenance (TPM) philosophy. Motorola, Selangor had already implemented Total Quality Management, Baldrige Criteria and Six Sigma. Total Productive Maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment to reduce the maintenance cost and to increase the equipment productivity. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. The TPM program closely resembles the popular Total Quality Management (TQM) program. Many of the same tools such as employee empowerment, benchmarking, and documentation are used to implement and optimise TPM.

TPM consists of eight pillars; which are Autonomous Maintenance, Focused Improvement, Planned Maintenance, Quality Maintenance, Training and Development, Office TPM, Safety and Environment and finally Initial Flow Control (Suzuki, 1994). Focus Improvement activities are designed to minimize targeted losses that had been carefully measured and evaluated in TPM. This project used Focus Improvement to improve yield at the Front End Assembly process. Focus Improvement is comparable with other improvement tools available in the market. Focus Improvement as part of TPM package gives a comprehensive solution to improve productivity and quality.

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A drive to improve quality continuously had resulted in the importance of performance measure in any industry especially in manufacturing. One of these measures of performance is yield improvement (reducing defects) in every process, which is very important since rework is not allowed according to the Motorola, Selangor specification and such each defect will increase the cost of production and reduce the competitiveness in the demanding market.

In Front End Assembly there are a few processes. Figure 1.1 illustrates the process flow to describe the Front End Assembly process.

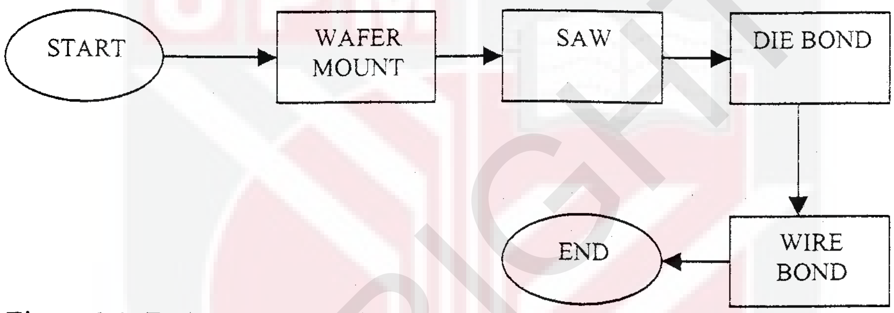

Figure 1.1: Front End Assembly Process.

Front End Assembly consists of four types of machines: Wafer Mounter, Saw, Die Bond and Wire Bond.

There are three models of wire bond machine in Front End Assembly namely Esec 3088, Esec 3008 and Kns 8020 in the company. Refer to Appendix A for the wire bond pictures.

Integrated Circuits (IC) is also known as die in the assembly/production floor, it comes in wafer shape from the wafer fabricators. The wafer is circular in shape with a diameter of 8 inch. The wafer consists of 100 to 1000 or more dies depending on the die size, which can fit on the wafer radius.

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Wafer is mounted to wafer ring using Mylar tape then it is taken to saw machine to cut the wafer into die form. At Die Bond machine the dies are attached to lead frame flag using glue known as epoxy. Wire Bond machine will attach wire to the input/output (I/O) of the die to the leads of the frame. The I/O point on the die is known as pad or bond pad. Figure 1.2 shows the basic step in Front End Assembly.

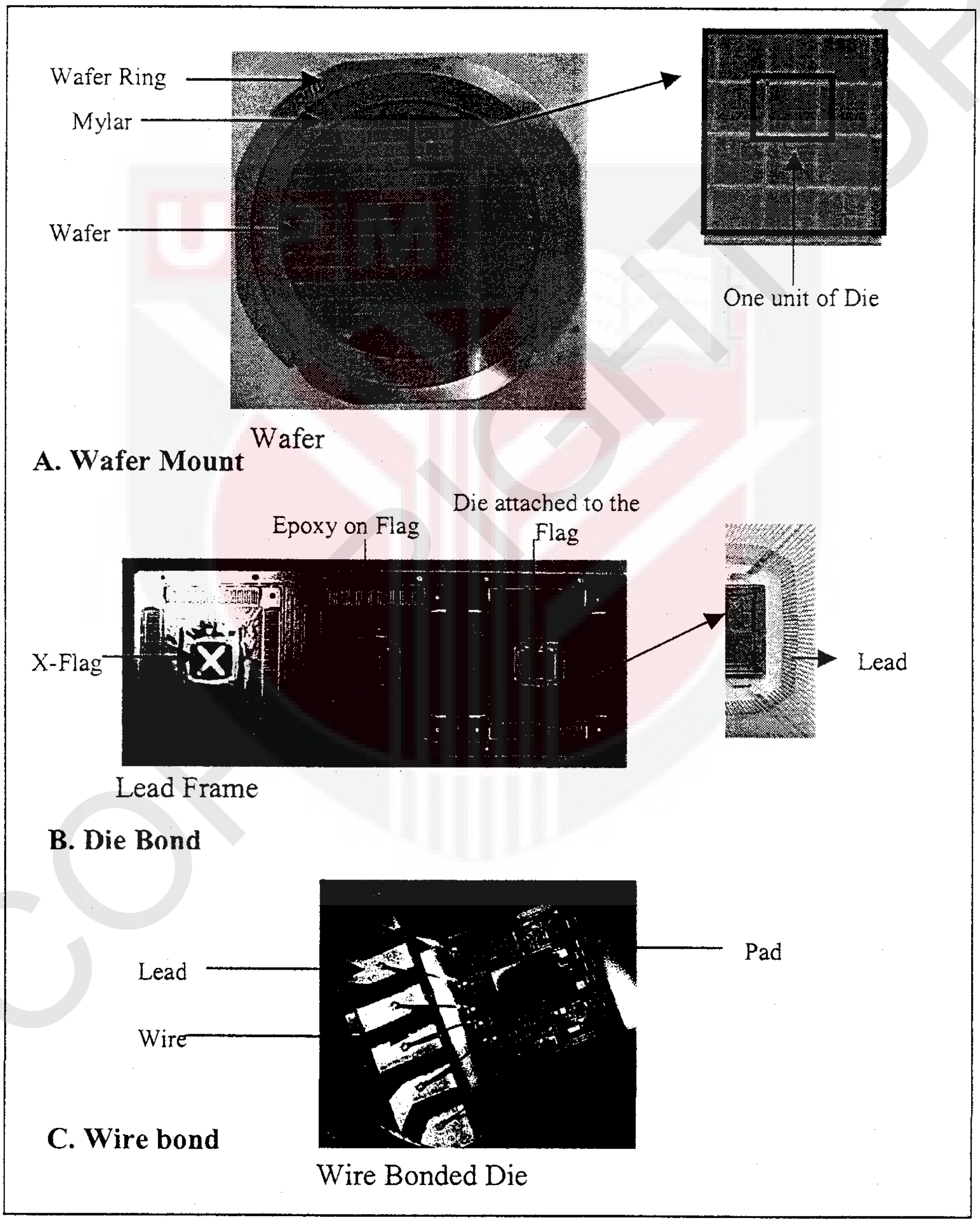

Figure 1.2: Basic Step in Front End Assembly: A. Wafer Mount, B. Die Bond, C. Wire bond.

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1.2 Introduction to Wire Bonding

Wire Bonding is a critical stage in the assembly process. By this stage, most of the device costs have been absorbed; therefore, the success of the remaining processes is critical. Precision and quality of performance are imperative at this stage to assure high yields.

The wire bonding process is an interconnection technology linking the die to the lead within the micro-scheme. The four main phases of the cycle are shown in Figure1.3 (KNS, 2001).

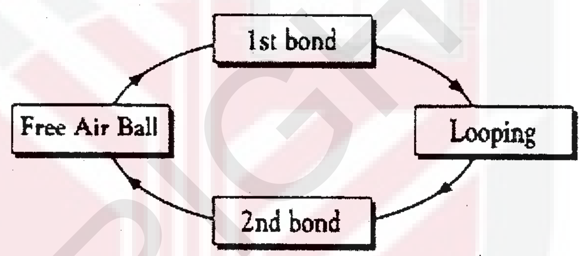

Figure 1.3: Four-Main Phase of Wire Bond Cycle

Each phase is the result of several operations performed by the capillary. These operations can be defined by eight stages that complete the ball bonding cycle.

1.2.1 Ball Bonding Cycle

At stage 1 the capillary is accurately targeted by a computerized, video-enabled system on the die bond pad; the Free Air Ball (FAB) is formed at the end of the wire. When the capillary descends, the FAB is pulled into the Inner Chamfer and centred right above the pad.

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At stage 2 the 1st bond is created when the FAB is squashed by the capillary against the pad. During this process, the FAB is gripped in the capillary chamfer while force and ultrasonic vibrations are transmitted through the capillary and heat is applied throughout.

At stage 3 when the 1st bond is formatted, the capillary rises above the pad. The opening of the clamp allows the wire to slide through and reach the desired loop height. At this point the clamp closes again.

At stage 4 while the clamp is closed, the capillary moves towards the lead and is lowered to form the 2nd bond. This lowering motion forms the loop.

At stage 5 the capillary presses the wire against the lead while force, heat, and ultrasonic energy are applied. This pressure produces the 2nd bond, which consists of the stitch bond and the tail bond.

At this stage 6 the clamp opens while the capillary rises from the lead to a carefully defined point. The strength of the tail bond is a critical factor for the success of the entire cycle. A proper tail bond assists in avoiding such phenomena as "EFO open" and "short tail". The tail bond needs to remain attached to the lead until the capillary reaches the desired height.

At stage 7 the capillary rises above the lead. At the desired height, as the capillary continues its upward ascent, the clamp closes and the tail bond is detached from the lead while the stitch bond remains attached.

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At stage 8 the tail bond is now positioned above the pad. The end of the tail melts as the result of an electrical spark originated by the Electronic Flame Off (EFO) wand. The surface tension of the melted gold causes the drop to acquire the shape of a nearly perfect sphere, thus, creating the FAB. When the FAB solidifies, the cycle begins anew.

Figure 1.4 shows the stages in the bonding cycle (KNS, 2001).

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