DIE DEFECT CLASSIFICATION USING IMAGE PROCESSING

DARMADEVAINDRA
MANIAM

UNIVERSITI TEKNOLOGI MALAYSIA

DIE DEFECT CLASSIFICATION USING IMAGE PROCESSING

DARMADEVAINDRA MANIAM

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical-Computer and Microelectronic System)

Faculty of Electrical Engineering
Universiti Teknologi Malaysia

JUNE 2015

This thesis is dedicated, in thankful appreciation for the support and encouragement from my parents Mr. Maniam Sinnaperian and Mrs.Rukumany Kumarasamy, my beloved wife Shamini Muniandy, my brother, Mithirendra Maniam, families and friends.

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartily gratitude to my academic adviser and supervisor, Dr. Usman Ullah Sheikh for his proposal, insightful comments, and guidance on this project. Without his guidance, assistance, and involvement in every step throughout the process, this research would have never been published. I would like to say thank you very much for your support and understanding over these past two semesters and for being a friend. Thank you.

My appreciation also goes to my family especially my parents, Mr Maniam Sinnaperian and Mrs Rukumany Kumarasamy for believing in me and giving me encouragement to continue the Master Program. To my brother, Mitherendra Maniam for all his encouragement and for being a role model in my life.To my beloved wife, Shamini Muniandy who has been so patient and supported me through out the time of my studies. I am blessed for all their encouragement, love and emotional support that they have given to me throughout my studies.

Last but not least, I would like to express my appreciation to my friends especially my Master Group batch of 2011 and Lee Meng Chuan,Thank You for listening to my problems and guidance. Millions of gratitude also goes to those who were involved directly or indirectly in this project.

ABSTRACT

This work presents die defect classification using image processing. The detection of the flaw is based on the defect features in the die. Each unique defect or feature structure is defined from samples that has been collected by Visual Inspection Inspectors. The defects are then grouped into user definition categories such as blob, pin hole, underfill and die crack.This work also describes the image processing algorithms utilized to perform defect classification. The defect classification was developed from MATLAB program.It is aimed at locating the Region of Interest of the die from the image and extract it. The extracted image is then used to classify or recognize the specific classification category of the defect.Total samples that is being used in this project is 67 die samples. The results obtained from this work shows the overall accuracy of 94% for die defect detection and 87% for defect classification.

ABSTRAK

Kertas ini membentangkan klasifikasi kecacatan dai menggunakan pemprosses imej.Pengesanan kecacatan ini adalah berdasarkan kepada ciri-ciri kecacatan dalam dai. Setiap kecacatan atau ciri struktur unik ditakrifkan dari sampel yang dikumpul oleh Inspektor Pemeriksaan Visual. Kecacatan kemudiannya dikumpulkan ke dalam kategori definisi pengguna seperti blop , lubang pin, underfill dan retakan dai.Kajian ini juga menerangkan algoritma pemprosesan imej yang digunakan untuk melakukan klasifikasi kecacatan. Klasifikasi kecacatan dibangunkan dari MATLAB
.Ia adalah bertujuan untuk mengesan kecacatan daripada imej. Imej yang dikeluarkan kemudiannya digunakan untuk pengelasan atau mengenali kategori klasifikasi tertentu daripada jumlah sampel tersebut.Imej-imej yang digunakan dalam projek ini adalah 67 sampel dai. Keputusan dari kerja ini menunjukkan keseluruhan 94 % ketepatan mengesan kecacatan dan 87 % untuk klasifikasi kecacatan .

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE

LIST OF ABBREVIATIONS

ADC	-	Automated Defect Classification
EOL	-	End of Line
FOL	-	Front of Line
FVI	-	Final Visual Inspection
ROI	-	Region Of Interest
SIFT	-	Scale-invariant feature transform
SECS	-	Semiconductor Equipment Communication Standard
SEMI	-	Semiconductor Equipment and Materials Institute

CHAPTER 1

INTRODUCTION

1.1 Introduction

The semiconductor manufacturing process is regarded highly as complex in nature with a high tendency of introducing defects into the final manufactured product. Defect detection and classification are becoming an important diagnosis tools for systematic and structured defects screening and producing high product quality and reliability. Most of the die from wafer fab usually go through visual inspection.The common visual inspection process of die surfaces is very dependent to a manual review by a human experts. These experts categorize the defects into two categories: die saw defects and defects from die. The visual inspection job requires a lot of concentration, and the time taken for inspection tends to be quite slow and inaccurate. The unstable decision of an inspector can be quite large against various defect classes and each inspector relies on different features and strategies. There is no standard classification of defects from all the human visual inspectors. The availability of multiple data sources and the evolution of automated analysis techniques such as automatic defect classification and analysis is providing solutions to convert basic defect, parametric, electrical data into useful prediction and control. These techniques do not have any knowledge about defects generated during wafer mounting, dicing or even ink marking.

1.2 Background

The standard defect classification process is categorized into two stages, firstly,defect detection and secondly defect classification. In the actual production factory, human inspectors will interface with the review station to classify defects based on the defect classes defined by the engineer [1]. The engineer then uses these results to adjust the process to eliminate these defects or to perform further experiments to isolate the source of the defects. Final Visual Inspection (FVI) is to screen for visual and mechanical defects as shown in the Figure 1.1 . Figure 1.1 shows the overall manufacturing flow that consists of FOL (Front of Line) and EOL (End of Line) and FVI is sh [1]own in red. The inspection is to be performed at 1X (naked eye), with an overhead task light. FVI is the final step in the manufacturing process. Inspectors view each component at 1X to screen out visual and mechanical defects. Components that pass inspection are placed in trays, which are then stacked and strapped together to form bundles in preparation for packing. This type of information about defects needs a large amount of time and a skilled manpower to obtain. A lot of time is needed to enable a classification system that consists of human and to train a personnel to recognize the defect type characteristics and classify them accordingly. This is an ongoing process as new defect types appear and trained personnel move on to other positions. The time is added to the overall lot cycle time through the factory as this review and classification procedure is performed at several sampling points in the process. The large amount of effort is invested in training operators to perform the tiresome task of defect review and sorting. Variability can be obtained even from the same operator from die to die depending on the type of defects observed. If the defect types observed seem to fit accurately into the categories previously defined, then it would be expected that the results from operator to operator for the same die would be consistent. This is not usually the case and the classification of defects draws heavily on basic judgment and understanding of the individual who happens to be sorting the defect classification. The results obtained can be heavily influenced by the particular time of day. For example, if the review process needs to be completed in a short time towards the end of a shift, the operator is likely to spend less time at each defect anti settle for the “first impression”. Moods, attitudes, and fatigue can all become important factors in the “accuracy” of the results obtained. [1]

1.3 Problem Statement

Electrical testing will determine if each die on a wafer functions as it supposed to be. But these tests do not normally detect all the defective dies in a clustered defects on the die, such as blob, pin hole, chips, crack or localized failed patterns.The alternative way is to have five to 10 visual inspectors check the dies and hand mark the defective dies in, or close to these defect regions. The inspection task takes extreme concentration and the time taken by an inspector to validate the defect is very limited. The downside is that these defects are being detected at the finish operation.

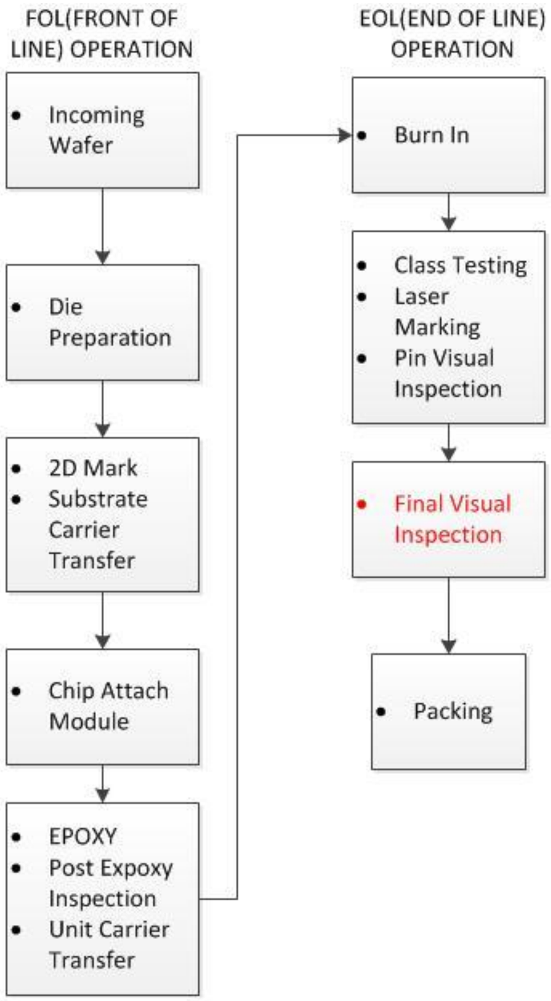

Figure 1.1: Generic Assembly and Test Process Flow

The detection will be based on the judgment of human operators while most other manufacturing activities are automated hence it is a quality control enhancement by detecting and classifying the defect using image processing.

1.4 Objective

The following are the objectives of this work:

1. It aims to locate the Region of Interest (ROI) of the die from the image and it will be extracted.
2. The extracted image will be used to identify or recognize as the specific classification category of the defect.
3. To achieve high detection rate of defects from the image.
4. To speed up the manual time consumed by using the method of Visual Inspection.

1.5 Research Scope

The research scope is as follows. Firstly, this project is implemented using MATLAB for offline processing. Classification are based on different defect categories which are Blob, Pin Hole, Underfill and Die Crack. Images are from the front profile of the die and no slight angle. The scope of this research will start from loading a static image of the die into the tool from the local computer hard drive and end at the process of displaying the die defect using MATLAB Image Processing.The focus will be on three identified Region of Interest (ROI) (ROI A, ROI B and ROI C) in Figure 1.2. Identification of the defect is based on qualitative feature of shape centered across the range of area and perimeter. No real time image capturing as all images were taken from factory production floor under controlled machine vision environment.

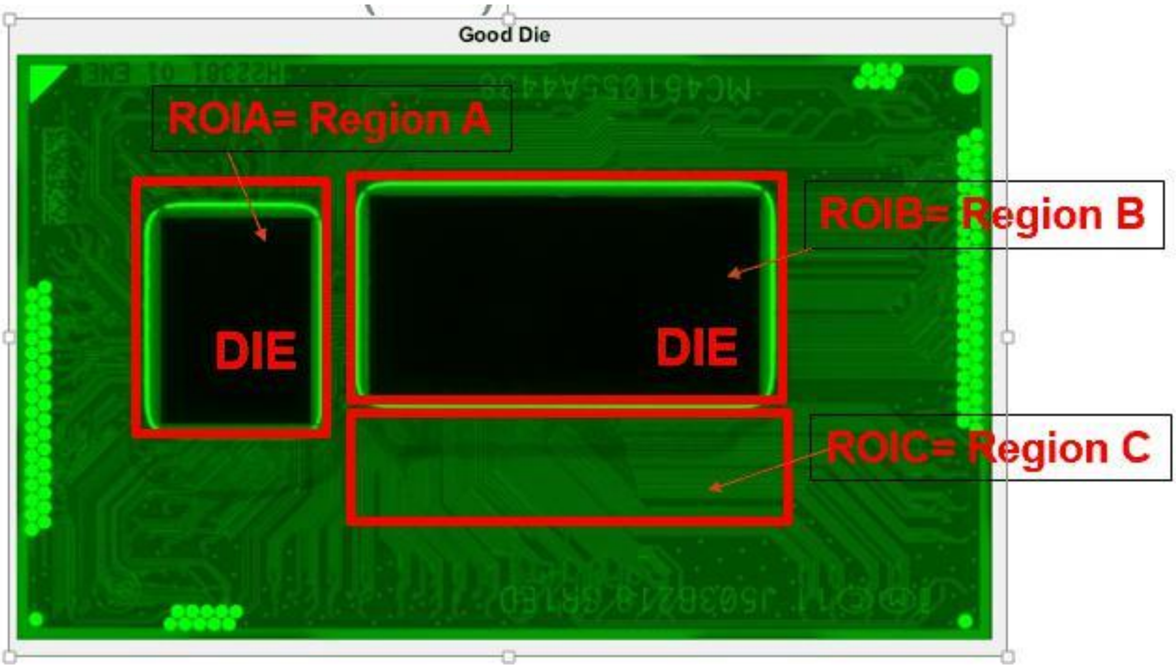

Figure 1.2: Regions of Interest

1.6 Organization

This study includes five chapters. Chapter two provides a comprehensive literature review on the methods on how to have die detection based on previous studies. Finally, based on the literature review the problems are identified. Chapter three proposes the methodology. In this chapter the methods and steps that are proposed in order to perform the detection and classification of the die are described. The methods consist of; Absolute Subtraction, Connected Component Label and Image Analysis. In chapter four the results of the die detection is provided. Discussions on the results of the project are also included in this chapter. Last but not least, chapter five concludes this work. Some comments and suggestions for future improvements are provided in this chapter.

REFERENCES

1. L. Breaux and B. Singh, “Automatic defect classification system for patterned semiconductor wafers,” pp. 68–73, IEEE, 1995.
2. C.-J. Huang, C.-F. Wu, and C.-C. Wang, “Image processing techniques for wafer defect cluster identification,” Design & Test of Computers, IEEE, vol. 19, no. 2, pp. 44–48, 2002.
3. N. Shankar, Z. Zhong, and N. Ravi, “Classification of defects on semiconductor wafers using priority rules,” Defect and Diffusion Forum, vol. 230, pp. 135–148, 2004.
4. H. Elbehiery, A. Hefnawy, and M. Elewa, “Surface defects detection for ceramic tiles using image processing and morphological techniques.,” WEC (5), pp. 158–162, 2005.
5. J. W. Cheng, M. Ooi, C. Chan, Y. C. Kuang, and S. Demidenko, “Evaluating the performance of different classification algorithms for fabricated semiconductor wafers,” Electronic Design, Test and Application, 2010. DELTA’10. Fifth IEEE International Symposium on, pp. 360–366, 2010.
6. P. B. Chou, A. R. Rao, M. C. Sturzenbecker, F. Y. Wu, and V. H. Brecher, “Automatic defect classification for semiconductor manufacturing,” Machine Vision and Applications, vol. 9, no. 4, pp. 201–214, 1997.
7. A. K. Jain, R. P. W. Duin, and J. Mao, “Statistical pattern recognition: A review,” Pattern Analysis and Machine Intelligence, IEEE Transactions on, vol. 22, no. 1, pp. 4–37, 2000.
8. C. H. Chen, T.-H. Cheng, W.-T. Wu, and S. Driscoll, “Machine vision algorithms for semiconductor wafer inspection: a project with inspex,” in Photonics East (ISAM, VVDC, IEMB), pp. 221–228, International Society for Optics and Photonics, 1998.
9. F. E. Babian, Optical defect detection limits in semiconductor wafers and masks. PhD thesis, Stanford University, 1987.
10. T. S. Newman and A. K. Jain, “A survey of automated visual inspection,” Computer vision and image understanding, vol. 61, no. 2, pp. 231–262, 1995.

11. M. Moganti, F. Ercal, C. H. Dagli, and S. Tsunekawa, "Automatic paraboard(pcb) inspection algorithms: a survey," Computer vision and image understanding, vol. 63, no. 2, pp. 287–313, 1996.

12. K. Wiltschi, A. Pinz, and T. Lindeberg, "An automatic assessment scheme for steel quality inspection," Machine Vision and Applications, vol. 12, no. 3, pp. 113–128, 2000.

13. B. H. Khalaj, H. K. Aghajan, and T. Kailath, "Digital image processing techniques for patterned-wafer inspection," pp. 508–516, International Society for Optics and Photonics, 1993.

14. A. Paulraj, R. Roy, and T. Kailath, "Estimation of signal parameters via rotational invariance techniques-esprit," in Circuits, Systems and Computers, 1985. Nineteeth Asilomar Conference on, pp. 83–89, IEEE, 1985.