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Safety Practices for Wafer Back Coating Process in Semiconductor Manufacturing Plant

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Terence Soosai Palaventhram[1], Norliza Mohd Noor[1,*]

[1] Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia

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ABSTRACT

Manufacturing industry is the pinnacle of any nation's industrialization development. The stringent safety protocols are vital for smooth accident free manufacturing operations. The high energy transfers and operational work involved in manufacturing products can pose various occupational and environmental hazards if not managed and controlled appropriately. However, there has been very little attention given to the occupational health and safety division in this industry in the early stages. Recent decades, the industry has place many focused initiatives in safety to curb the growing occupational health and safety cases in this semiconductor industry. The number of processes in this manufacturing industry is continuously growing to support the constant development in this semiconductor technological segment. Wafer back coating process, is a considerably new process that requires safety attention. This research focuses on identification of the hazards such as physical hazards and chemical hazards based on the accident cases, reporting and observations. The hazard analysis tools such as Hazard Identification, Risk Assessment and Risk Control (HIRARC) used to analyze the hazards and risk levels at the wafer back coating process. With reference to information from hazard analysis, effective safety practices will be proposed to improve the safety levels at the wafer back coating process with suitable hazard control measures. In inference, Safety practices implementation are established to control hazards at wafer back coating process.

1. Introduction

Energy transfers that occur during the manufacturing of a product can either be by the manufacturing equipment used or by the human dependent process involved in transforming the input product to produce the desired output [1]. The high energy transfers and operational work involved in manufacturing products can pose various occupational and environmental hazards if not managed and controlled appropriately. The statistics shown in Fig. 1 from DOSH (Department of Occupational Safety and Health), the highest occupational accidents in Malaysia is caused by the manufacturing sector with a total of 1691 accidents [2].

* *Corresponding author.*
E-mail address: norliza@utm.my (Norliza Mohd Noor)

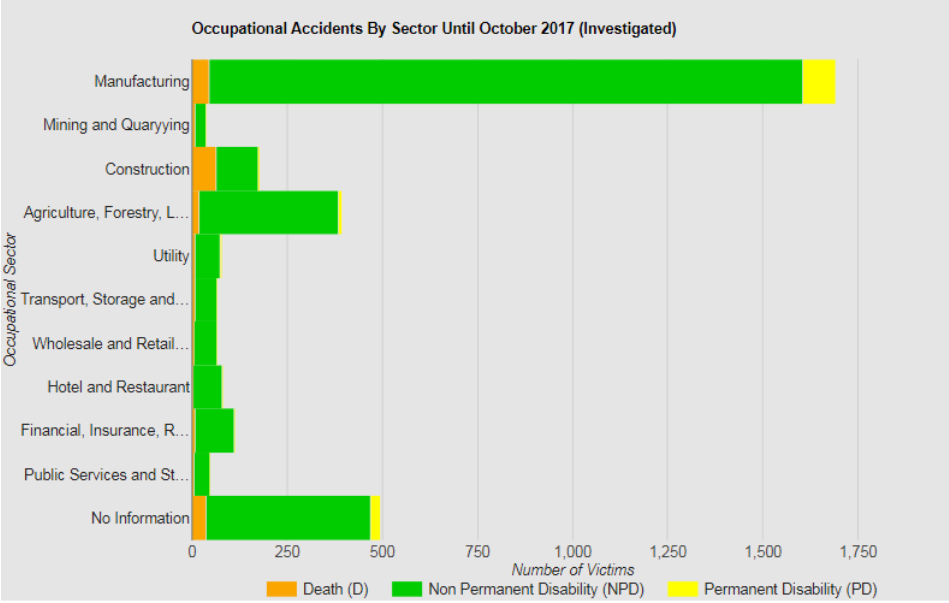

Fig. 1. Occupational Accidents by sector (Source: Department of Occupational Safety and Health, 2017)

Throughout the last few years, there has been speedily increasing demand in the wafer with epoxy or solder back coating for die bonding process using bonding agent methods. There is a growing consumption of Wafer Backside Coating (WBC) adhesives in semiconductor application due to the fast application of coating and increase productivity, as manufacturers do not have to go through the time consuming process of epoxy writing to attach the semiconductor die [3]. Moreover, the WBC process is cost effective, as it reduces the material consumption for die attach process [4].

Hazard Identification, Risk Assessment and Risk Control is a fundamental practice to identify, plan, manage and control risk [5]. Hazard identification, risk assessment and risk control are one of the key elements of the work safe plan.

Semi qualitative hazard risk assessment provides an intermediate level of risk assessment between textual evaluation and evaluation based on numerical data. Semi quantitative assessment quantifies the risk levels by evaluating risk with scores for each qualitative factor in the risk assessment [6].Semi qualitative risk assessment is more effective to provide a structured way to rank risk levels of an identified hazard. Semi qualitative approach can be further enhanced by including some quantifiable data such as accident trends, frequency of occurrence and loss of working days to support the risk scoring. In cases whereby, no quantifiable data is available, the risk rating shall be based on qualitative assessment which then be converted to quantifiable scoring [7-8].

The risk assessment method by Fine and Kinney is commonly used to develop semi quantitative HIRARCs that are has more details to gauge the risk ratings, since there is high levels of vagueness involved in the Occupational Health and Safety data. The Fine and Kinney methods allows rule based system of Probability (P), Exposure (E) and Consequence (C) for evaluating the risk score [9-11].

This study offers a brief overview on the wafer back coating process flow in semiconductor manufacturing industry. On a detailed scope, this research provides focused analysis on the hazards present in wafer back coating process and the effective hazard identification methods used to identify hazards in manufacturing environment. Furthermore, this research focuses on application of hazard identification tools such as Hazard Identification, Risk Analysis, and Risk Control (HIRARC) to identify and analyse the risk hazards and risk levels in wafer back coating process.

2. Methodology

The research will develop a structured safety practice and design for wafer back coating process in a semiconductor company in Malaysia. The base of the research will be on the quantitative data of accident records and clinic records of the staffs working at the wafer back coating process. Moreover, there will be some baseline qualitative survey done to gauge the perception of staffs on the current safety conditions of wafer back coating process. With the initial baseline data, hazard identification tools will be used to analyze the hazard levels at wafer back coating process in a semiconductor company in Malaysia. Final course of this research will focus on proposal of robust safety practices and design implementation at wafer back coating process.

Company accident records and clinic data will be the main baseline records for the startup of this research. Hazards identification tools and methods such as accident trend, interview and observations will be used for hazard identification and analysis at wafer back coating process. Finally, the analysis from Hazard Identification, Risk Assessment and Risk Control (HIRARC) will be used to propose robust safety practices and design. Furthermore, to ensure continuity of safe practices implementation, execution of all safety activities will be documented in company change management folder and properly proliferated to all operation team through documented training programs.

The operational framework shown in Fig. 2 is the flow of activities or work that is needed to accomplish the research objectives, which is, to identify hazards in wafer back coating process in the semiconductorcompany in Malaysia, to analyze the hazard levels in wafer back coating process and to propose robust safety practices and design for wafer back coating process.

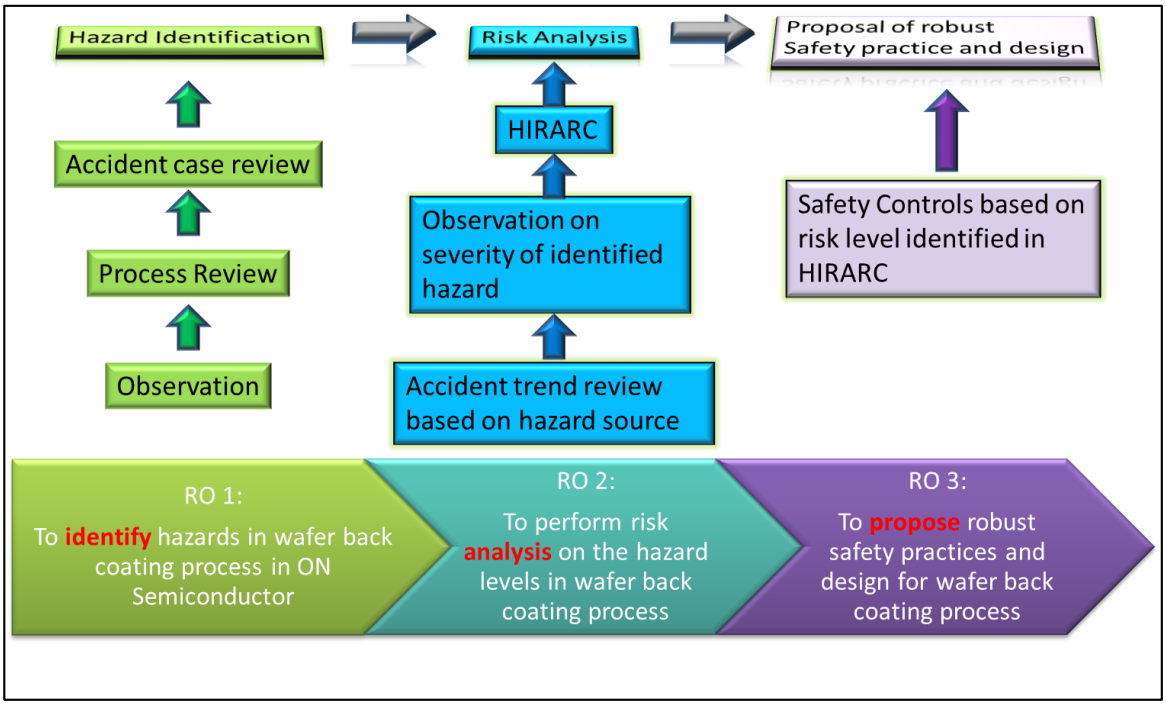

Fig. 2. Operational Framework

2.1 Establishment of Hazard Identification, Risk Assessment and Risk Control (HIRARC) template

The HIRARC template will be a semi qualitative template created in this study as shown in Fig. 3. Unlike the HIRARC from Department of Safety and Health (DOSH), consisting of Likelihood and

Severity, the Semi qualitative HIRARC used in this study will consist of Probability, Exposure and Consequences. This increased granularity of risk analysis will ensure a precise risk assessment and risk control. The probability and Consequences is similar to Likelihood and Severity in HIRARC by DOSH. However, the differences are in the Exposure, whereby the Exposure determines the rate of exposure of the worker to the hazard. The exposure rates are a semi-qualitative measure that determines the risk level with more precision. The higher the exposure of a worker to the hazard the higher the risk level of the hazard. Exposure levels are also affected by the number of times the worker failed to wear Personal Protective Equipment (PPE) and the exposure hours if PPE failed. This data can be achieved by calculating the number of hours the worker is working with the hazard in place [7,8,9,10].

Hazard Identification			Risk Assesment					Risk Control				
Activity	Steps	Hazard	Risk	Risk Qualification				Implemented Controls	Risk Qualification After Correction			
				P	E	C	R		P	E	C	R

Fig. 3. HIRARC template

3. Results and Discussion

The Risk assessment is done based on brainstorming, team discussion, and work process observations and also with reference to accident cases reported for the past five years. The number of incidents reported by plant clinic (Fig. 4) and the number of near miss cases reported (Fig. 5) at wafer back side coating process is analysed and is referenced during determination of the Probability (P) factor in the risk analysis.

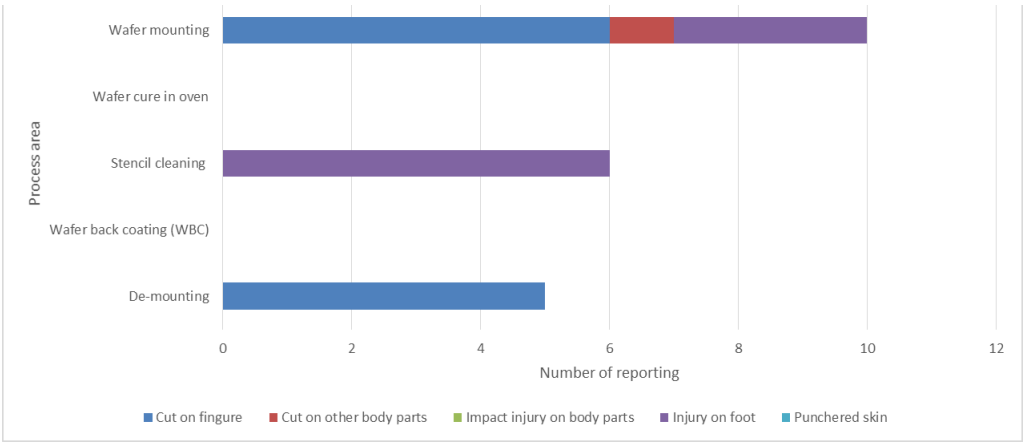

Fig. 4. Accident cases trend at wafer backside coating (WBC) process from year 2013 to 2018

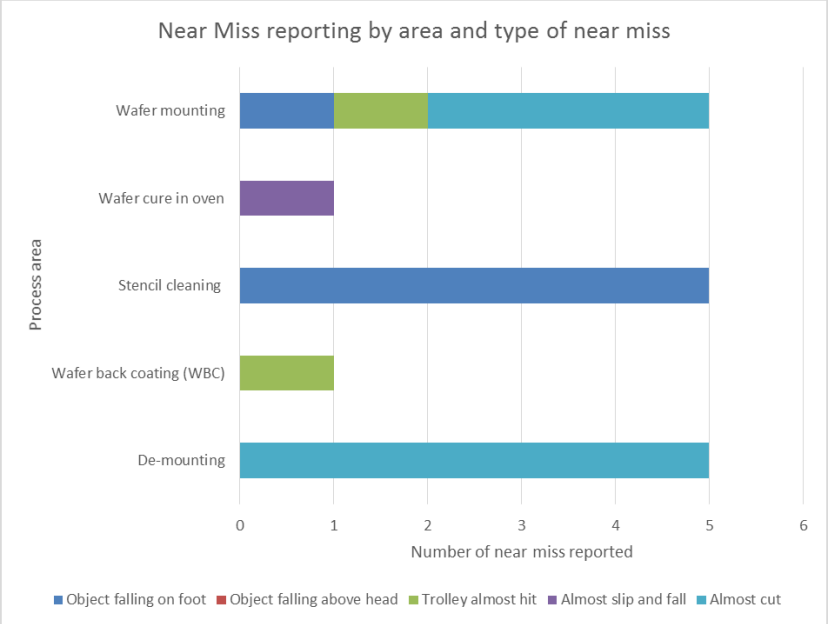

Fig. 5. Near Miss reporting from June 2017 to January 2018

The initial risk assessment of the hazards without taking into consideration of the risk controls show a variety of high risk levels as implicit in any manufacturing processes. The risk levels of the hazards are then lowered down through implementation of control measure in the Risk Control segment of the HIRARC. However, even though the risk levels have been further reduced through implementation of controls, the risk levels of at some process step still remains high due to increase in probability factor or minimal reduction in the probability factor that is a direct impact from incident cases reporting and near miss reporting at some process steps. Thus, the reporting of incidents and near miss at certain process steps is an indication that the implementation of risk controls at the process step is less than adequate.

The process steps that have high risk levels despite implemented controls are cutting process from mounting and de-mounting step, removal of stencil from stencil cleaning process and wafer carrier transfer from de-mounting step. Table 1 shows the process selected from HIRARC that have high risk ratings due to the incident reporting and near miss reporting.

3.1 Additional Controls to Reduce Risk Ratings at Wafer Back Coating Process

The risk rating at mounting, de-mounting, removal of stencil and wafer carrier transfer needs to be further reduced to ensure the risk levels at wafer back coating process is at an acceptable level. The additional controls implemented are prioritized according to the hierarchy of controls which is from highest hierarchy to the lowest, Elimination, Substitution, Engineering, Administrative and Personal Protective Equipment (PPE).

For mounting and de–mounting process, the hazard identified is cutting hazard from the blades used by the operators during the manual cutting process. The cutting risk levels are high at 900 risk rating, due to the frequency of blade usage, as operators will need to perform the cutting throughout the 12 hours shift, and anti-cut glove (PPE) usage recommendation as a control measure is proven to be inactive due to the high numbers of cut injury accidents resulting from operators forgetting to wear PPE.

The safety practice proposed is redesign of wafer mounter to eliminate the cutting hazard. Additional top cover is introduced with embedded cutting tool that is fully isolated from contact to operator's hand.

Table 1
Process steps that have high risk levels with remarks on incident reporting and near miss reporting

Step	Hazard	Current controls	Type of controls	Risk Rating	Remarks
Mounting	Cutting and puncher hazard from the blade usage	On Job training	Administrative	900	High probability (P), even with PPE control measure, due to recent accident of operator not using PPE
De-mounting		PPE: Anti-cut gloves	PPE		
Removal of stencil	Object falling on foot and causing foot injury	On Job training	Administrative	147	High Probability (P), due to recent reporting on near misses
		EMO switch	Engineering		
		Loader safety cover door	Engineering		
		Door open alarm	Engineering		
		Safety interlock with cut-off sensor	Engineering		
Wafer carrier transfer		Angled wafer carrier handle	Engineering	180	

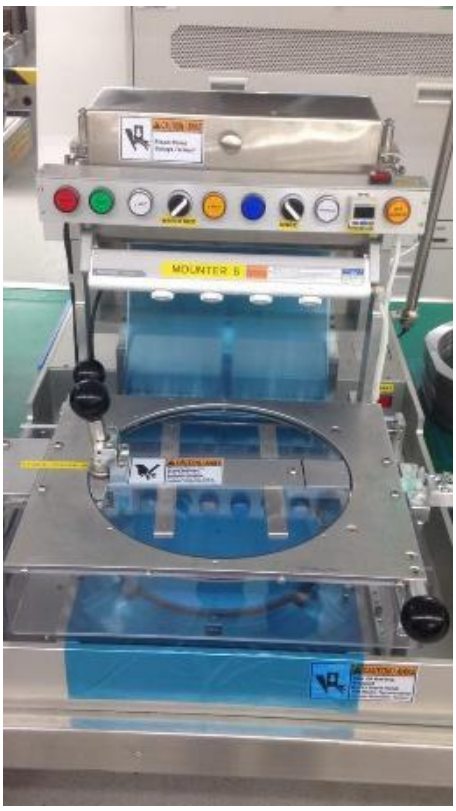

Fig. 6. New mounter design with top cover

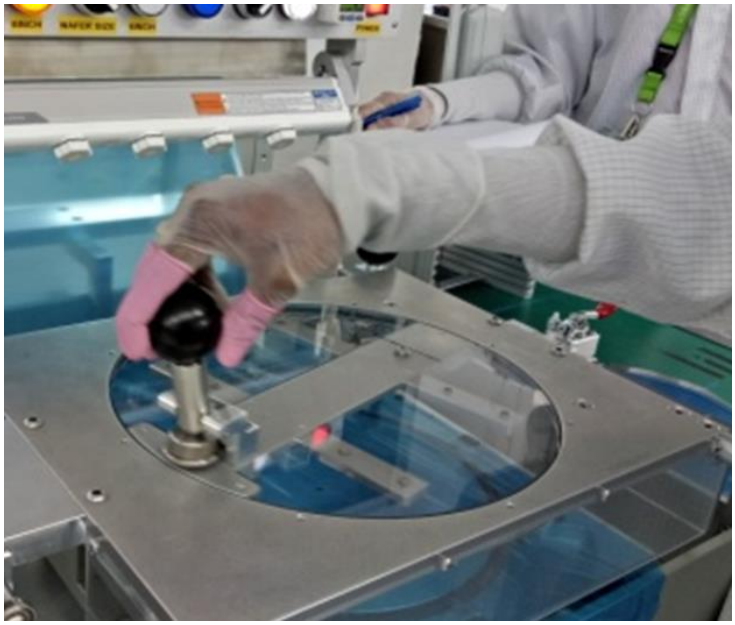

Fig. 7. Handle to rotate cutter for cutting process, isolation from ring of fire (hazard area)

The need to use metal blades for manual cutting process is eliminated through the introduction of the new mounter design (Fig. 6). The new mounter design would not require operators to user metal blades, and operators will just need to close the cover and rotate the cutter guide (Fig. 7). Thus, the new design, eliminates the exposure of operators to the cutting hazards, and isolates the operators from the rig of fire (hazard area) which is the cutting area of the blade in the mounter.

Another area that shows high risk rating from the HIRARC is removal of stencil and wafer carrier transfer with a risk rating of 147 and 180 respectively. The contributing hazard to the high risk rating at this process steps are objects falling on foot. The foot injury risk is high due to the design of the anti-static shoes used by the operators, which has no protection to the top side of the foot. The design of the shoes is changed by introduction of safety shoes with Kevlar reinforced toe shoes. The new shoes design uses Kevlar material instead hard heavy steel to cover the toe as the shoes need to light to ensure comfort of the operators. Figure 8 shows the old and new design of the anti-static shoes.

Fig. 8. New versus old design of anti-static shoes

The introduction of safety shoes at the wafer back coating process has reduced the risk ratings of foot injury at wafer back coating process. The new shows design will protect the foot of operators from injury as it reduces the exposure of the foot from physical impacts.

4. Conclusion

The final risk rating of the HIRARC at wafer back coating process after implementation of the additional control measures have been further reduced to acceptable levels. The major significance of this research is the usage of a semi-qualitative HIRARC to identify the current hazards at wafer back coating process in ON Semiconductor and analyze the risk ratings and the implications of the control measures to reduce the risk ratings.

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