Using Kaizen Method to Eliminate Negative photo resist Non Coating Detection Issue in Manufacturing Industry
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Abstract
Defect free management is the ultimate goal of any organization. One of the best method to create a defect free manufacturing will be kaizen. The term kaizen itself comes from the word Gemba Kaizen meaning ‘Continuous Improvement’ (CI). Continuous Improvement is one of the core strategies for excellence in production, and is considered vital in today’s competitive environment.

Thus, the aim of this paper is to explore the Kaizen approach implementation in company X which is having problems with Negative Photo Resist non coated products being scraped in huge quantity. Thus it can help on the subsequent case studies and idea to further improve on other industry process. It will seize a great improvement opportunity in order to improve and resolve with the existing process in any fields. They are various sectors have been studied on the Lean Six Sigma approach and what is impact of intercept this methodology. Therefore, an analysis was constructed in this paper which will help scholars and practitioners to better understand the concept and the influence of this approach. By applying the Kaizen methodology, a solution for the problem in hand was able to be conceptualized and executed. Based on this study it is recommended kaizen methodology in various industries for continuous improvement in cost, quality and so on.

Key words: Kaizen, Non coating, Photoresist, Detection

1. Introduction

Photoresist is a material that is photographically exposed and processed, and used to "resist" a sandblast stream and thereby transfer a pattern to the object being sandblasted. Globally, there are two types of photoresists: positive and negative. For positive resists, the resist is exposed with UV light wherever the underlying material is to be removed. In these resists, exposure to the UV light changes the chemical structure of the resist so that it becomes more soluble in the developer. The exposed resist is then washed away by the developer solution, leaving windows of the bare underlying material. In other words, "whatever shows, goes." The mask, therefore, contains an exact copy of the pattern which is to remain on the wafer.

Negative resists behave in just the opposite manner. Exposure to the UV light causes the negative resist to become polymerized, and more difficult to dissolve. Therefore, the negative resist remains on the surface wherever it is exposed, and the developer solution removes only the unexposed portions. Masks used for negative photoresists, therefore, contain the inverse (or photographic "negative") of the pattern to be transferred. The figure below shows the pattern differences generated from the use of positive and negative resist.

![Fig 1: Different pattern](image)

![Fig 2: Different Resist](image)

This technology is widely used in world wide especially in asia for the following application:

- Fabrication of printed circuit boards: This can be done by applying photoresist, exposing to the image, and then etching using iron chloride, cupric chloride or an
alkaline ammonia etching solution to remove the copperclad substrate.
- Sand carving: Sand blasting of materials is done after a photolithographically printed pattern has been applied as a mask.
- Microelectronics: This application, mainly applied to silicon wafers/silicon integrated circuits is the most developed of the technologies and the most specialized in the field.
- Patterning and etching of substrates. This includes specialty photonics materials, MEMS, glass printed circuit boards, and other micropatterning tasks. Photoresist tends not to be etched by solutions with a pH greater than 3.

There is no comparable technology to photoresist at this point of time and the technology has evolved only on the application.

Company X uses Negative photo resist for the purpose of patterning and the technology is used as it offers better process controllability for large geometry features. Negative photo resist is an equipment used in company X as application to separate each cell and to prevent short circuit forming between cells.

This process is used after a process called laser scribing. Laser scribing is the process of cutting the film into smaller cells and provide series of interconnection. By cutting the film into smaller cells, small current will be produced at a higher voltage which produce the same wattage. The cutting on the panel is then filled with NPR material.

This film is rolled onto the surface of the products arriving in the applying unit after sensed by a sensor which invokes the linear path control to start lowering the upper applying unit. Rotary encoder is used to sense the speed of the transport unit.

1.2 Motivation of Study

Each time the defect occur, company X need to scrap almost 200 products with the potential value of USD200K. This cost does not include the manpower cost related to this scrap and there is always a possibility of this scraps reaching customer creating a big quality problem. Every year it was noted that this problem happening at least eight time and this becomes a big issue in company X.

1.3 Significant of Study

The losses due to this non coating defects are significant for company X. The losses can be divided into 2; tangible and intangible.

The tangible losses loss in potential profit, delay in shipment as the company need to run additional production run to cover the loss in shipment target. There will also an impact in the yield. This is very significant to the company as the losses represent a loss in total company profit. If the company misses the shipment target, the company will lose potential customer as it could not provide good support to customer. The customer for this company uses the product immediately once it is receives the product from company X.

The intangible losses are the losses in the material used to produce the product, man hours to sort out the defective products once it reach shipping and hours spend to troubleshoot this issue.

The significant of this study will be to create a system to detect the non coating products as it happens.

1.4 Problem Statement

There Negative photo resist is the name of the machine that company X uses for its process. As the name implies, it uses the photoresist technology. The operation of the machine is basically involves activation of the material circulation system. Once activated the coating material circulates continuously between the material container and the applying unit.

The material flow is controlled via a flow monitor in the feed pipe. This film is rolled onto the surface of the work piece passing through the roller gap by the applying roller pressed against the panel. Electrical material pump sucks the coating material from the material container and the coating material distributes itself in the roller gap. The feed rate of the coating material or cleaning agent is controlled by the metering valve built into the feed pipe. The material pump is in continuous operation in order to ensure uninterrupted circulation and movement of the coating material.

Given the nature of mechanical complexity of the panel coating and the potential failures which is usually associated with it, the need for a system to address potential failures is imminent. This is very important as in the event of mechanical failures such as encoder malfunction, the products will moved thru the applicator to the next station process without any coating and the colour of the products will not give any inclination of the non coating situation.
Due to this the products will escape the inspection point after the subsequent process and will end up at the finishing area where it will create no connectivity issues. Normally there will be about 250 passed thru machine without coating before detection and this products will be scrapped.

What this shows is that we need to control the mechanical failures and since the Negative Photo Resist is full of mechanical parts, there is a need to detect the condition of the products in the event there is a mechanical failures. With an opportunity for improvement, kaizen approach was used to create a solution to resolve the issue. The objective of this study is to use kaizen method in creating a solution to prevent the no coating defect from reaching customer or the final process.

1.5 Research Question
It is important to understand and study the way to create non coating detection. Two variables which is the fundamental for the non coating incidents are mechanical failures and the inability to detect the no coating situation are selected as the parameter for this study. The recommendation is to apply DMAIC to drive the variables in order to achieve the objective.

- What will be the best improvement/solution that can be done to ensure early detection of non coated products?
- Is defect free manufacturing and cost reduction possible by using Kaizen method?

1.6 Research Objective
The objective of this research is are:
I. Eliminate the possibility defective products reaching customer
II. Ensure defect free manufacturing and to reduce cost by eliminating scraps

1.7 Methodology

Literature review was done on Kaizen related journals and this information as used as a platform to do product development that will help to resolve issues with the non coating detection of the plates.

Unintentional failure of product coating has been found to cause issues at process end area as products without the coating yields zero function products. This effect was discovered when recent failure on the machine caused products moves without coating.

In order to scrutinize the mode of failure, a research was initiated with a purpose to test various hypothesis that could cause products without coating to proceed to the subsequent station without any triggering and based on this verifications, a solution was conceptualized as a mean of interventions to mitigate no coating products.

Several DOEs were used in order to understand the all probable causes for the possible non coating situation to happen. Once a basic process was dialed in, checkout and pre-qualification was performed on a unit in KLM.

The DOEs was carried by using statistical hypothesis test/confirmatory data analysis with the intention to carry out information-gathering exercises with the inclusion of variation. In this design of experiments, the effect of induced intervention on the experimental units studied. The result was further confirmed with a repeating test and experiment to get a consistent results

The following indicates the parameters that were experimented and tested in order to realize the nature of failure. The hypothesis selected is based on the most probable occurrences.

1. **Hypotheses 1:** Abnormalities in solution dispensing
2. **Hypotheses 2:** High humidity causing coating to evaporate
3. **Hypotheses 3:** Abnormality on the incoming products
4. **Hypotheses 4:** Failure on mechanical assembly/parts(Encoder, Bearing assembly and Metering valve)

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<thead>
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<th>Parameter</th>
<th>Description</th>
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<td>Negative Photo Resist system</td>
<td>Does not have any capability to provide inline reaction in the event of mechanical failures.</td>
</tr>
<tr>
<td>Coating detection system</td>
<td>Used to detect the panel arrival while the fiber optic sensor is used to trace coating reflection.</td>
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Based on the outcome of the experiments conducted, it could be safely concluded that Negative Photo Resist system does not have any capability to provide inline reaction in the event of mechanical failures. If there is any mechanical failure there will be no alarm and the machine will continue processing and as a consequence defective products are produced and it is very hard to determine this kind of panel with naked eye.

To mitigate this and to further enhance the tool capability, Kaizen option was explored and non-coating detection system was established. A coating detection system is totally independent from current machine and no coating triggering is by a revolving lamp and a buzzer system. The system will ensure that there is a detection to catch any products that are sent on without coating. The main component of this system is photos sensors, fiber optic sensors, PLC and triggering systems this system will detect the products that are not coated and prevent products scrap.

The system uses both fiber optic (red light source) and photoelectric sensor. Photoelectric sensor is used to detect the panel arrival while the fiber optic sensor is used to trace coating reflection. This is ideal for sensing environments with light restrictions, such as places where light-sensitive film is being handled. The system includes full-auto teaching function which allows sensitivity to be set without stopping the work piece line. Once a panel without coating is detected the system will trigger a buzzer and a revolving beacon lamp. This triggering will create an awareness to the operator and they in turn could react to the situation accordingly.

1.8 Discussion and Conclusion

This paper investigates and seeks for the solution for non coating detection. The incorporation the new detection system as part of the Kaizen approach does not have any impact on the existing line. The following parameters was observed to ensure there is no shift in the process with the incorporation of the new detection system. The following page will show some of the data from the pilot run.
In summary, the no coating detection system was found to be an effective way of controlling the unintentional movement of non coated products and maintaining the products coating with specification limits. The idea which came from literature review of Kaizen related journals and applying the concept has produce a fruition.

The intentional mechanical failure induced was able to detect by the detections system. With the introduction of sensor beam on the products, no destabilization factors are induced on the coated products. Negative Photo Resist coating has been noted to be applied uniformly.

Based on the study the best improvement to ensure the early detection of non coated products will be the development of the implemented system as the system is proven in detecting problem products and Kaizen method is effective in the system development.

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