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# Non-Product Wafer (NPW) Tracking Guidelines

**International SEMATECH Manufacturing Initiative**
**Technology Transfer #08094955A-ENG**

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**Abstract:** This report from the MFGM033M project presents concepts and strategies for tracking non-product wafers (NPWs) in semiconductor fabs. It is intended to be used by device makers and others in the industry to lower manufacturing costs.

**Keywords:** Automated Data Collection, Costs, Non-product Wafers

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## Acknowledgments

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# 1 EXECUTIVE SUMMARY

This report represents the consensus of the International SEMATECH Manufacturing Initiative (ISMI) member companies on their vision of the future and an industry direction for tracking non-product wafers (NPWs) to further reduce manufacturing costs. It presents general concepts and strategies, rather than specific methods or procedures, that can be used by device makers and others in the industry.

# 2 INTRODUCTION

Modern semiconductor fabs are constantly striving to reduce costs. In addressing key factors of semiconductor manufacturing efficiency with its member companies, ISMI has identified NPWs as a significant contributor to fab costs. NPWs are used for multiple purposes (e.g., equipment qualification, process conditioning, and process qualification). Figure 1 shows typical NPW usage per tool type at multiple fabs. Since the quality of NPWs is almost the same as production wafers, the quantity of NPWs used in manufacturing impacts cycle time, manufacturing cost, and manufacturing capacity. To accelerate a reduction in cost and NPW use, the ISMI NPW Working Group is proactively identifying best practices. Currently, modern fabs employ automated handling of product wafers with considerable wafer-level tracking. In contrast, NPWs are handled manually with only minimal tracking. This inadequate tracking capability has been targeted as a major impediment to reducing NPWs.

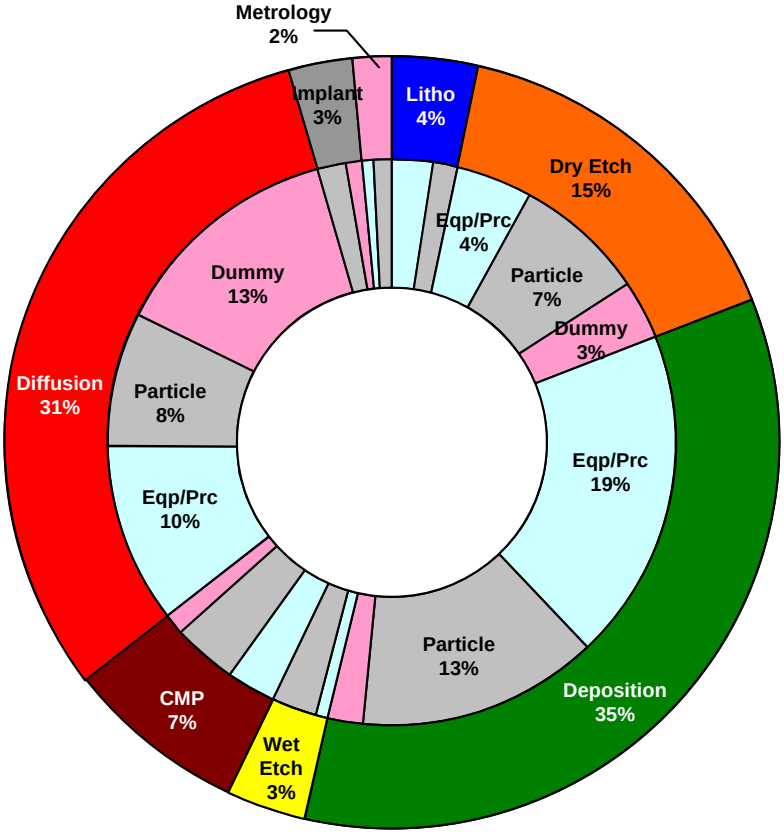


**Figure 1 NPW Usage by Tool Type**

## 3 PURPOSE/SCOPE

This document presents comprehensive approaches to track non-product wafers as they are used in semiconductor manufacturing. The key concepts inherent in these guidelines are as follows:

- Visibility into NPWs
- Maximized utilization of NPWs
- Adjustability for multiple flows
- Enhanced automated material handling system (AMHS) functions
- Enhanced the traceability of NPWs history
- Optimized sampling frequency
- Alternative method of NPW tracking

## 4 GENERAL EXPECTATIONS FOR NON-PRODUCT WAFER TRACKING

In addition to technical challenges, such as increasing process steps and various new materials, the increase in silicon wafer cost in recent years has impacted manufacturing costs from using NPWs. Although various activities have reduced NPW costs, tracking NPWs using the following guidelines can further reduce costs for the semiconductor fab.

### 4.1 Visibility into NPWs

NPWs are used in the following process flows:

- Tool conditioning
- Stabilization of process performance
- Qualification of tool performance
- Qualification of process performance
- Process development

NPWs are processed separately from production wafers, and sometimes they are used for multiple purposes and reused until a criterion is reached. To be used multiple times, NPWs are recycled or reclaimed. Because fabs use a large number of NPWs, it is important to collect NPW information, including wafer location, specifications, previous usage, and history. It is also necessary to analyze NPW information with forecasted usage and improve usage visibility to help the fab operation and reduce the number of NPWs used.

To provide more visibility, large amounts of data may be collected to track NPW usage. Efficiency of storing the data and the speed of response are important considerations.

### 4.2 Maximizing Utilization of Non-Product Wafers

Maximizing the utilization of NPWs is key to reducing manufacturing costs. The cost of a virgin wafer, a reclaim wafer, a recycled wafer, and a reused wafer varies considerably. Using fewer virgin wafers is a cost-effective measure, hence an NPW tracking system is needed to maximize the usage of reclaimed, recycled, and reused wafers. Particle checking also uses a number of

NPWs. Downgrading the wafers for other usage, instead of reclaiming, is also effective. To do this, the historical data for these various NPW flows must be adequately tracked.

### 4.3 Adjustability for Multiple Flows

There are various NPW flows in a fab, and their total number can be quite large. These flows sometimes contain the same specifications during processes to create film, recycle, or reclaim. Because the NPW specification easily affects the number of NPW flows, a specification should be kept as common as possible. Also to recycle or downgrade NPWs effectively, they must be reallocated even if they have already started in another process flow. Because this reallocation is indispensable to the overall NPW movement within the fab, it must be done correctly and be subsequently tracked.

### 4.4 Enhance the Function of the AMHS

The factory's lot-handling system manages a variety of qualification wafers. If qualification wafers are handled manually, they can be easily damaged and data cannot be captured and stored correctly for subsequent decision making and analysis. Keeping coherent data and adequately handling qualification wafers are important activities.

### 4.5 Enhance the Traceability of the NPW's History

Manufacturing execution system (MES) recipe constraints, especially in carrier recipe operations, may restrict NPW operations. The MES should apply single-wafer recipe operation to operate NPWs effectively. The traceability of an NPW's history may be enhanced when combined with the external silicon supplier's history.

### 4.6 Reporting and Sample Scheduling

NPW usage history must be reported to better understand current usage and to estimate future usage. To estimate the future required numbers of NPWs and their planned utilization date, a detailed usage report is required for each tool. Since tool qualification and process qualification sometimes use the same procedure, using NPWs raises the potential for redundant qualification. Reporting detailed sampling data and analysis will help avoid redundancy.

### 4.7 Alternative Method for NPWs

By continuously using equipment data, equipment abnormalities can be detected earlier than during the normal NPW sampling period. By combining two or more equipment information streams, process performance can be predicted and substituted for measurements by NPWs.

## 5 REQUIREMENTS FOR NPW TRACKING

The following requirements for NPW wafer-level tracking are based on current operation practices within the semiconductor industry.

### 5.1 NPW Visibility and Wafer IDs

Visibility into NPW usage should be tracked under normal operation. Each NPW should be scribed just as production wafers are. The scribe is useful for troubleshooting fab issues. The ID must comply with SEMI-M12-0706; it should also be both human- and machine-readable. The

ID should be the same over the wafer's lifetime to track its historical data. Historical data need to identify the production line, tool, and chamber for both the fab and the reclaim supplier.

Using the same software for tracking both product and non-product wafers is advisable. The tracking capability should include the following features:

- The software should provide basic operation such as dispatching, sorting, and verifications.
- All dummy wafer information located in the tool buffer station or port must be recorded.
- The classification of a wafer, its history, the number of times it has been recycled or reclaimed, and its thickness are important for NPW operations; these data should be recorded in the same software used for product wafers and updated automatically.
- If the MES does not adequately track NPW information, an electronic note associated with the carrier will help to understand the monitor type, thin film type, thickness, and current number of times the wafer has been internally reclaimed. Automated NPW tracking provides a comprehensive view of the wafer's history.
- The reclaim supplier must rescribe the same ID in the same position. If the ID cannot be read, reclaim suppliers can rescribe it based on the IC maker's requirements at that time.
- Data must be backed up in robust data storage with a fallback system similar to the production system with multiple mechanisms for tracking product and non-product wafers.

### 5.2 Sorting Rule and Prioritization Management of Non-Product Wafer

Fabs employ various activities and approaches to sorting and prioritizing their NPWs. Figure 2 highlights the complexity of a typical NPW flow between process areas in the fab. Sorting is a basic function for NPW operation; it also is an important activity to prioritize NPWs operation. Sorting should be supported by additional rules, such as the following:

- Data-mining to monitor particle counts on wafers
- Down grading
- Controlling reclaim wafers
- Preventing cross-contamination

Each rule should work independently, without conflicting with the other rules. Other features of these rules are as follows:

- Managing the prioritization of each rule must consider actual fab inventory information.
- A bank system helps to collect NPW information easily and execute downgrading effectively.
- Tracking overall NPW history will minimize the sorting operation and maximize the NPW's life.
- Mutual sharing of data between the fab and reclaim supplier supports cohesive tracking.

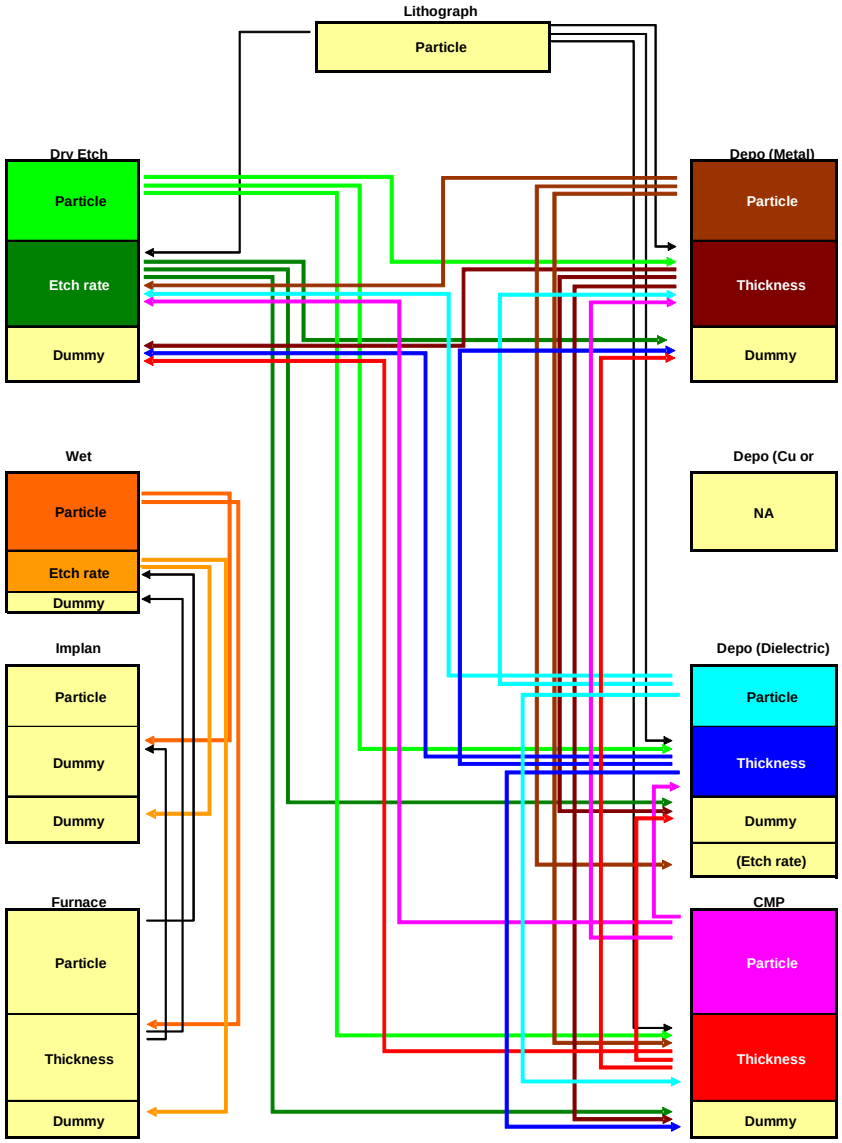


**Figure 2 Sample NPW Downgrading Between Process Areas**

## 5.3 Adjustability for Multiple Flows

Using NPWs, recycling internally, and downgrading wafers between process areas will complicate wafer-level tracking. Activities such as creating rules and establishing a banking system, registering total NPW flows, and operating with sufficient function will need to be supported. To use NPWs efficiently, a gradual introduction is suggested:

- Consider internal reuse until a better wafer tracking system is installed.
- Create a bank system and keep enough information so that a wafer-level tracking system for NPWs can execute downgrading and sorting.
- Adopt a route-based cascade system that allows for alternative route move-outs. This system helps control where the wafers can go.

### 5.4 Enhanced the Function of AMHS

The wafer handling system must be the same for NPWs as for product wafers. Just as for operational wafer-level tracking software, the AMHS operation should handle NPWs in the same way as product wafers. The goals are as follows:

- Use the same handling system for product and non-product wafers.
- Use the same physical ID system for product and non-product wafers.
- Eliminate manual handing and manual data input.
- Maintain the same wafer handling system for NPWs as for product wafers.

### 5.5 Enhance the Traceability of the NPW's History

While 300 mm tools can assign different recipes to each wafer, most 200 mm tools can assign only lot- or carrier-based recipes. For 200 mm cluster tools, which have more chambers than carrier stages, this lot or carrier recipe loading will cause an operational loss during NPW qualification because of changing multiple carriers. The following capabilities will improve NPW traceability:

- A slot-level (wafer-level) recipe downloading system will help the carrier handling operation for NPWs.
- External reclaim supplier should support single wafer tracking.

### 5.6 Reporting and Sample Scheduling

Tracking NPWs supports the collection of sample status (e.g., ready for use, area, location, grade, available for downgrade/rework/recycle/reclaim). Lot-based sampling and time-based sampling can be redundant. When they are, one can be eliminated.

- Scheduling the next usage for a specific NPW promotes redundant sampling
- Setting the priority and dynamic sampling rate will improve redundant sampling
- Tracking condition-based sampling will help reduce the sampling frequency

Any reporting provided for product wafers must also be provided for NPWs. Additionally, NPW tracking requires other reports (e.g., recycling history, reclaim forecast, and number of NPWs not used).

### 5.7 Alternative Method for NPW

The periodic diagnosis and stability of a tool can be evaluated without NPWs by effectively using tool fault detection and classification capability. By practical use of equipment data, lot data can be substituted for NPW usage monitoring. This is a good opportunity to reduce the inventory by focusing only on non-periodic usage.

- Substituting tool monitoring data for NPWs by using Virtual Metrology can reduce NPW usage.

## 6 SUMMARY

Non-product wafers, which are used extensively by semiconductor fabs, have played an important role in diagnosing equipment conditions and process performance. However, the total number of NPWs used has a significant impact on production costs. Many process flows and specific rules govern NPW operation; some of them are very different from normal production flow. Recognizing these differences and providing wafer-level tracking of NPWs are paramount to reducing their usage and improving fab productivity. These guidelines emphasize the importance and benefits of non-product wafer-level tracking to reduce manufacturing costs for the semiconductor fab.

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