300mm Prime Guidelines

Phase 2
Version 2.5
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JEITA-JSIA

Japan Electronics and Information Technology Industry Association-Japan Semiconductor Association

300mm Prime Task Force

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Figures:

1. Next Generation Fab Image Intended by J300P Guidelines

1.1. Introduction

This guideline booklet was developed by 300mm Prime Task Force affiliated with JEITA-JSIA (Japan Electronics Information Technology Association -Japan Semiconductor Industry Association) Technology Committee (hereafter *J300P Task Force*). The area of the guideline requirements is limited to production equipment and related peripheral capabilities per the agreement made among the JEITA-JSIA member companies.
This set of guidelines is expansion of the existing global guidelines (GJG300: Global Joint Guidance for 300mm Semiconductor Factory CIM and EEC: Equipment Engineering Capabilities Guidelines) to capture the requirements in the next generation semiconductor fabs as reduction in production cycle time, more stable and elaborate process outcome controllability, and, reinforced productivity in the production equipment. J300P Task Force reviewed the existing guidelines of both GJG300 and EEC. J300Ptask Force found they are all reusable except for new additional requirements.
Phase 1 guidelines focus on wafer point of view visualization of factory and equipment activities, and phase 2 guidelines focus on equipment controllability.

1.2. Background

The first generation 300mm factories were designed for thorough factory automation and built worldwide. There are following issues in terms of productivity and a paradigm shift in the manufacturing methodology is now being sought.

(1) Process outcome control for individual wafers in response to process node advancement
(2) Productivity and cycle time improvement in response to rapidly changing business requirement

Figure 1 shows the image of above mentioned paradigm shift in semiconductor factory and its manufacturing methodology. This figure was created by STRJ and presented in 2005 winter ITRS meeting.

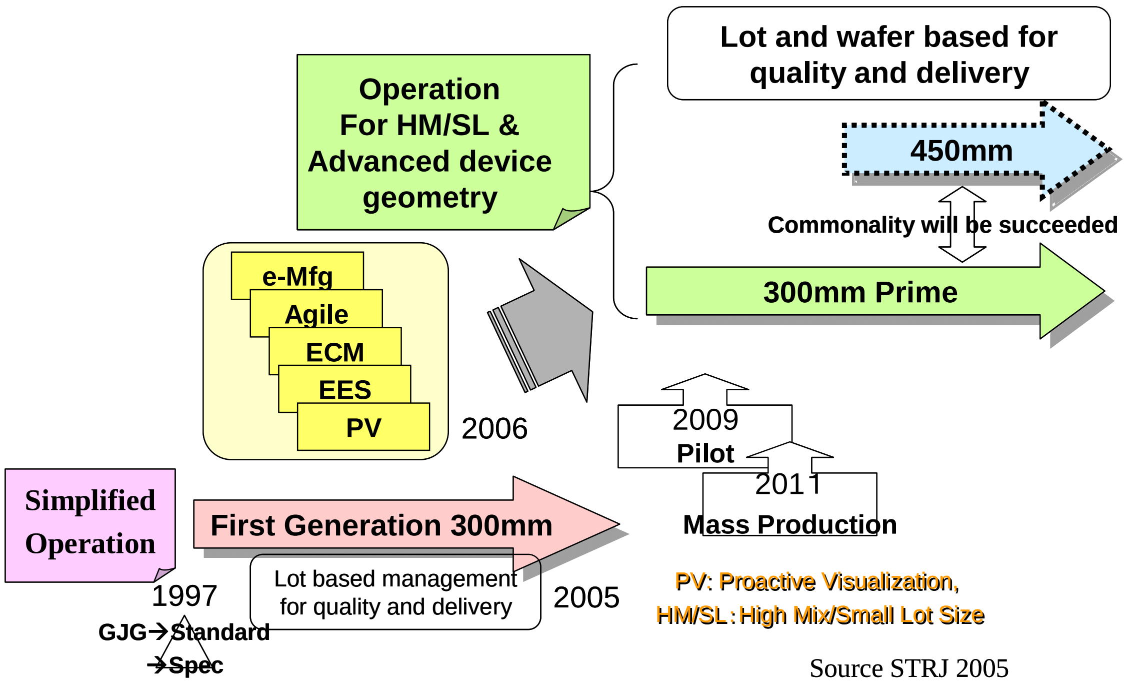

Figure 1: **Paradigm shift for the next generation semiconductor factory**

STRJ disclosed following manufacturing concepts in the past 5 years; e-Manufacturing, Agile-Manufacturing, Engineering Chain management, Equipment Engineering System, Proactive Visualization, Hierarchical Strategic Quality Assurance. J300P Task Force formulated requirements as guidelines out of these manufacturing concepts with focuses on productivity and cycle time improvement.

1.3. Implementation Timings

Followings are implementation timings of the capabilities required in this guideline.

2008
Completion of equipment engineering data contents and data provision readiness that are asked in the base guidelines
Standardization of structured information of wafer's attributes and status
2009
Implementation of wafer traceability information from wafer point of view that is asked in the base guidelines
Completion of standardization for equipment capability and relevant data models
Standardization of information definition for Dandori visualization
Implementation of graceful shut down of equipment that is asked in the individual wafer equipment control guideline

Standardization of wafer management information at the interface between production equipment and factory for wafer

2010
Standardization and implementation of those individual wafer control capabilities required in Phase 2

2. Basic Guidelines

Manufacturing Management and Control in Wafer Point of View (Explanation)

Wafer processing operations are graphically represented in Figure 2. A lot has been defined as a carrier containing 25 wafers and most of the production information has been defined based on this lot definition, and manufacturing is controlled and executed based on this lot basis and the information has been gathered.

For the further improvement of the cycle time and productivity it will become important to utilize individual wafer's movement information that describe all experienced states in the course of fabrication at individual wafers internal and external to the equipment together with equipment operation log data. The scope of the basic guidelines is that equipment productivity and equipment process control activities are to be analyzed for individual wafers so as to visualize individual wafer activities as well as productivity losses that have not been explored before and the process outcome control and related peripheral activity control are to be done for individual wafers as well to improve the productivity in a comprehensive manner.

Phase 1 basic guidelines present the requirements for factory activity visualization from the viewpoint of individual wafers and from the other viewpoints as well. Phase 2 basic guidelines present the requirements for factory control activity from the viewpoint of individual wafers and from the other viewpoints, such as equipment's Dandori control and equipment's chronicle drift compensation. The viewpoint of individual wafers requires structured information of wafer's attributes and status to play a very important role. This structured information needs to be standardized urgently. GL requires equipment to have individual wafer traceability based on this structured information as well.

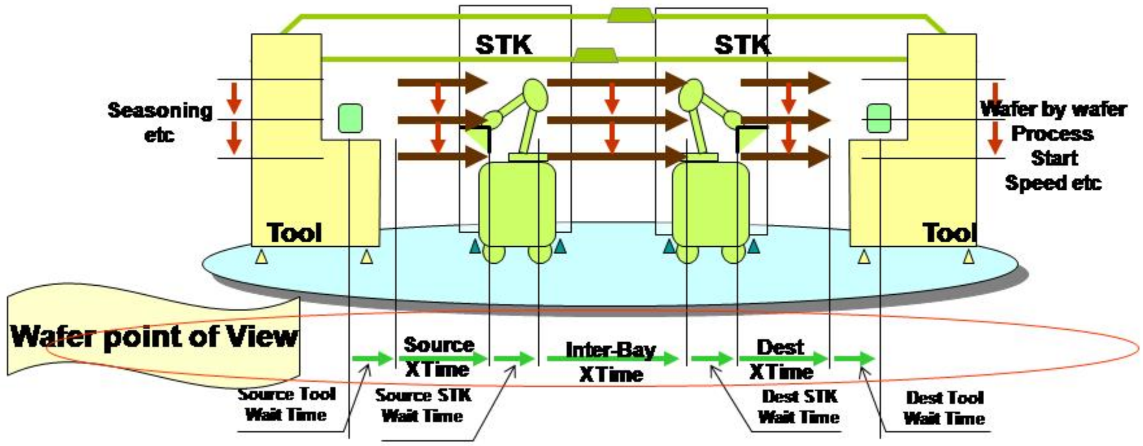

Figure 2: Cycle time visualization concept from wafer point of view

2.1. Manufacturing management and control in wafer point of view

Manufacturing management and control information shall be designed to allow elaborated wafer view utilization and information sharing both in the factory and equipment systems.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
For the consistent improvement both in the cycle time and productivity it will become important to utilize factory information comprising of individual wafer's movement information that describe all experienced states in the course of fabrication internal and external to the equipment in conjunction with hierarchically structured relevant equipment activity log data. Wafer view factory information such as cycle time and waiting time information has been defined by individual device makers. The equipment activity information from the wafer viewpoint such as wafer movement upon load, port transfer and equipment internal transfer events is provided by equipment suppliers in their specific manner. Wafer view information utilization will play an even more important role in the context of more complex and finer geometry fabrication where, for an example, subtle time difference in process set up timing can cause serious process outcome degradation.

Standards:
1. Wafer view cycle time related data such as individual wafers' waiting time, process time need clear definitions. Wafer view cycle time related data are to be defined to have a hierarchical structure in the standard.
2. The individual wafer traceability data shall be defined to have finer granularity in comparison to the lot based traceability data. Particularly event data upon equipment's state changes shall be defined with high granularity for standardization.
Examples of data definitions of data definitions for elaboration of equipment management and control that require standardization:

- Time duration of equipment internal fabrication or fabrication related operations from the viewpoint of individual wafers
- Graphical representation methods of equipment internal paralleled operations on multiple wafers,
- Discrete waiting time segments for individual wafers that comprise of overhead time for individual wafers (know as B values):
    - Across the factory-equipment boundary;
        - Time of "paper work" of wafer carrier acceptance
        - Physical transfer time and some wait time
    - External to equipment;
        - Wait time for a carrier to be delivered

Wait time in a queue

Wait to time for manual operation, wait time for quality judgment, etc.

Internal to equipment;

Time segments that can not be hidden by parallelism of equipment internal processes that add up to the total lot cycle time

Production time discontinuity between consecutive 2 lots with different recipes

Time needed for batch formation

Cleaning and seasoning time, time used for particle check

Wafer traceability information element examples:

Process sequences log data for individual wafers, Wafer rotation at relevant wafer positions, equipment group, equipment, equipment modules that individual wafers went through, carriers in which that wafer was contained

Examples of event data that support above mentioned wafer view data utilization;

Event of equipment status changes, its contents, and, event data definition in terms of engineering specifications and structural definition that contains relevant context information.

Remarks: None

2.2. Quality assurance across business boundary

Production equipment quality shall be visualized, traced, and maintained across the equipment supplier-device maker business boundary.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers
Background and Purposes:

Production equipment quality is built into the equipment in the manufacturing process. This equipment quality will be succeeded and used at device maker's production line. It is important that quality maintenance and improvement activities at the equipment supplier and those at the device maker are mutually interrelated so as to improve the quality and efficiency of equipment engineering operations at both parties.

Standards:

Standard requirements will be described in the dependent lower level guidelines. For the implementation of this guideline following standardization efforts are required in plural industry domains.

Consortia campaign:

Business model study of Enhanced Equipment Quality Assurance
For EEQA see *http://jeita-smtc.elisasp.net/*

Implementation encouragement by consortia:

Following publications are to be provided and shared in the industry

Establishment of EEQA's technical procedure as a common knowledge
Format of EEQA contents sheet
EEQA contents standardization of well-known equipment capabilities
Standardization of EEQA equipment engineering data and data specifications
EEQA equipment engineering data reutilization and efficient data sharing

Remarks:

Business model study as an industry is required for implementation of this guideline. Industry organizations from both equipment suppliers and device makers should conduct mutual and open investigation. For effective and proactive visualization of equipment quality each party should prepare to propose the equipment quality visualization contents. Device makers can propose important EEQA contents from their experiences in manufacturing. Device makers' active support of equipment suppliers' reutilizing the EEQA data for the further equipment quality improvement should become a common practice.

2.3. Hierarchical assurance of equipment's process execution performance

Equipment's process execution performance quality (such as low failure rate, short equipment state validation time, reduced process outcome quality fluctuation, reduced machine-to-machine or chamber-to-chamber difference) shall be assured in accordance with equipment's hierarchical logical structure model (e.g., per whole equipment functionality level, control level, and, process actuator level) . The necessary EE data shall be shared between the equipment supplier and the device maker.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers, device makers, and third parties

Background and purposes:
Selected equipment engineering data sharing is required between the equipment supplier and the device maker for sufficient information support to maintain the equipment at the specified performance. Data selection shall be decided by collaboration between the equipment maker and the device maker.

Standard:
Hierarchical equipment logical structure (equipment level capability layer, equipment module level capability layer, part level capability layer) should be standardized.

Remarks:
Equipment reliability improvement is important to semiconductor manufacturing where inherent feature shrinkage continues. Scientific approach to the more stable equipment performance is eagerly expected with hierarchical quality traceability being in place from low component level to the whole equipment level.

3. Equipment Engineering Data/Model Definition

Proactive visualization of production equipment quality

3.1. Proactive visualization of production equipment quality

Production equipment quality shall be visualized with sharable healthiness and productivity evaluation methods and evidence data, and that visualized information shall be able to be reutilized.

Who to implement this guideline: equipment suppliers, device makers
Who to use this guideline: Equipment suppliers, device makers

Background and purposes
Production equipment is the most important factory resource and its quality influences semiconductor product quality, cost, delivery time. Therefore the equipment quality validation at the time of acceptance to the production line and the equipment quality maintenance and tracking are very important equipment engineering operations. They need to be consequentially reinforced with scientific equipment engineering data.

Standard:

Equipment quality validation procedure shall be standardized.
Equipment engineering data for equipment quality description and evidence shall be standardized.

Remarks: None

3.2. Reinforcement of production equipment quality assurance

Production equipment quality visualization, assurance, validation, traces, and, maintenance shall be reinforced with using steadily available equipment engineering data from the production equipment.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers, device makers

Background and purposes:
Currently available on-line equipment data is not utilized in a positive manner for production equipment quality assurance. Equipment capabilities shall be tuned, validated for performance with using steadily available equipment engineering data for the purpose of enhancing equipment quality assurance. Production equipment performance visualization and maintenance should use this steadily available equipment engineering data so as to succeed the initial equipment performance validation by using the same data.

Standard:
None

Remarks;
See guideline 3.6 for production equipment quality reinforcement.

3.3. Focus on basic equipment capability visualization

Visualization of individual equipment capabilities and equipment control capability shall be prioritized in conducting production equipment quality validation, trace, and maintenance operations.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
A process tool is, for example, consist of process condition generation means such as for reaction conditions of pressure and reactant concentrations, wafer temperature. It is a basic and the very first step to examine if individual equipment capabilities are functioning in accordance to their specifications or to what equipment has been designed.

Standard:
Validation procedures and the relevant data shall be standardized at least for the principal equipment capabilities.

Remarks;
There are several well-known equipment capabilities in production equipment. These capability performances shall be expressed as logical capability components. The whole equipment functionality shall be validated by integration of these capability components and relevant validation results.
Examples of equipment capability performance focus;
(1) Famous capabilities with well-known high trouble potential such as mass flow controllers, automatic pressure controllers, …
(2) Machine-to-machine and/or chamber-to-chamber difference
(3) Repeatability of in-equipment process execution sequence

3.4. *Provision of critical values for equipment performance healthiness determination*

Equipment supplier shall provide both sets of critical values to determine the healthiness of equipment capability performances and/or behaviors for the initial validation at the time of production line acceptance and for the continuous operation in production.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Back ground/purposes:

Currently the critical values to determine the healthiness of an equipment capability performance for the initial validation at the time of production line acceptance and the critical value for the continuous operation in production that is the expectation of the performance stability are not well distinguished, and, hence, equipment suppliers have very often no such pairing design values. This ends up with poor traceability of equipment quality since examination of particular equipment capability's healthiness is difficult without the provision of critical values for performance stability.
It is expected that the equipment supplier is most knowledgeable about the healthiness definition or designed criteria. Device maker engineers are also knowledgeable enough to set reasonable critical values for healthiness determination from his/her experiences, but not necessarily know all the equipment capabilities and because of their large number it is impossible to cover wide good portion of the capabilities.

Standard:

Behavior models and healthy operation models of principal equipment capabilities shall be standardized.

Remarks:
Equipment supplies are expected to continuously collect field data and proactive equipment quality visualization data to accumulate knowledge so as to elaborate visualization contents such as equipment capability healthiness determination criteria. Equipment suppliers are expected to improve their traceability capability with statistical analysis of equipment quality proactive visualization data from a large number of shipped tools, a large number of process chambers, or large number of individual logical equipment capability components

3.5. Collaboration between device makers and equipment suppliers

Device makers and equipment suppliers are to investigate and improve the contents of proactive equipment quality visualization collaboratively.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
Device makers are expected to propose the better contents of proactive equipment quality visualization from their experiences in running the production tool in mass production environment. The equipment quality data obtained for equipment capability validation at the time of production equipment acceptance to the production line shall be used by the equipment suppliers for improvement of equipment quality and services.

Standard:
Typical proactive equipment quality visualization shall be standardized.
Typical measurement methods of productivity and equipment capability performances shall be standardized including important trigger data.
Visualization items of productivity and equipment capability performances shall be distinctly sorted for standardization from the viewpoints of factory operation, production equipment, and, product wafers.

Remarks: None

3.6. Improved efficiency in equipment engineering data collection and data utilization

Equipment engineering data collection and data utilization shall be systemized with being embedded in the current workflows.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers, device makers

Background and purposes:
If data gathering and analysis take too long for equipment quality improvement and maintenance, equipment quality visualization with enough coverage and depth can not be achieved. The data gathering shall be done on-line as much as possible. Furthermore the necessary data extraction, information abstraction, data sorting and accumulation per individual equipment capabilities, statistical determination of individual equipment capability healthiness shall be automated and systemized so that data reliability and healthiness determination reliability are to be improved. This also contributes to establish equipment quality improvement cycles.
While equipment data collection systems have been implemented for years at device makers for process condition data retrieval, equipment suppliers shall implement equipment engineering data collection and utilization system at their own manufacturing sites for proactive equipment quality visualization or enhanced equipment quality assurance with equipment capability level granularity.

Standard:
Data utilization for proactive equipment quality visualization shall be standardized in terms of the data and its data retrieval capabilities with individual equipment capability granularity and in order to promote efficient equipment engineering data utilization.

Remarks: None

Equipment engineering data definition

3.7. Areas of interest in equipment engineering data usage

Production equipment shall provide elemental data for the information used in the various equipment engineering operation areas.

Above-mentioned equipment engineering operation areas should include followings;

1. Management and control operations of factory system view equipment behavior (GEM300)
2. Productivity management and improvement operations in terms of OEE , cycle time from factory system view, equipment view, and, product wafer view.
3. Energy consumption management and reduction and consumables management and reduction operations
4. Process condition management, monitor, fault detection, and advanced process control operations where process parametric information is mainly used
5. Equipment engineering operations such as process tool healthiness monitoring, equipment capability performance validation, malfunction identification, maintenance management where equipment capability activity information is mainly used.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers, device makers

Background and purposes:

The history has been that the equipment data is superimposed onto the SECS communication, and that the main data utilization purpose was to monitor the process conditions. Production equipment is the most precious resource in the factory, and consequently it is involved in many aspects of equipment engineering operations. The equipment engineering data shall be reexamined from above mentioned plural aspects of relevant data usage.

Standards:
Equipment engineering data items, data types, and, relevant context data shall be standardized for each of the equipment engineering operations of interest.

Remarks:
It is note worthy to mention that equipment does not necessarily provide readily usable information for above mentioned 5 operation areas. Since there are many data that are

used commonly in the 5 equipment engineering operation areas, information extraction from the equipment engineering data shall be done external to the equipment in accordance with targeted operation areas of interest.

3.8. Structure of equipment engineering data

The definition of equipment engineering data is designed in accordance with the logical modular structure per equipment's control capability logical structure.

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
Equipment engineering data should be designed so that it is used both by the equipment suppliers and device makers for the purposes of equipment quality maintenance and improvement. Although the process parametric monitoring has been historically the center of interest at device makers, equipment data that more directly describes equipment capability activities is required from the viewpoint of equipment supplier.
The process performance of a production tool is hard to be described in terms of the process results since it is considerably dependent on process parameter settings and the wafer itself. Equipment quality should be visualized by visualizing individual capability performances. It should be understood that a production equipment is described as a logical combination of many individual equipment capabilities, and that some of these capabilities are common to other production equipment; i.e., an rf power application means is used in plasma CVD, PVD, dry etching tools. Design and utilization of equipment engineering data will be made efficient by standardized modeling of these basic capabilities.

Standards:
Equipment capabilities shall be described in a standardized hierarchical logical structure. Basic equipment capabilities should be standardized for their behavior models comprising of data definition and healthiness models.

Remarks:
It is required that equipment engineering data is used per each of data utilization purposes with high efficiency. Information extraction from equipment engineering data should be well defined for automation without much labor. This means that equipment suppliers are able to gather data from the all process chambers delivered to users as needed and to evaluate the necessary part of the data with ease. If these are done by hand or with lots of mouse clicks, systematic and continuous equipment quality improvement will be jeopardized.

3.9. Equipment engineering data quality

Equipment engineering data shall be designed to suffice its data specification in accordance with individual data usage purposes. More concretely following 4 data qualities shall be considered;

(1) Data items and their precisions defined after healthiness models of individual equipment capabilities

(2) Sufficiency of context for equipment internal activity description endorsed with equipment activity event data

(3) Sufficiency in time stamping that allows correct interpretation of series of equipment activity accompanied by control sequential structure information

(4) Provision of context data from the viewpoint of equipment control sequence that helps a cluster of data be allocated in the right timing of equipment's control sequence data where that cluster of data is obtained external to the equipment control. Such "external data" gathering examples are data collection of supplemental equipment such as slurry supply units or fast trace data collection by dedicated data collector hardware such as an etching end point detector.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and Purposes:
Although the specification of equipment engineering data can not determined uniformly since there are many different data utilizations and different tool types, equipment engineering data should be provided with the quality data that assures correct data interpretation. This data quality corresponds to context data provision. Context data should enable data extraction of particular focused area with the right logical state of equipment and recognition of start and end of a certain control sequence. Some equipment sequence context may be deduced from combination of plural equipment activity event data. Plural data sets with different time stamps with different clocks can be correctly interpreted by provision of adequate sequence context data. In other words very high time stamping accuracy would be required with less adequate context information (equipment activity event data) to read the data in some cases.

Standards:
Data quality standard development is required whose scope includes interpretation of equipment engineering data with using the combination of time stamping and equipment control consequence information from the viewpoint of data utilization procedure.

Remarks: None

3.10. Focus on machine-to-machine/chamber-to-chamber difference

Equipment suppliers shall visualize process condition generation capabilities built in the equipment by equipment engineering data in accordance with the granularity that matches to the relevant sensitivity of the process with using reusable methods and referencing values. Equipment suppliers shall collect above mentioned equipment engineering data from the relevant process condition generation capabilities in all the shipment so that the data is to be statistically analyzed for reasonable management of chamber-to-chamber and machine-to-machine differences.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and Purposes:
Process tools are designed to perform intended process execution of the relevant processes to the tools, validated, and, supplied to the market although there are many tool types and many relevant process contents to execute. Process condition generation means are to be validated for the stability, repeatability, and, fidelity to the instruction with the criteria at least through execution of the relevant best-known methods. The performances of the process condition generation means are to be compared with those in another tool using the defined criteria over all the shipment. Statistical performance management of these equipment's process condition generation means at equipment suppliers is expected to encourage more rationalized management of equipment's performance to provoke further effective reduction of chamber-to-chamber or equipment-to-equipment differences at equipment suppliers.

Standards: None

Remarks: None

4. Individual Wafer Equipment Control

4.1. Graceful shutdown of production tools (EEC Guidelines)

While production tools are designed to have the maximized effective production time, a production tool shall cease processing wafers safely when malfunctions in safety or base equipment capabilities are detected with the minimum granularity unit such as individual wafers or individual chambers. The consecutive sequence from the decision making of ceasing processing to actual shut down shall be reported.
(Ref.: EEC Guidelines 2002)

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and Purposes:
The granularity of production tool's process ceasing action has not been standardized. It is important that the number of scrap wafers is minimized by designing production tools with minimum number of granularity of ceasing action.

Standards: The process ceasing actions are to be standardized with considering the equipment types and variety of process status.

Remarks:
The malfunction of the equipment should be detected within the process time of the relevant chamber in multi-chamber tools. Processed wafers and unprocessed wafers are recognized accordingly. Process ceasing method should be selected per information available from and out of the tool, depending on tool/process configuration such as series or paralleled sequence in multi-chamber tools.

4.2 Equipment capability performance conditioning and adjustment not linked to wafer processing control

Equipment shall have a control means that allows either internal control or external control to compensate equipment capabilities' performance variations that are described as chronicle variation models. This control shall be delegated to equipment by the host system and made visible by and to the factory system controller.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background/purpose:
Equipment has well-known chronicle performance variations such as discharge impedance's decrease and its film growth rate change as the sputter target erosion proceeds, or vacuum pumping speed's decrease due to debris accumulation inside the pump's piping of CVD equipment. Such equipment process performance change is characteristics specific to individual chambers even though they are gradual.
Equipment's process performance adjustment control needs delegation mechanism of control to the equipment by the factory system in order to compensate process performance variations and the chamber differences. This mechanism enables recipe operation without describing the compensation measure in detail per chamber or equipment differences.

Standards: For the compensation, the logical interface needs to be standardized.

Remarks: None

4.3 Continuous wafer feeding and pick-Up

Equipment shall support operation using different input carriers and different output carriers to realize continuous wafer feeding and pick-up. This operation shall include dividing or mixing groups of wafers as required. Equipment and the factory system shall mutually exchange the necessary information in order to pick-up empty carriers and feed necessary carriers to receive the processed wafers.

Who to implement this guideline: Device makers and equipment suppliers
Who to use this guideline: Device makers

Background/purpose:
In case of tools with large number of process positions such as linked litho tools, carriers may need to wait to receive all the processed wafers of that carrier for a prolonged time and resultantly this prevents carriers with unprocessed wafers from being delivered to the equipment at the right time. If there is enough number of lord ports, such productivity degradation can be eliminated, but actually the number of load ports in equipment is physically limited.
One solution is to increase virtually the number of lord ports, by picking up the empty carrier from the lord port for a while so that a carrier with unprocessed wafers can be delivered to the equipment. Another carrier needs to be delivered to a load port to receive processed wafers and it is to be picked up at right time by AMHS. This GL contributes to factory productivity improvement.

Standards: In addition to the uni-cassette operation already defined in GEM300, the above mentioned operation scenario of equipment needs to be standardized.

Remarks: None

4.4 Hot-wafer overtaking in batch equipment

In batch equipment that has the internal buffer hot-wafers shall be able to overtake the other reserved wafers for a batch until before the factory system gives relevant process start instruction.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background/purpose: Batch equipment such as oxidation/diffusion, wet-cleaning, and low pressure-CVD is one of the biggest cycle time detractors for hot-wafers or hot-lots. Following operations may enable reduction of hot-wafer's cycle time and should play an important role in SoC business.

(1) Fill-dummy wafers to be replace with product wafers
 The hot-wafers replace the filling dummy wafers already planned to be in the batch, and batching will be redefined by the host system.
(2) Reserved product wafers to be replaced with hot-wafers or simply hot-wafers are to be added to the reserved batch
 Reserved product wafers will be replaced with the hot-wafers and batching will be redefined. Hot-wafers may be simply added to the reserved batch, and batching will be repeated.

Standards: The definition of hot wafer's over taking and its controlling method need to be standardized.

Remarks: None

5 Production Improvement

Definition of Dandori

Dandori operations are peripheral operations to the throughput-constraint main thread operations. Dandori operations include preparatory operations before the processing, post process operations, wafer transportation, wafer identification operation.
Dandori operations may be categorized per operation responsibility owners;
Class 1 Dandori operations: where Dandori operations are all delegated to the equipment and designed by equipment suppliers to be executed within that production equipment.
Class 2 Dandori operations: where Dandori operations reside across the boundary of factory and the production equipment, and they are very often related with the information transfer.
Class 3 Dandori operations: where Dandori operations are controlled by the factory

5.1 Dandori visualization

Dandori operations shall be categorized for the ease of solutions development by device maker and the equipment supplier. The categorization of Dandori operations shall be defined together with the relevant state triggers. Dandori data shall be designed so that the device maker and equipment supplier can share.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
Dandori operation elimination or its time reduction, paralleling Dandori operations with the other operations, evaluation of effectiveness and related effects of each Dandori operation are important to plan to improve equipment cycle time and OEE. Dandori operations have not been categorized and defined per logical locations, i.e., equipment side, factory side, and their boundary. Dandori operations are required to be categorized as described in Dandori definition of the following table and analyzed in detail.

Standards:
Dandori operations should be defined and categorized in standard.

Remarks: it is important to eliminate productivity losses by deploying effective measures of which examples are listed in Figure 3 that are possible with sharing Dandori information between the different control layers

Category	Improvement in Specific	Improvement in Control Technology

Technology

Class 1	• Reduce seasoning and/or cleaning time • Reduce equipment internal preparation time for process generating means for new recipes	• Optimize tool internal wafer transfer scheduling • Optimize tact balance between equipment side and factory side
Class 2	• Reduce process instruction information time • Reduce carrier identification time • Reduce NPW preparation time	• Parallel such operations as seasoning and cleaning with other operations • Preset the process instruction • Optimize the wafer process order
Class 3	• Reduce carrier dispatching time • Reduce time used for equipment process performance stability • Reduce time used for product quality confirmation	• Pre-create of NPW process jobs • Synchronization of job exchange and dispatching • Paralleled product quality confirmation operations and other operations

Figure 3: Counter measure examples against productivity losses induced by Dandori operations

5.2 Dandori control from factory system

Equipment's Dandori shall be instructed by the factory system in a similar fashion to wafer processing instruction. The instruction of the Dandori operations inside equipment shall be structured.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background/purpose: If Dandori operation inside equipment is instructed in a manner like as wafer processing, the order manipulation of wafer processing and Dandori, and the visualization of Dandori become possible with ease and contribute to productivity improvement.
The equipment's schedule information, such as start time and end time, of Dandori or wafer processing needs to be reported to the factory system.

Standards: The interface to control the enforcement of Dandori operation needs to be standardized.
The instruction of the Dandori operation inside equipment needs to be standardized.

Remarks: Please refer to the requirements related to wafer processing order. Simply repeated Dandori operation inside equipment is not interest of the factory system and the operation needs to be delegated to equipment. The equipment needs to have such two simplified controlling methods as start Dandori and delegate Dandori to equipment.

5.3 Continuous wafer processing across lot boundaries

A single wafer processing tool shall be able to process wafers continuously across lot boundaries when that tool is fed with multiple different process lots except for a possible discontinuity due to the lack of process resource availability for the consecutive lots with different recipe contents

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
There are often observed unnatural discontinuity in production time between lots with different recipe contents.
Equipment in some cases needs to wait for a tool internal processing resource will become available to the wafers in the following lot in such cases as bake temperature change from one value to another across the lot boundary.
This guideline intends to require that the wafer in the subsequent lot will be processed without excessive delay so as to minimize the discontinuity in the production time.

Standards:
Standards for single carrier multi-lot capabilities need to be reinvestigated

Remarks:
Production discontinuity can also occur when continuous wafer supply is not possible from the load ports.

5.4 *Intended stable wafer processing*

A single-wafer processing tool shall control execution of identical processing to individual wafers within a lot or across adjacent lots

Who to implement this guideline: Equipment suppliers and device makers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
There are many factors beside what is written in a recipe that determines the process condition in process tools. A good example is the condition between the process steps in a multi-chamber configuration tools. It is important to understand the process conditions while a wafer is transferred between chambers such as time between steps, environment where the wafers are immersed, temperature changes, etc.
Process tools are expected to provide identical process execution to all wafers within a lot, or even for wafers in different lots with the same processing conditions in accordance to the equipment design concept.

Standards: None

Remarks:
Some process tools are designed to use plural process chambers in parallel.
Chamber-to-chamber differences are to be sufficiently reduced by proactive equipment quality visualization.
Equipment control for identical wafer processing is to be visualized and should be able to be validated as required.

5.5 External utilization of equipment internal counter information

Wearing information about consumables inside equipment shall be externally accessible.

Equipment interlock's setting values and current monitored values shall be externally accessible.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background and purposes:

To know the wearing condition of the consumables inside equipment is indispensable to scheduling equipment maintenance and Dandori operations for improved productivity.

After exchanging consumable parts in maintenance the confirmation of resetting consumable's wearing counter is effective to prevent equipment's frequently happening accidents and wrong doing occurrences. Systemizing the confirmation procedure is important.

Also the reconfirmation of setting values against the normal values of interlock criteria is effective to prevent equipment's frequently happening accidents and wrong doing occurrences. Systemizing the reconfirmation procedure of interlock's critical values is important.

Standards:

Access items and access methods need to be standardized.

Remarks: None

5.6 Efficient Operation of Multi-Chamber Equipment

Each process chamber in equipment shall provide its availability status. This status value shall be able to be altered by the factory system.
The availability status is such that the chamber can process all relevant product wafers, or it can process some certain product wafers, or it can not process any product wafers, or it can process only non-product wafers such as "dummy wafers" or monitor wafers. The change of the status by the equipment shall be reported to the factory system.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background and purposes:
The overall operation of multi-chamber equipment may be influenced by one the process chamber's status; where if one of 2 process chambers that are expected to be used in paralleled operation becomes not functional, some special recipe needs to be used to accommodate some necessary adjustment to assure the same fabrication outcome. Because of the high flexibility multi-chamber tools require complex host instructions depending on individual process chambers' statues to attain the high productivity expected. Productivity data collected from multi-chamber tools are not utilized to full extent because of the low granularity of chamber level data contents.
There are cases that multi-chamber tools especially undergoes maintenance work for one of the process chambers while as a tool it can execute manufacturing with possibly a limited applicability. In such circumstances dummy runs or seasoning processes needs to be handled at the same time processing product wafers by different chambers.
Chamber statuses are need to be defined for the stages from shut-down for maintenance to requalification decision being made and that these statuses are able to be manipulated from the host so that the host can control that equipment using less number of recipes combined with the product wafer information and the chamber statuses. This may allow seasoning of a process chamber and processing product wafers in another chamber in the same process tool.
Such chamber status information may allow more effective utilization of productivity data from multi-chamber tools.

Standards:

The instruction method of setting availability status from the factory system needs to be standardized.

Remarks: None

6 Factory-Production Equipment Control Interface for Individual wafer control

6.1 Addition of individual wafer management interface

Following information shall be defined across the interface where individual wafers are transferred to process part of the production equipment. This information shall be shared with the system external to the equipment.
The information to be handled is as follows;
wafer identification information, process sequences log data for individual wafers, wafer rotation at relevant wafer positions, Process Positions, equipment group, equipment, equipment modules that individual wafers went through, carriers in which that wafer was contained, processing instruction information such as the recipe, Variable Parameters.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
In high-mix production various process/chamber configuration and operations are possibly used. Therefore process management requires the granularity of individual wafers and individual processes encountered. Although the uni-cassette operation has been implemented for many years where carrier integrity and slot integrity are well managed at hardware level, such integrities will be possibly subjected to change by the implementation of individual wafer control required in the next generation fab. Such elaborate management will eventually require optimization of wafer feed to individual process parts of the production equipment in terms of stable process and productivity control including cycle time reduction. This guideline is a basic prerequisite requirement to individual wafer manufacturing control.

Standard:
The information handled across the wafer management interface and its method of information provision shall be standardized.

Remarks: None

6.2 Individual wafer -equipment control interface

Equipment's wafer processing order and Dandori order shall be controlled by the factory system.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Equipment suppliers and device makers

Background and purposes:
There is often necessity to improve equipment productivity by changing the wafer processing order within the wafers provided to the tool so as to enable reducing process change number and reducing Dandori between process operations.
One carrier accommodates a commensurate number of wafers to the factory's AMHS capability, but this new control of the factory system enables virtually single wafer production. Wafer processing order manipulation is to be done within one carrier, or among different carriers. It is sometimes required that this process order change needs to be done at late timings.

Standards:
Queuing manipulation of Jobs defined in GEM300 needs to be investigated and extended.

Remarks:
Requirement on Dandori control should be also referred along with this guideline requirement. There may be such cases where relevant Dandori operations are to be scheduled accordingly for a given wafer process execution order. Equipment's processing schedule information, such as process start and process end time of individual wafers and or those times for relevant Dandori operations are to be informed to the factory system.
Equipment needs to have capability to provide the following information to the factory system so that the factory system can decide the next processing wafer(s).

1. Scheduled end time of a wafer being processed
2. Scheduled process start and end time for a reserved wafer
3. Load port and the internal buffer status information of the next wafer(s) to be delivered to the tool
4. Scheduled end time of Dandori operation such as tools process condition stabilization time associated with a certain wafer
5. Scheduled process start time for the next wafer

6.3 Individual wafer traceability in production equipment

Equipment shall be able to trace individual wafers even after the processing order of individual wafers is changed.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background and purposes:
The current 300mm production equipment processes wafers in an order of the slot number of a carrier that contains the group of the wafers, and the processed wafers are returned to the same slot of the same originating carrier (known as Slot Integrity and Carrier Integrity). The wafer processing order may have to be changed in order to attain a better productivity, or the processed wafers may have to return to the different slots or to the different carriers in some cases. In such cases the traceability of individual wafers is important.
Host side information on relation of individual wafers to the current carriers and to slots is relatively hard to be renewed quickly once wafers are given to the production equipment. Implementation of individual wafer traceability capability in the production equipment is, thus, important.

Standards:

The wafer traceability guaranteed by equipment needs to be standardized. Standards operation scenarios for reading wafer ID and verification of this ID are to be developed.

Remarks: None

6.4 Processed wafer and unprocessed wafer notification

Equipment shall clearly distinguish processed wafers from unprocessed wafers and notify the information to the factory system in case of urgent equipment shutdown.

Who to implement this guideline: Equipment suppliers
Who to use this guideline: Device makers

Background and purposes:
When equipment shutdowns ongoing processing urgently, equipment shall clearly distinguish properly processed wafers, likely improperly processed wafers, and unprocessed wafers based on process log of individual wafers. This information will facilitate the recovering operation.

Standards: The notification method of the required information about urgent equipment shutdown needs to be standardized.

Remarks: None

7 Contacts

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8 Revision Record

1.02	2007/06/22	Edits and bug fixes. Set page links from the Contents.
1.03	2007/06/25	Updated Chapter 1.2, Chapter 2, Chapter 2.1, Chapter 2.3, Chapter 5, Chapter 6.1 and Figure 3
1.04	2007/06/27	Updated Chapter 1.3 and Chapter 4.5
2.00	2007/11/14	Added some contents to Phase 2, and updated Phase 1
2.02	2007/11/21	Revised Figure 1, updated Chapter 3, Chapter 4.6, Chapter 5.6 and Mailing List
2.03	2007/11/22	United the terms and updated the contents over the booklet
2.04	2007/11/26	Added structured information
2.5	2008/08/28	Exact match between Japanese and English versions together with some updates.