JEITA

Guidelines for Reticle Data Management Ver.2.0
(English Version)

JEITA (Japan Electronics and Information Technology Industries Association)
Committee on Semiconductor Production Engineering
Sub-committee on Reticle Management System

Sub-committee Members

Nobuyuki Iriki (Renesas)
RENESAS Technology Co.
LSI Manufacturing Unit
Wafer Process Engineering Development Div.

Michio Honma (NECEL)
NEC Electronics Corporation
Corporate Strategic Planning Unit

Takashi Satoh (Toshiba)
TOSHIBA CORPORATION
Process & Manufacturing Engineering Center
Advanced ULSI Engineering Dept.II

Norihiko Miyazaki (Fujitsu)
FUJITSU LIMITED Semiconductor Group
Manufacturing Technology Development Div.
MASK Technology Dept.

Toshio Onodera (Oki)
Oki Electric Industry Co., Ltd.
Silicon Manufacturing Company (SiMC)
WP Business Div.
WP Business Dept.

Toshiharu Matsuda (SANYO)
SANYO Electric Co.,Ltd.
Semiconductor Company
LSI BU
Engineering Dept.

Tamotsu Uga (ROHM)
ROHM Co.,Ltd.
MASK Production Dept.
VLSI Operation Div.

Observers

SEMI Japan Reticle Data Management TF: Hidehiro Higashino (Oki)
Oki Electric Industry Co., Ltd.
Silicon Manufacturing Company (SiMC)
WP Business Div.
WP Business Dept.

Selete: Iwao Higashikawa , Nobuyuki Yoshioka
Semiconductor Leading Edge Technologies Inc.
Advanced Technology Dept.

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1. Introduction

1.1 Preface

Our semiconductor business has experienced the period of severe depression when market shrank and there was severe competition. Now we are getting over crisis. The market is recovering and business restructuring progresses. And then we are trying evolutional change. In this state Market Innovation and Synergistic Innovation will be important.

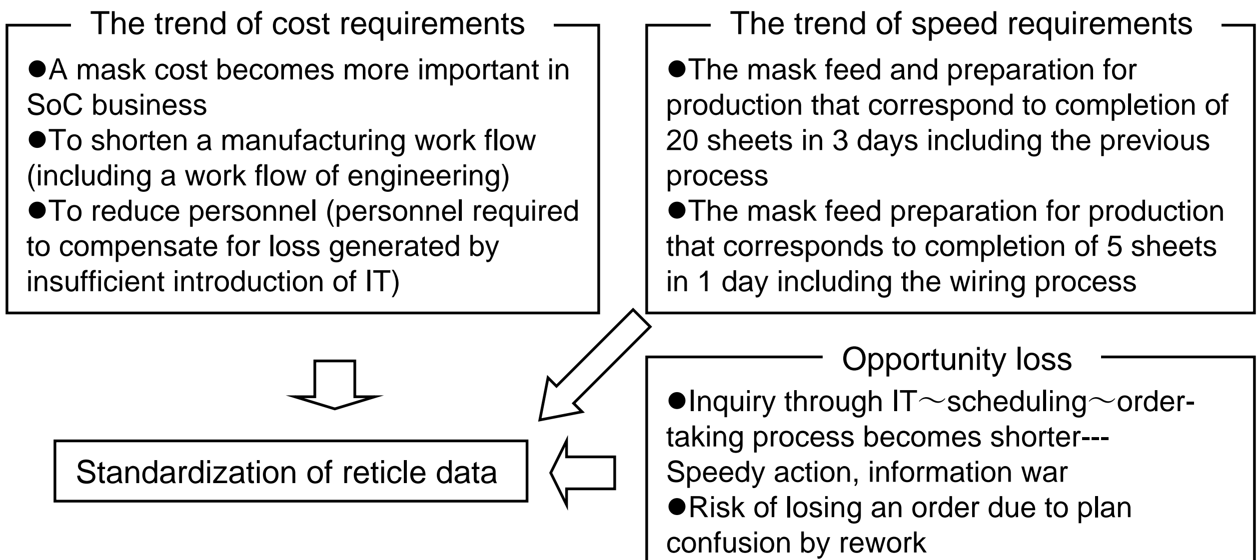
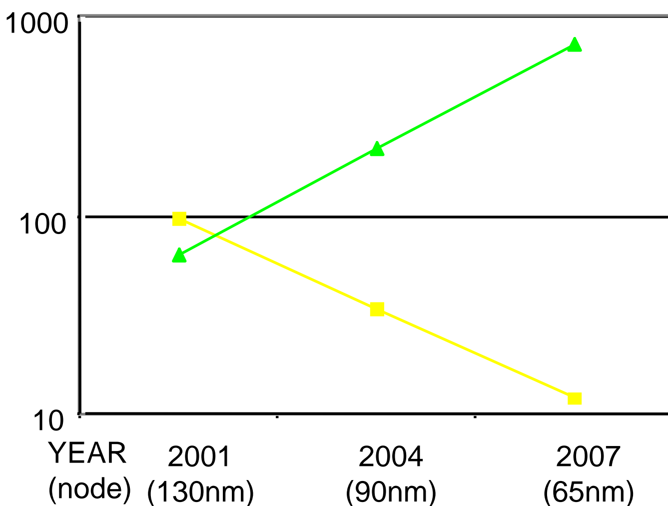


FIG. 1



The unit price for each function must be reduced sharply. The data volume of a mask increases sharply. Therefore, epoch-making increase in efficiency is required for cost and date of delivery.

MPU Chip Cost (microcents/transistors)
Data Volume(GB)

Figure 1. ITRS2003 roadmap

1.2 The overview of Ver1

We proposed the guideline Ver.1 for the efficient data handling except pattern data, in order to respond to the time of Engineering Collaboration when production manufacturing and design are performed over plural companies.

FIG.2 shows Guideline Ver1's scope. For SoC Business we must improve efficiency of all works concerning each one reticle through Design, Mask Fab, and Wafer Fab. Based on consideration about this work-flow, we focused communication at interfaces. In this diagram, design area has design activities based on design tool such as circuit design, pattern design, and design rule check and so on. Mask shop has data conversion and process step such as OPC generation, EB exposure, inspection. Wafer Fab has incoming QA and frame specifications. The numbers from 1 to 5 show focused standardization scope. We think these interfaces need improvement of efficiency most.

FIG.3 shows summary. Order entry, Recipe Maintenance, Defect Analysis, and Equipment clustering have QC data standardization as common part. If QC data standardization should be comprehensive, standardization for application would be more efficient. In other words, heterogeneous representation of QC data in each application area could be integrated to common representation. Then, for example, data in Order Entry would be reused in Recipe Maintenance or Defect Analysis.

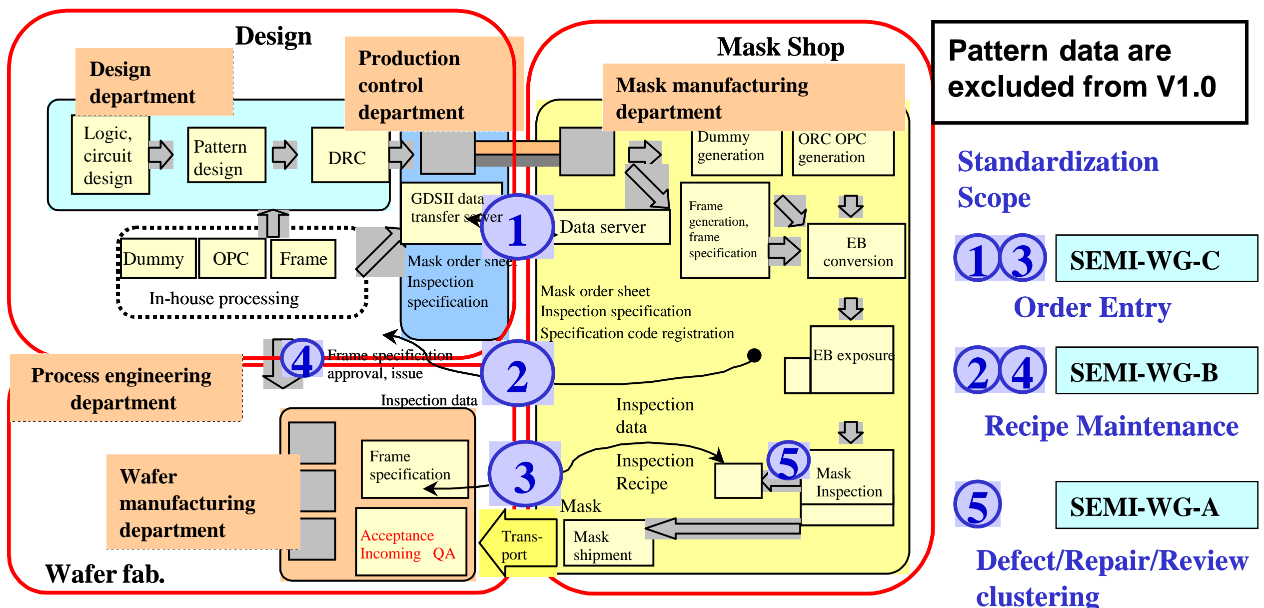
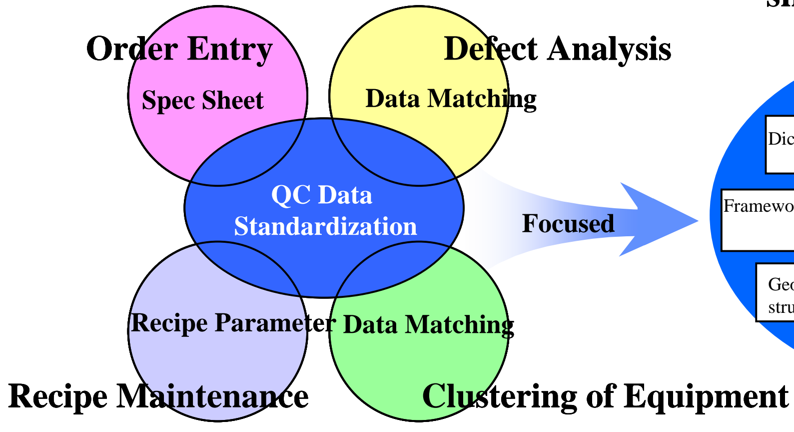


FIG. 2

Introduced Application Topics in JEITA Guideline Ver.1.0

QC data Standardization should be Comprehensive



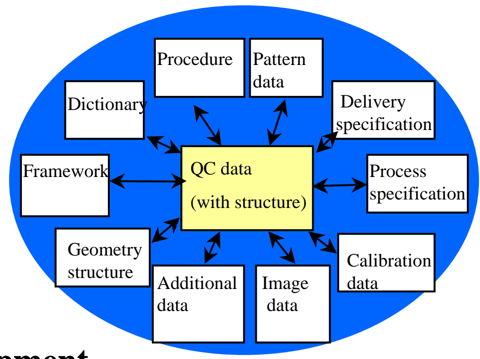


FIG. 3

1.3 Background from Ver1 to Ver2

With progress of device scaling, because it becomes necessary to optimize in every individual product, the optimization which considers lithography and etching process and further optimization of the whole which took the design into consideration have begun beyond the conventional optimization of an exposure process only. Therefore, the efficiency of data handling should be improved in order to do the linkage with the design information on an individual mask efficiently.

For example, it is considered to introduce production systems such as IP shuttle that carries two or more products on one reticle for the purpose of mask cost reduction indispensable to SoC business. It is necessary to share a means to solve the complicated data handling accompanying this among designer shops in plural companies and manufacturers.

New Engineering Chain Management Concept is emerging for Collaborative Innovation.

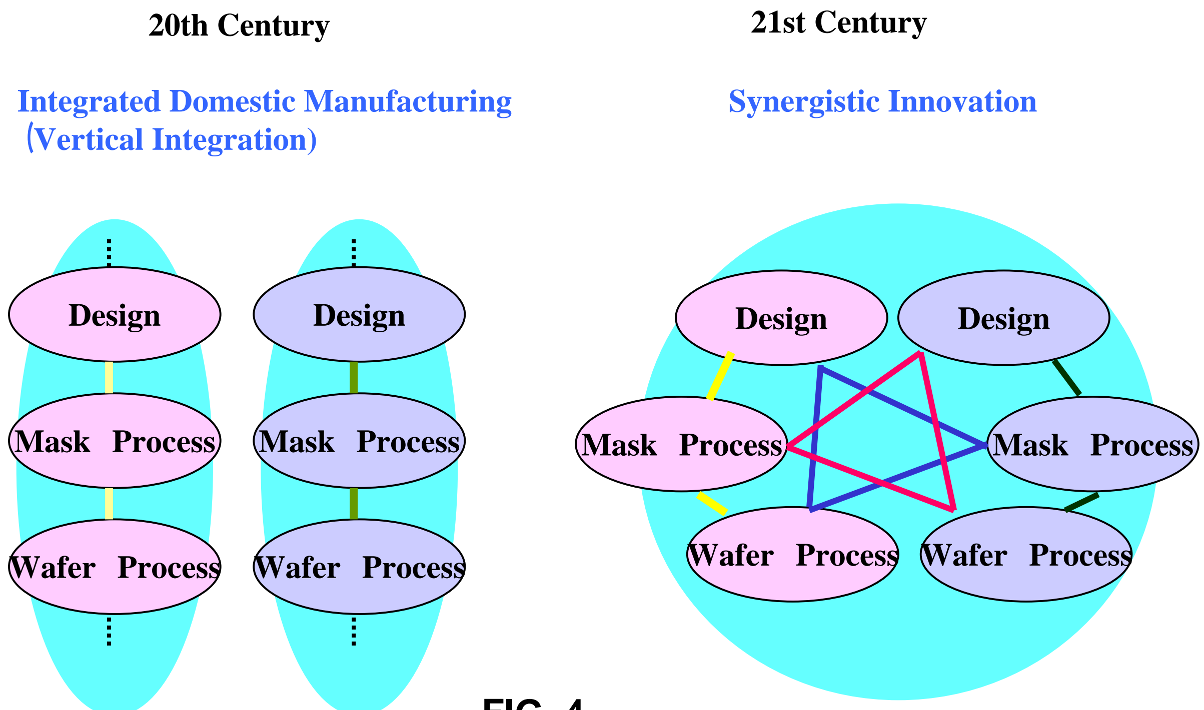


FIG. 4

1.4 Purpose of Ver2

The purpose is the linkage between design and manufacturing for the synergistic innovation.
The key of the synergistic innovation is deign optimization based on manufacturability, pattern printability, process specification,
and manufacturing optimization based on
integrated process module, pattern dependency device specification.

1.5 Scope

This guideline deals with expression for usage of the information relevant to the reticle. This expression will be considered from the view of engineer's activity using pattern data. This guideline dose not deal with pattern data format itself, that handled in EDA tool such as Stream Format. If both sides are well standardized, these will be connected easily in successive activity.

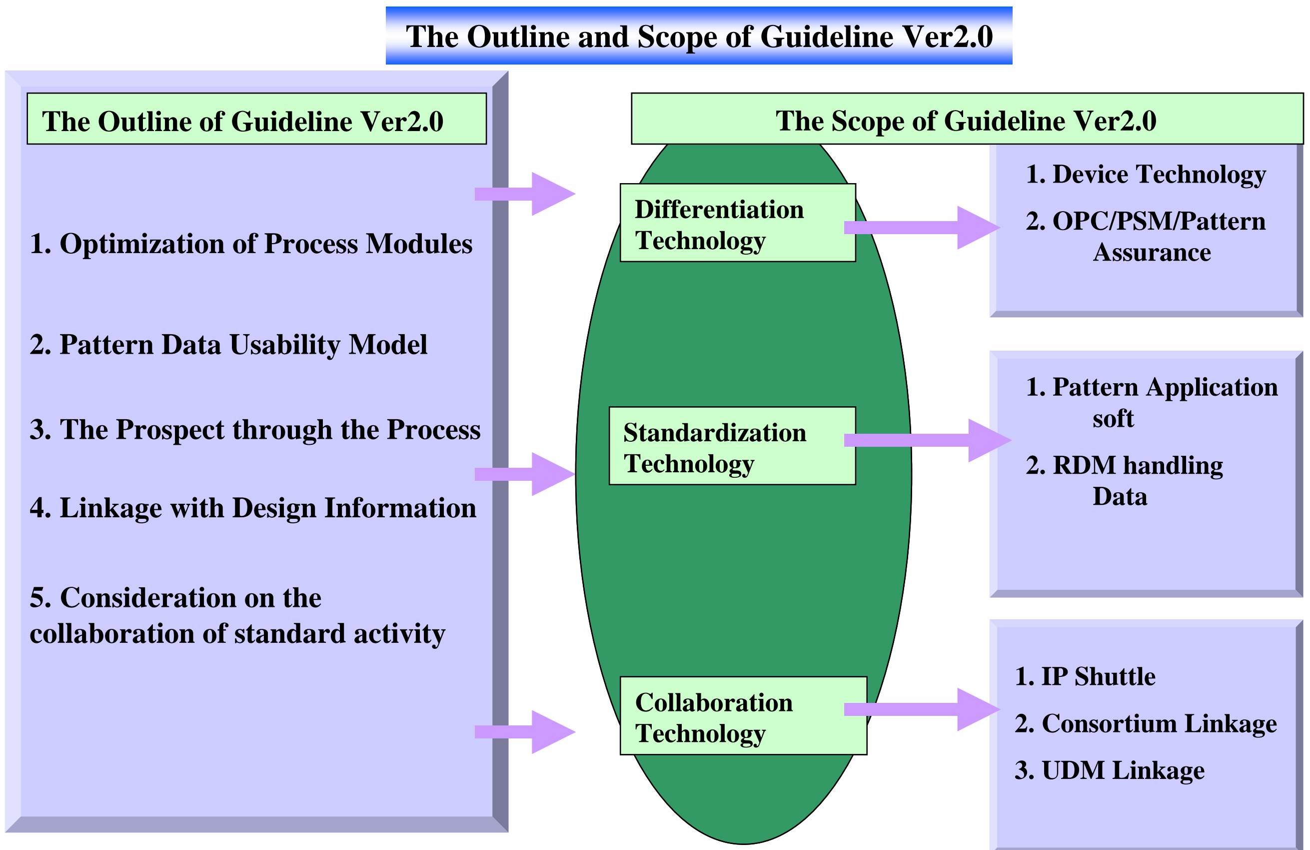


FIG. 5

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1.6 Standardization objects and definition

1) Index terminology and expression to handle pattern data

2) Common QC data expression related with various other information that will be needed in engineering in wafer fab and MASK shops.

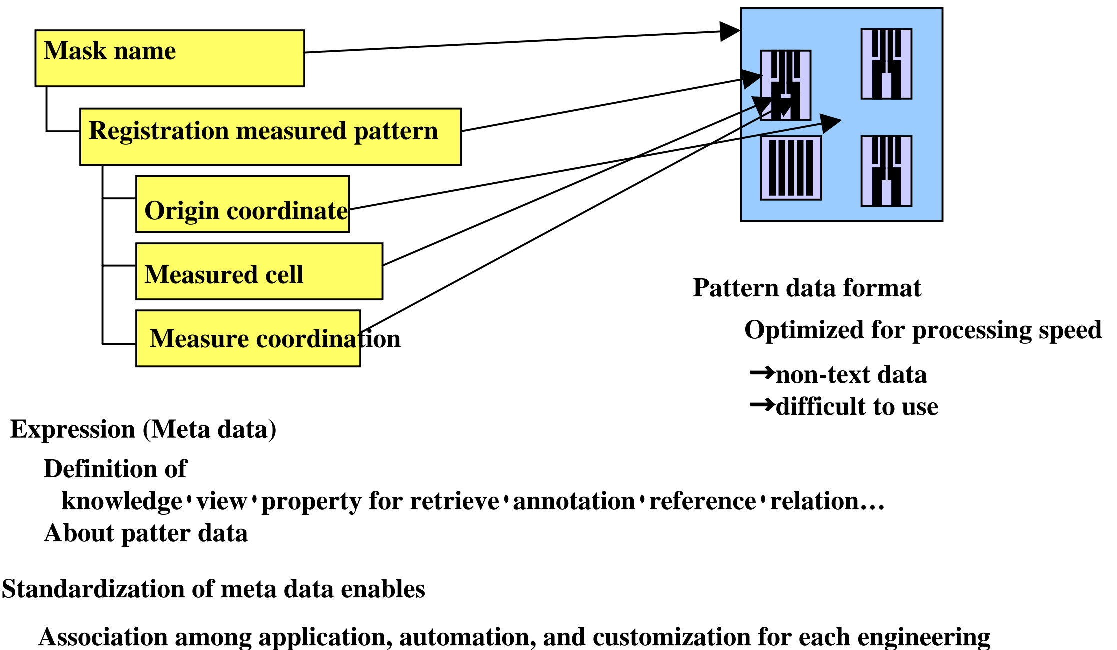

FIG. 6 Relation between “expression” and “format”

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1.7 Relationship with the related standardization requirement

The activities of the overseas organizations that have complementary relationship are mentioned below:

・**SEMI-Japan Reticle Data Management Task Force**
The standardization activities of micro patterning division
a) It discusses the data-exchange method of the information relevant to a reticle.
b) It intends to draft a guideline.
c) It incorporates mask data into stepper recipe data preparation. It performs standardization of communication of reticle-related information among design ~ mask vender ~ wafer fab.

・**SEMI-NA Mask Data Path Task Force**
Standardization activities of UDM (Universal Data Mode) Working Group.
a) It discusses the data-exchange method of the information relevant to a reticle.
b) It intends to draft a guideline.
c) In this, Open Access Coalition of Silicon Integration Initiative (Si2) is introduced. This consortium aims at offering the open standard to the IC design data access.

・**MOPXE (Mask Order Processing in the Extended Enterprise)**
This activity about the mask supply chain is proposed from IMS (Intelligent Manufacturing System).
The activity is carried out mainly in Europe.

2. General guideline

2.1 Sharing of reticle data

The standardization of expression of reticle related information including design information such as pattern data should be established, in order to make easy information exchange (it contains when it consists of two or more companies) relevant to the reticle, covering mask manufacture and wafer manufacture from a design.

The environment that can be utilized in common from design to wafer fab. must be established to fulfill the following conditions.

Conditions :
1. Reticle data and reticle-related data must be correlated with a hierarchic configuration.
2. Reticle data and reticle-related data must be delivered in a standardized method at each interface.
3. Reticle data and reticle-related data must be defined clearly in their contents.
4. Reticle data and reticle-related data must be stored for each fab. so that the required data can be taken out whenever necessary.
5. Reticle data and reticle-related data must be protected by the reasonable security system.

In Ver2, these include standardized expression to use design information such as pattern data.
In SEMI-TF activities based on guideline ver1, standardized expression are considered with XML technology.

2.2 The standardized expression for usability of pattern data

Apart from standardization of the data format of the pattern data itself, expression of referencing pattern data and other additional information that are associated in case pattern data is utilized should be standardized.

Pattern data itself is complexly structured and huge in volume. If it will be used in wafer fab, standardized expression is necessary considered from the point of view how engineers use it. Such expression works as indexing, annotating, relating with other useful information and combining several application. Figure 7 shows the image of this standardized expression. Engineering Chain Management must refer to Design Data through Quality Consideration, Process Consideration, and Cost Consideration.

Ex) Specification in desired pattern based on check Rule A

1. Check Pattern (must be assessed impact on wafer)

a. Minimum space in dense pattern
- **address**
  - **center of the area**
  - **location to be checked**
- **area to be observed**

b. Gap between Line End and Corner
- **Address**
  - **center of the area**
  - **location to be checked**
  - **area to be observed**
- **gap definition**
  - **upper edge**
  - **down edge**

c. Severe Line for performance

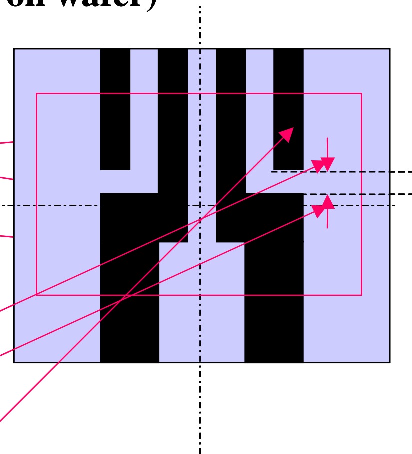

FIG. 7

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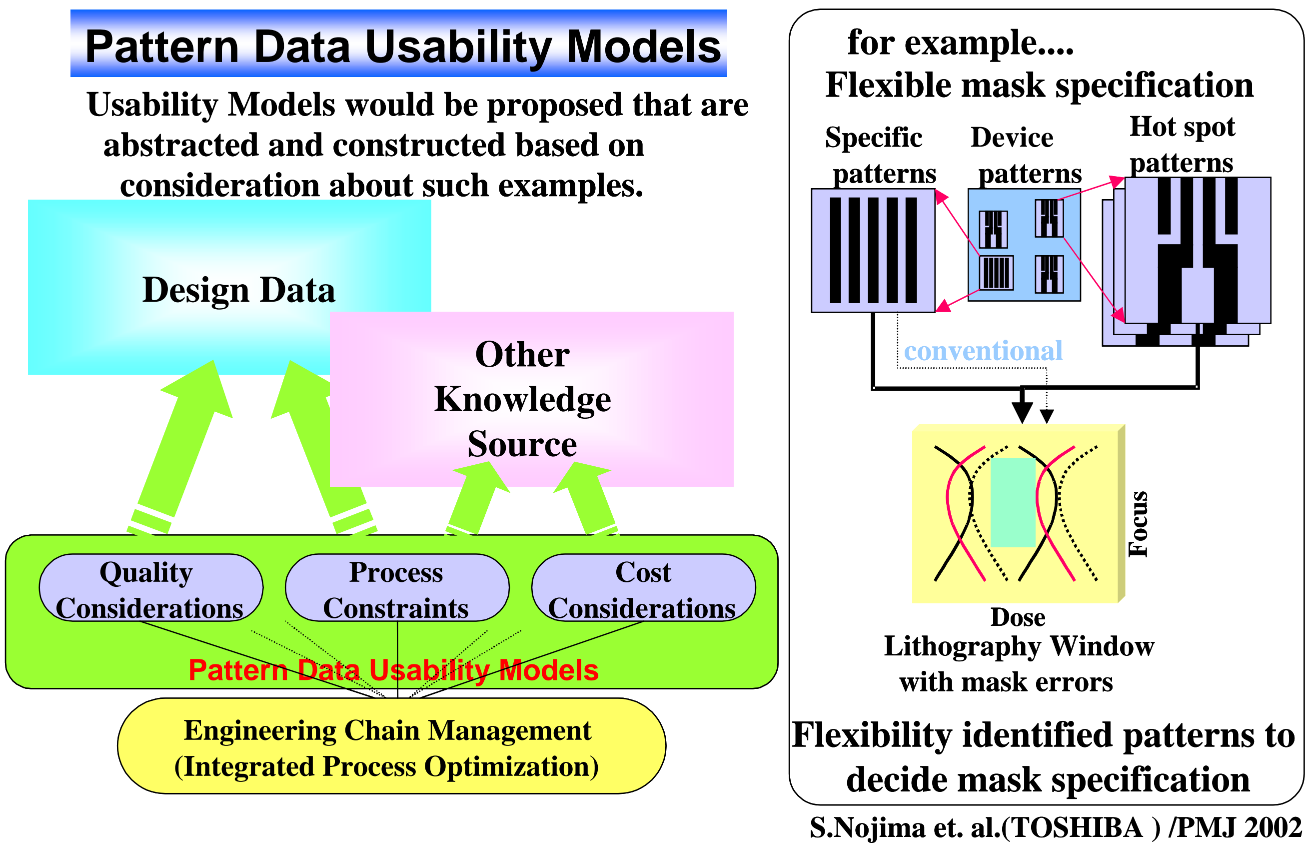
3. Guideline for application

3.1 Creative association among applications that use design information

The standardized representation should be considered with practical usage in order to make it possible to associate applications using design information.

For example, the Flexible Mask Specification Methodology proposed from TOSHIBA in 2002 Photo Mask Japan associates several concepts of applications. The Hot Spot Pattern is selected as most critical each reticle by verification tool. And Mask Specification is decided considering process window by simulation.



S.Nojima et. al.(TOSHIBA) /PMJ 2002

FIG. 8

3.2 Comprehensive reusability in process module optimization

Standardized expression should be comprehensible for every process in a module and be reusable.

Recently process optimization is considered based on integrated process modules. Like this device process consists of multiple process modules. And each process module consists of many process steps like this. And then nowadays all process steps need to be aware of pattern layout dependency. For this reason process engineers must refer to huge storage of design information. If there are comprehensive models between process modules and Mega Storage of design information, they will be convenient to optimize for engineering chain management. As Figure 9 shows, they are thin layer that process engineers use to index design information. This guideline is intensive only on Reticle Data Management, but naturally, they would be reused in all process modules,

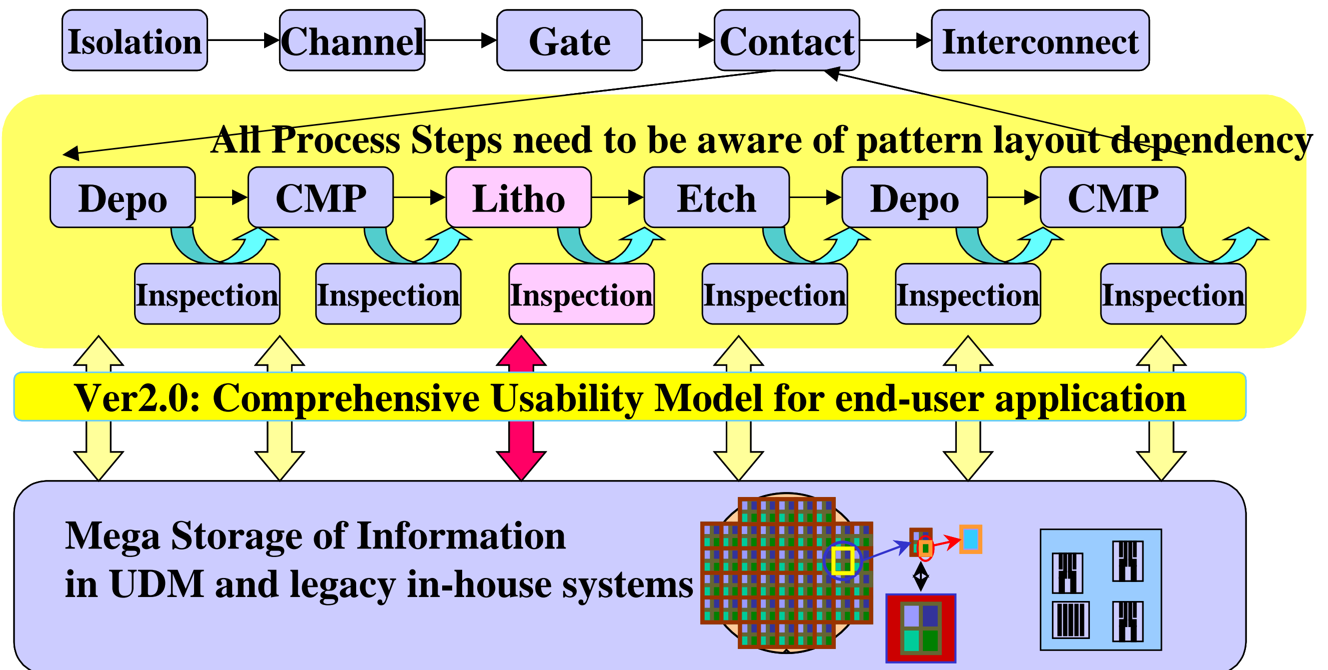


FIG. 9

3.3 Strengthening linkage between design and manufacturing

Standardized expression should be able to strengthen linkage between design and manufacturing that can improve mutual optimization based on understanding relations with extensibility and reusability.

Corresponding to the future production system of design/manufacture cooperation, the standardized expression should be extensible so that the design side information such as DRC information, adding to pattern data, and the manufacture side information such as process margin evaluation can communicate mutually, and so that it is reusable to optimization of pattern data dependency even with processes other than lithography process. Like Figure 10, Design and Manufacturing are depending and encouraging each other. Through this circulating communication, optimizations will be improved. In Design these are Optimizations based on Manufacturability, Pattern Printability, and Process Specification. In manufacturing these are Optimizations based on Integrated Process Module Performance, Pattern Dependency, and Device Specification.

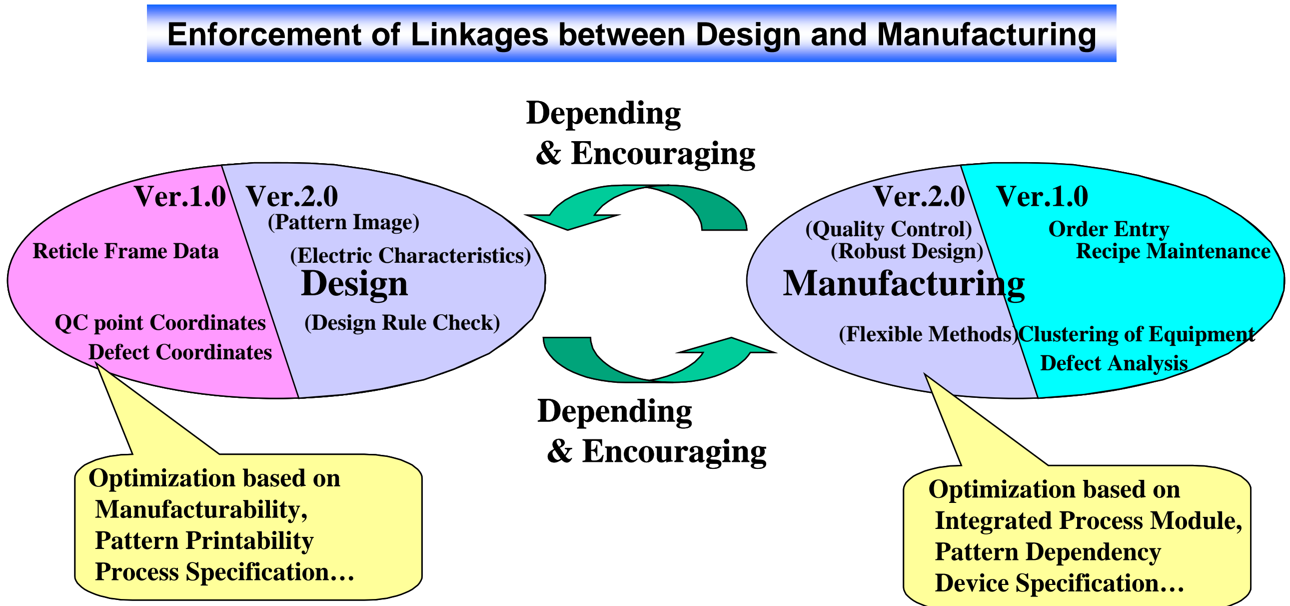


FIG. 10

3.4 The prospect through the process (extension from a design to a back process)

The standard expression of data exchange ranging from design to wafer process intensively (mentioned in Ver1), should be considered so that it is reused in Back End Processes, such as testing and defect analysis.

Same as in process module optimization, standardized expression might be reused through the process namely Design to Delivery. Already Wafer Map Information should be standardized through the process. If there would be the hierarchical model raging from wafer map to pattern data, they might promote pervasive integration in the semiconductor-manufacturing world. In the same way as process module integration, these guidelines are intensive only on Reticle Data, but it is possible to have such expectation.

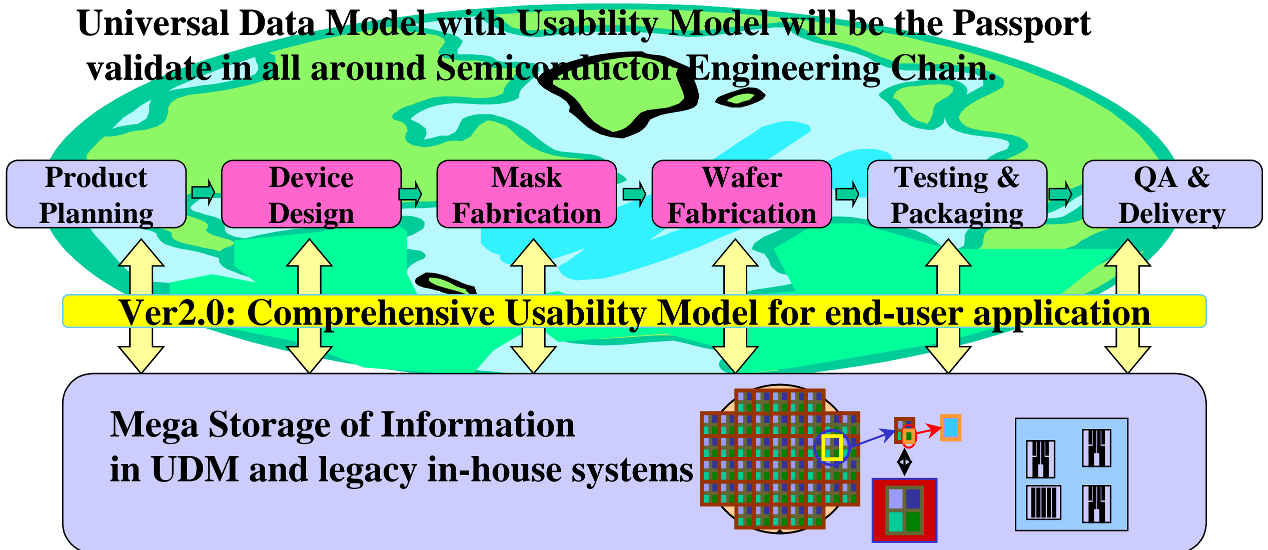


FIG. 11

4. The model of Global Joint Guidance

So that standard expression of RDM may cooperate with the standardization activities for the common interface of database storing information used in RDM, they should be considered to be convertible.

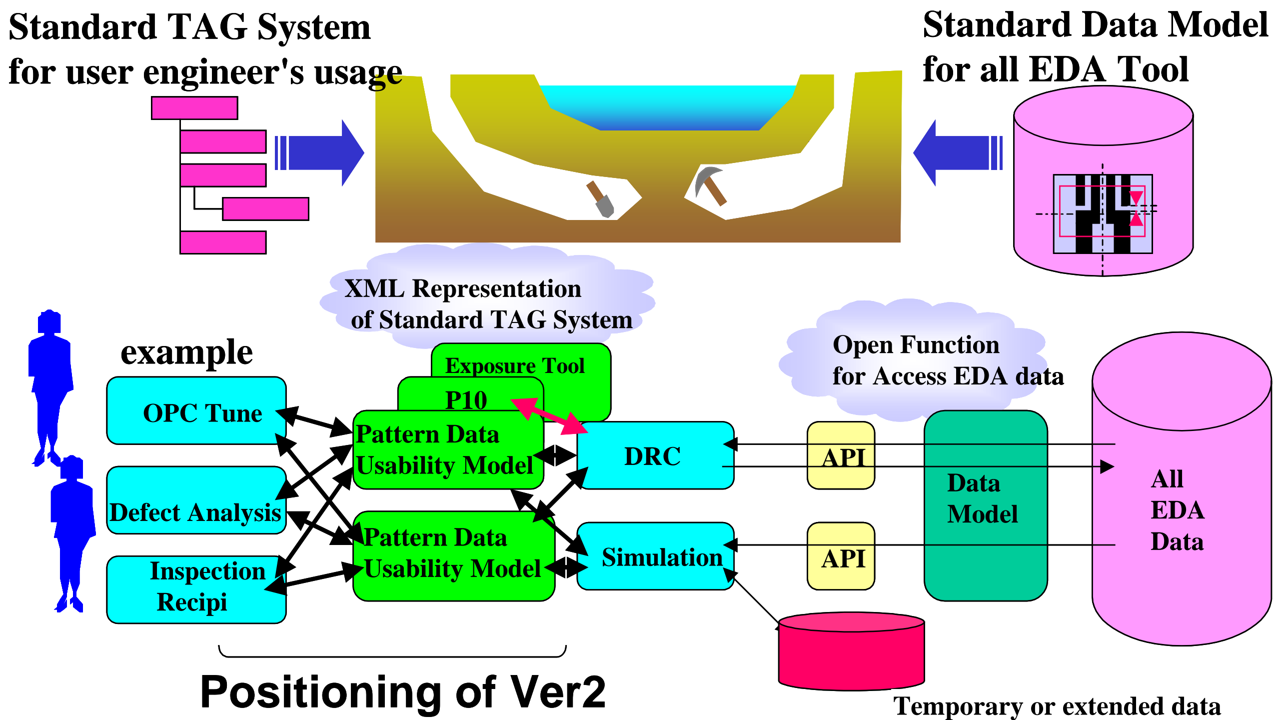


FIG. 12

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Contact JEITA Reticle Management Subcommittee Members

Role	Name	Company	Address
	Toshio Onodera	Oki Electric Industry Co.,Ltd. Silicon Manufacturing Company WP Business Div. WP Business Dept.	〒193-8550 550-1 Higashi-asakawacho Hachiouji-shi Tokyo TEL (0426)62-6234 FAX (0426)62-6709 E-M onodera021@oki.com
	Takashi Satoh	TOSHIBA CORPORATION Process & Manufacturing Engineering Center Advanced ULSI Engineering Dept. II	〒235-8522 8 Shinsugita Isogo-ku Yokohama-shi Kanagawa Yokohama Office TEL (045)770-3605 FAX (045)770-3570 E-M ta.sato@toshiba.co.jp
	Toshiharu Matsuda	SANYO Electric Co.,Ltd. Semiconductor Company LSI BU Engineering Dept.	〒370-0596 1-1-1 Sakata Oizumi-Machi Ora-gun Gunma TEL (0276)61-8043 FAX (0276)61-8836 E-M mats067701@sanyo.co.jp
	Michio Honma	NEC Electronics Corporation Corporate Strategic Planning Unit	〒211-8668 1753 Shimonumabe, Nakahara-Ku,Kawasaki Kanagawa TEL (044)435-1406 FAX (044)435-1870 E-M m-honma@cp.jp.nec.com
Sub-Leader	Norihiko Miyazaki	FUJITSU LIMITED Semiconductor Group Manufacturing Technology Development Div. MASK Technology Dept.	〒197-0833 50 Fuchigami Akiruno-shi Tokyo (Akiruno Technology Center) TEL (042)532-2158 FAX (042)532-2882 E-M miyazaki.norihi@jp.fujitsu.com
Leader	Nobuyuki Iriki	RENESAS Technology Co. LSI Manufacturing Unit Wafer Process Engineering Development Div.	〒312-8504 6-16-3 Horiguchi Hitachinakashi,Ibaraki-ken TEL (029)270-2185 FAX (029)270-1792 E-M iriki.nobuyuki@renesas.com
	Tamotsu Uga	ROHM CO., LTD. MASK Production Dept. VLSI Operation Div.	〒615-8585 21, Saiin Mizosaki-cho, Ukyo-ku, Kyoto, Japan TEL (075)321-5120 FAX (075)315-3231 E-M Tamotsu.Uga@lsi.rohm.co.jp

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Appendix

Guidelines for Reticle Data Management Ver.1.0 (English Version)

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3.4 Clustering of device in mask fab.
3.5 Standardization of QC data

4. Standardization and implementation procedure
4.1 Activity organization and schedule

1. Introduction

1.1Background

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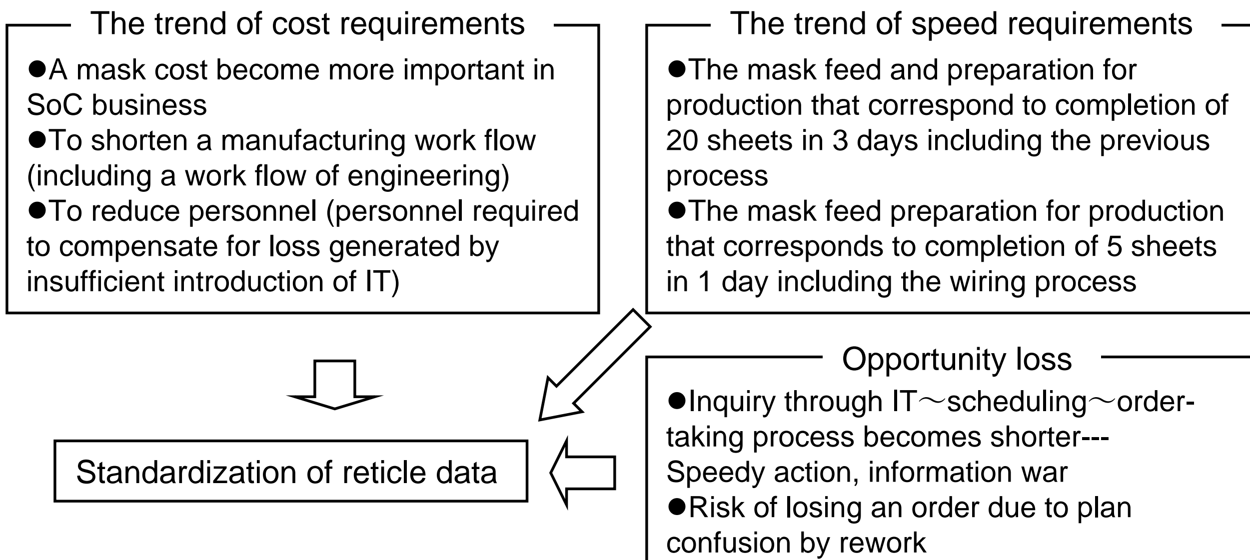
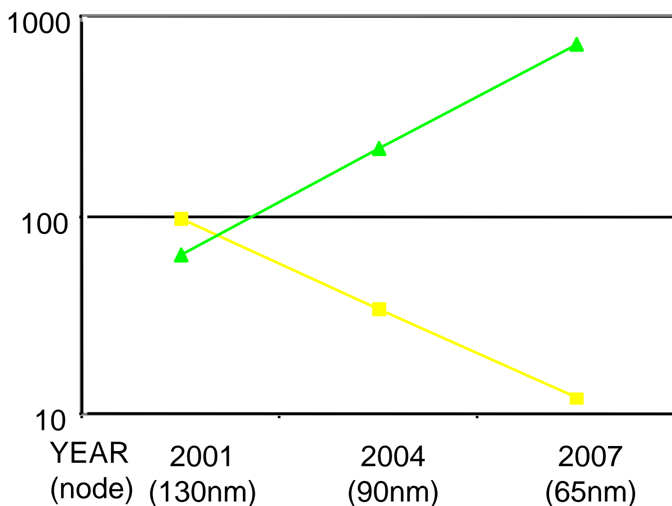
Through this semiconductor recession, the future situation of semiconductor industry has become apparent where various kinds of products vie in the limited demand. The trend to the limited production with a wide variety of SoC (system-on-chip) is remarkable. As a result, this trend increases severity of the following requirements: shorter life cycle of product, more difficult technique, lower cost, and shorter total TAT from design to shipping etc. Device venders, system venders, and material venders form a sector of semiconductor manufacturing technology. They are similarly forced to compete for the value to the business of device makers in the situation where capital investment and procurement cost continue to decrease.

Thus, in order to seek innovation of higher speed and efficiency, a major move has begun to utilize IT technology for manufacture of semiconductors. In the overall area of production technology, e-manufacturing has been introduced to every stage of production as utilization of IT technology, mainly Internet. Information is shared extensively through Internet. Not only that, powerful organization is intended to utilize more professional information such as devices. In this trend, production of a variety of products directly leads to thorough rationalization of many tasks involved for each reticle. This guideline has been planned against recognition of this background.





The unit price for each function must be reduced sharply. The data volume of a mask increases sharply. Therefore, epoch-making increase in efficiency is required for cost and date of delivery.

Figure 1. ITRS2001 roadmap

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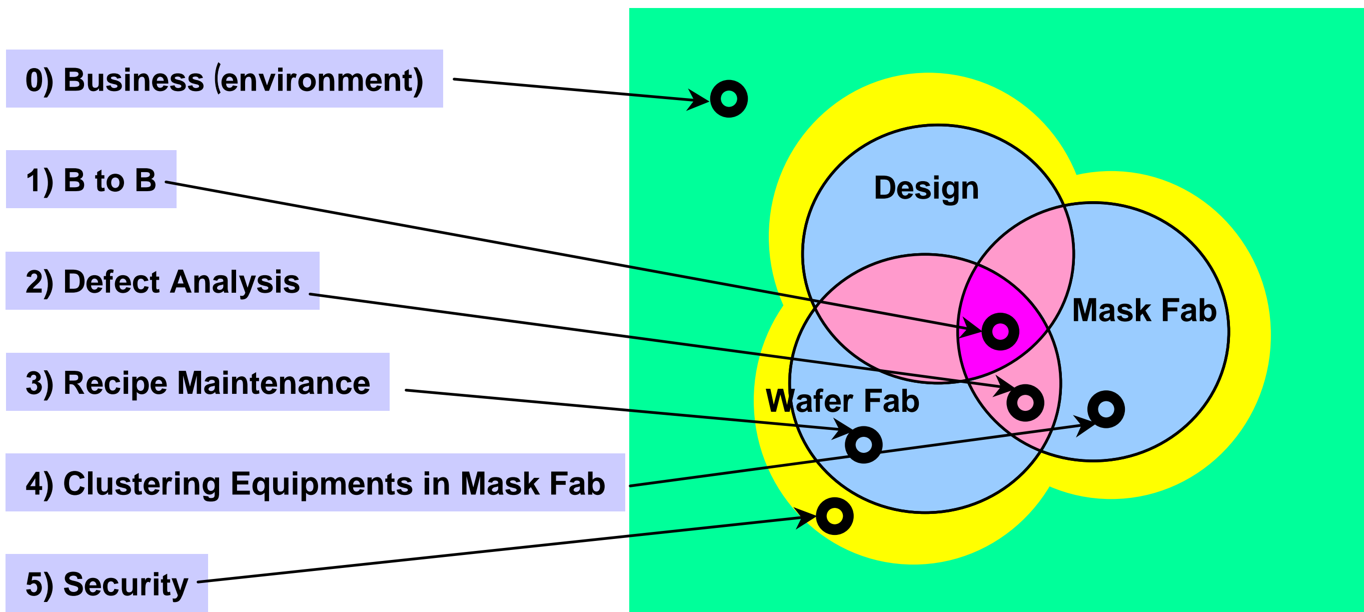
1.2 Purpose

As mentioned in 1.1 Background, the speed from design to merchandising is critical for digital electric household appliance and Internet-related devices. These devices are represented by SoC. Especially, in order to cope with the limited production with a wide variety of products, the speed for reticle tasks becomes critical. They include reticle feed, reticle-related preparation in manufacture, analysis of defect caused by reticle etc. The information related to reticle covers widely design, mask manufacture, and wafer manufacture. Despite a progress of partial automation, many exchanges of data rely on a conventional method such as telephone, resulting in loss of person-hours and time.

This guideline is primarily intended to address this issue by increasing efficiency consistently based on standardization that ranges from design, to mask manufacture, and to wafer manufacture.

Secondly, this guideline is intended to support efficient deployment of new automation application business of device and production system venders, by enabling them to share information among the systems in the innovation where a variety of product are produced in a small quantity.



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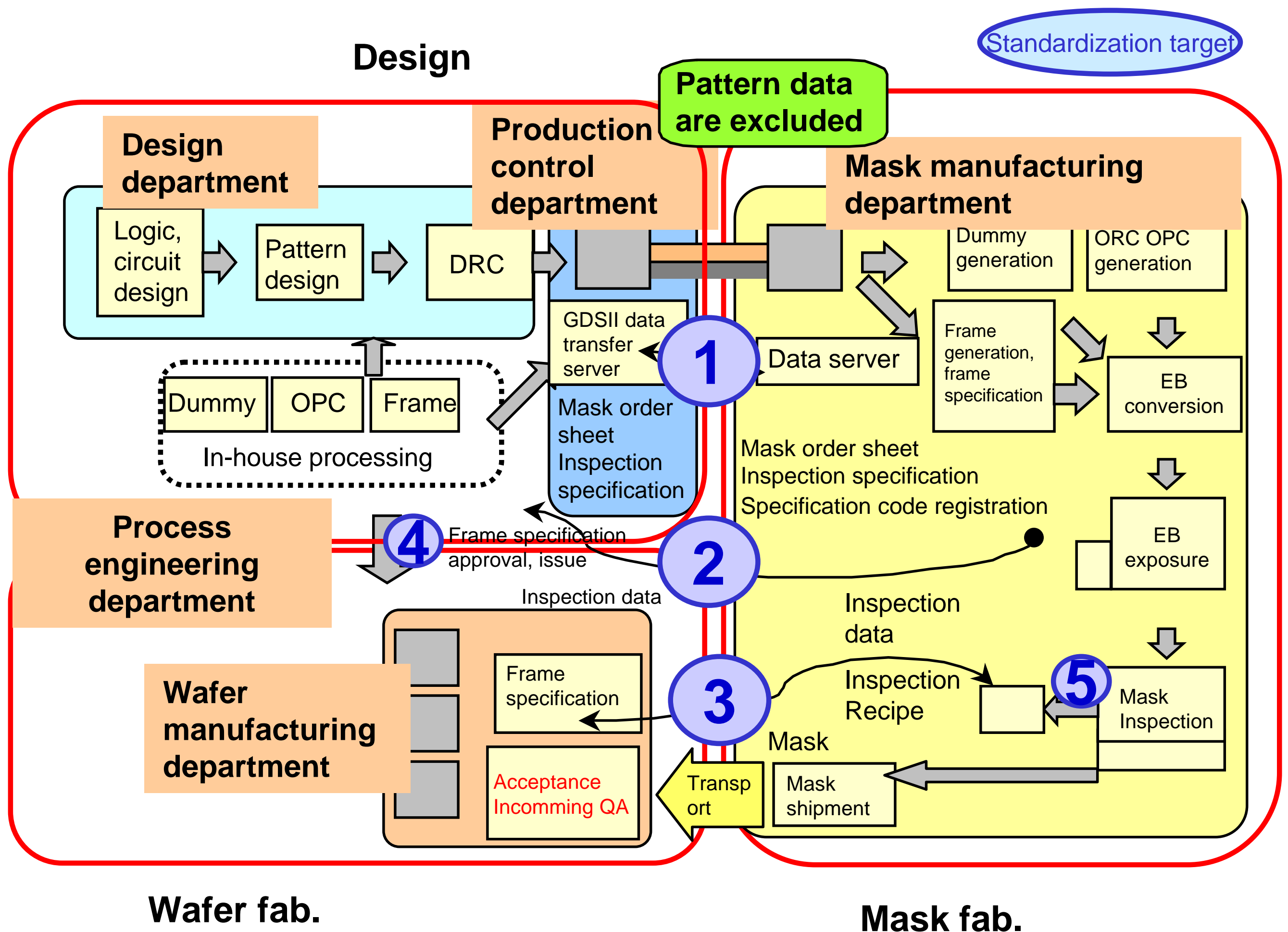
1.3 Scope

The following items, (1) through (5), are related to interfaces for information exchange (necessary minimum data structure for universal use of information) .
The scope proposes the guidelines for standardization of these interfaces.
(1)Production schedule, WIP tracking
(2) or (4)Quality Control in wafer fab.(recipe, device management, process monitor)
(3)Interchange and utilization of inspection, measurement data, and defect data
(5)Preparation of recipe of device in mask fab.
However, we exclude device H/W that is used for pattern data (graphic data required for CAD, OPC, PSM, TEG, and exposure/inspection), communication medium (network circuit, protocol), and device that is used for information interchange. In addition, the interfaces of above-mentioned (1) through (5) are so structured as to permit the mutual reuse of information.



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1.4 Standardization objects and definition

To be excluded from these standardization objects

1) Circuit pattern data
A data part of a product (GDS data, plot data, comparison inspection data)

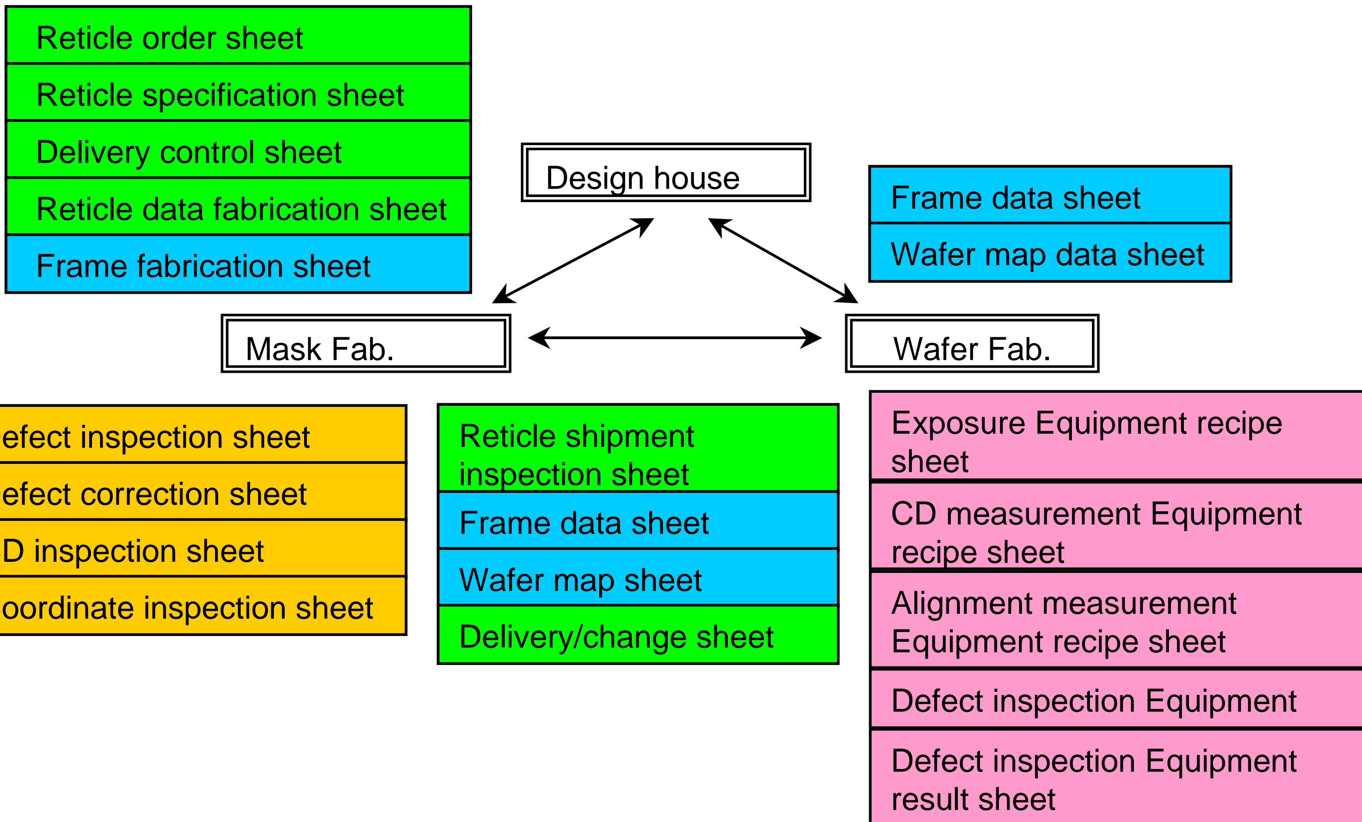
To be included in these standardization objects

2) Reticle data (calling the incidental data except circuit pattern data)
Reticle set specification sheet data (halftone, standard etc.)
Individual specification sheet
Pattern data (frame data and processing specification for CAD, plot, and inspection)
Inspection data (dimension, defect etc.)
Recipe data, correction parameter data

3) Reticle-related data
Management of plural reticle
Wafer inspection data (defect, dimension etc.)
History data
Tracking data
Order sheet data

Supplement

The above-mentioned standardization objects are controlled by the example sheets mentioned below.



Mask vender, mask device	Related to reticle data handling in mask house 1)Mask vender 2)Mask device vender 3)Selete
CAD, WP device, WP	Related to frame data (exposure device mark, inspection device mark, TEG, etc.) 1)WP device vender (exposure device, CD, alignment, defect inspection device) 2)CAD (frame CAD vender) 3)Wafer fab. user (JEITA)
CAD, WP device, WP	
Mask vender, WP	Related to order-taking and ordering, specification, delivery, change, inspection result 1)Mask vender 2)Wafer fab. user (JEITA)

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1.5 Relationship with related standardization

This guideline deals with the interface of the data exchange of the information relevant to the reticle except pattern data. The activities of the overseas organizations that have complementary relationship are mentioned below..

(1) SEMI-Japan Reticle Data Management Task Force
The standardization activities of micro patterning division
·It discusses the data-exchange method of the information relevant to a reticle.
·It intends to draft a guideline.
·It incorporates mask data into stepper recipe data preparation. It performs standardization of communication of reticle-related information among design～mask vender～ wafer fab.

(2) SEMI-NA Mask Data Path Task Force
Standardization activities of UDM(Universal Data Model) Working Group
·It discusses the data-exchange method of the information relevant to a reticle.
·It intends to draft a guideline.
·In this, Open Access Coalition of Silicon Integration Initiative (Si2) is introduced.
This consortium aims at offering the open standard to the IC design data access.

(3) MOPXE(Mask Order Processing In the eXtended Enterprise).
·This activity about the mask supply chain is proposed from IMS
(Intelligent Manufacturing System). The activity is carried out mainly in Europe

1.6 Requirement for establishment of common language for reticle-related information

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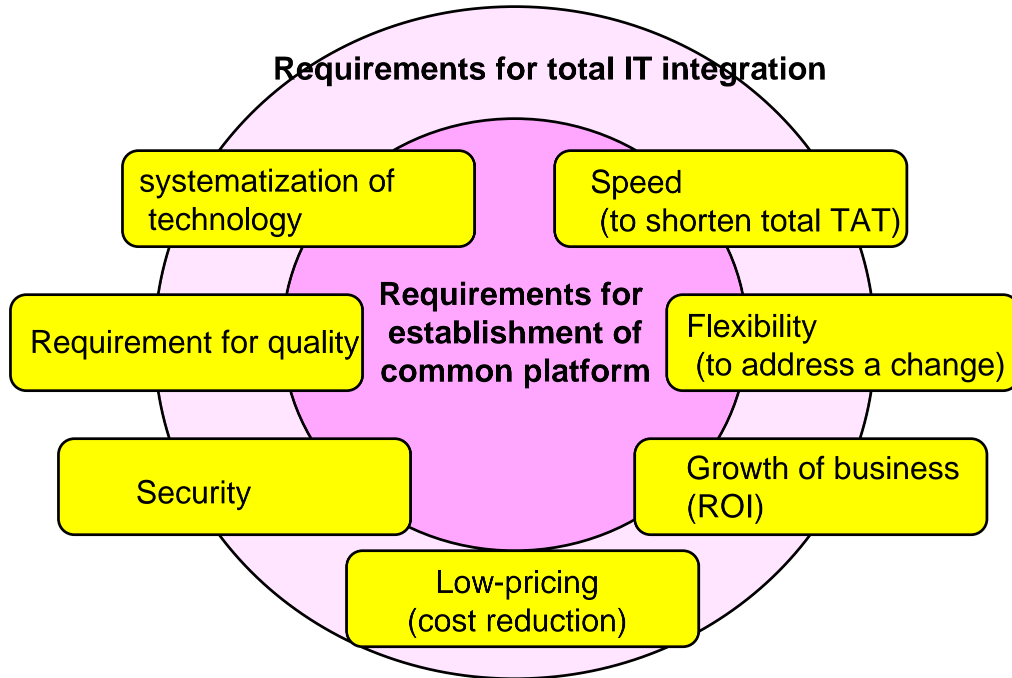
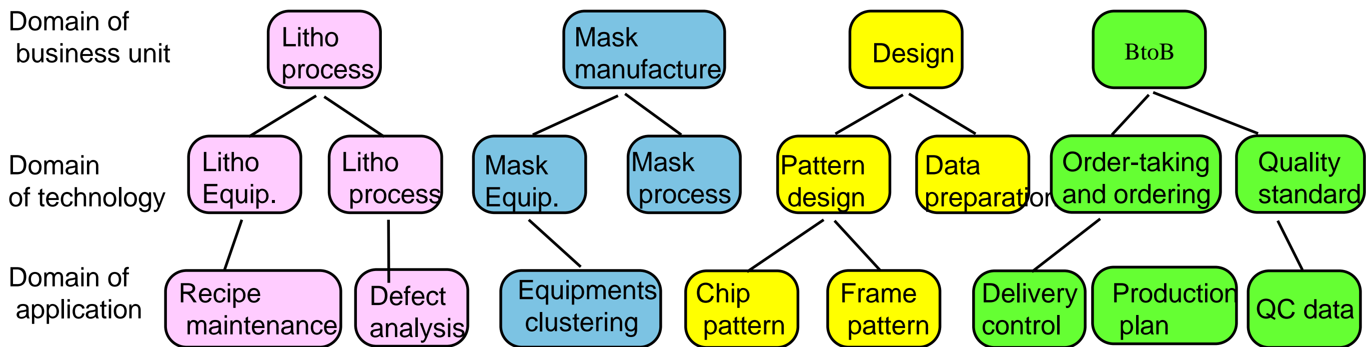
The requirements for SoC business of small production of many kinds of products lead to requirement for establishment of common language through requirement for total IT utilization. Utilization of many techniques that is based on XML in IT area must be so developed as to support the requirements for SoC business.



1) Technical systematization

The speed of technical accumulation is accelerated by IT technology. For that purpose, technical systematization that aims at high availability is required. The reticle-related information must be formulized in terminology/definition/methodology about several aspects of utilization, accumulation, and exchange in a wide area.



Necessity of interoperability among various domains

Reticle-related information is used by the entire area of domains through partial relationship.

Necessity of semantic interoperability is large.

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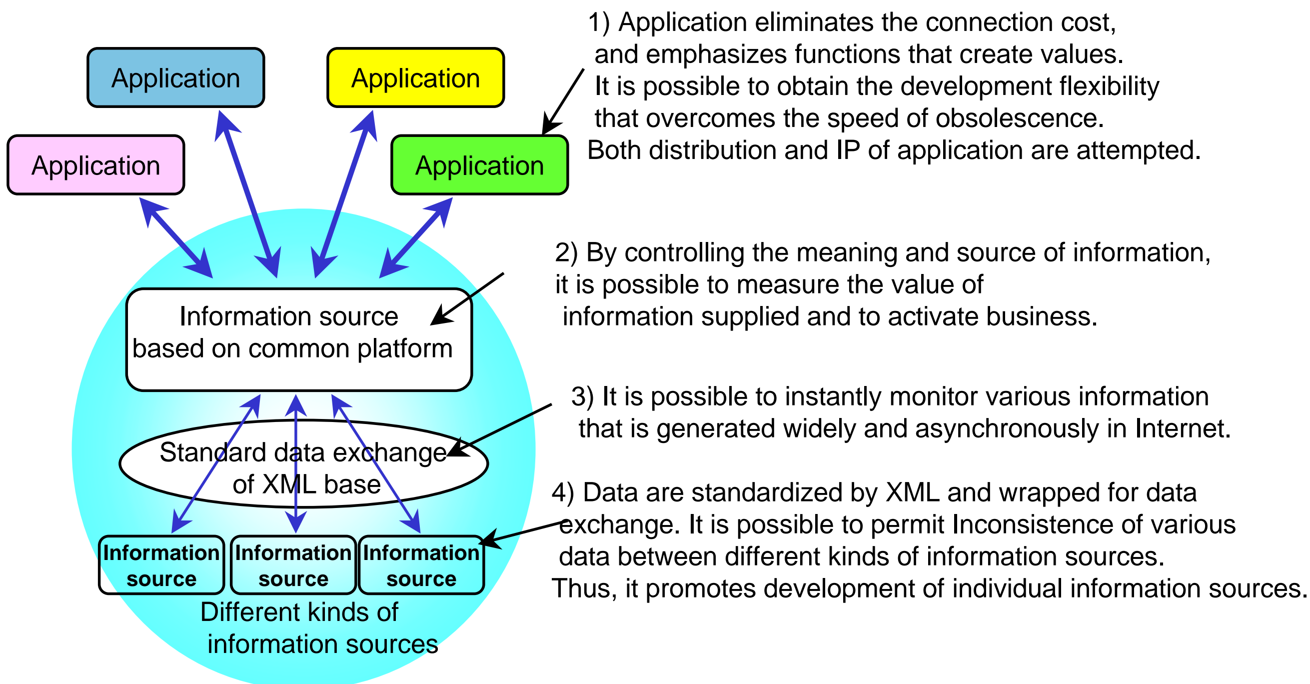
2) Flexibility

Production technology must continue to innovate obsolete technology to cope with an ever-changing market, and IT technology must be easily updated. In addition, the reticle-related information is generated and use in various aspects, and a data model with high flexibility is required.

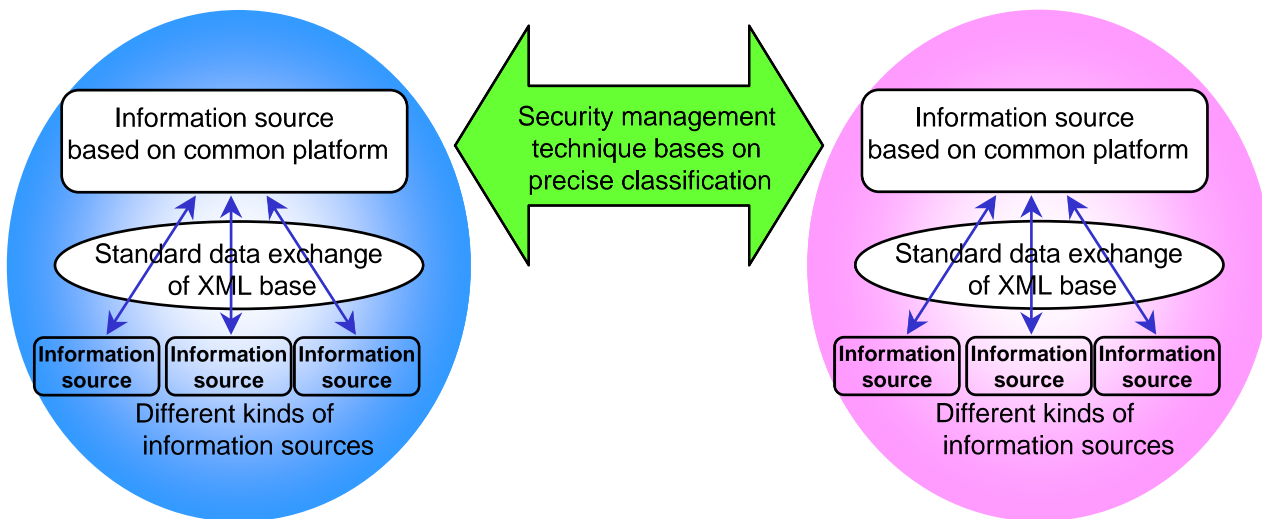
3) Return of investment in business

Activation of information service based on standardization is required to reduce the introduction cost. Owners and users should be clarified according to information classification. Collaboration should be realized among device makers, mask makers, equipment makers, and system makers. For that purpose, various business model should be built where security is precisely set up and license and fees are established.



4) Security

The information about a reticle must be maintained at high security for a customer. Share information must be systematized to set up security management that is partitioned appropriately and efficiently for various security requirements and usability requirements.



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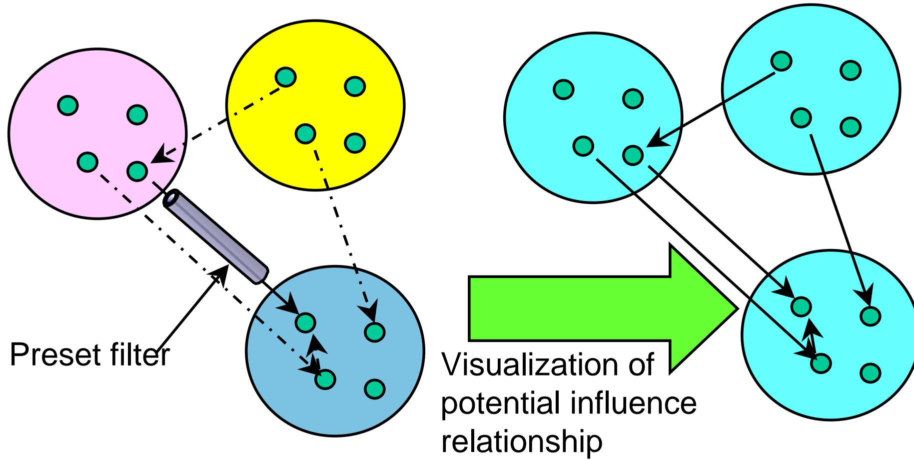
5) Quality

As the technology becomes more difficult, lack of consideration about quality generates the maximum loss. Application of IT technology to semiconductor production technology is not limited to a superficial support for quality control. It needs to support by incorporating analysis, which was difficult because of shortage of labor in the past. The requirements for quality of a reticle are also increased. Therefore, efficient development should be supported.

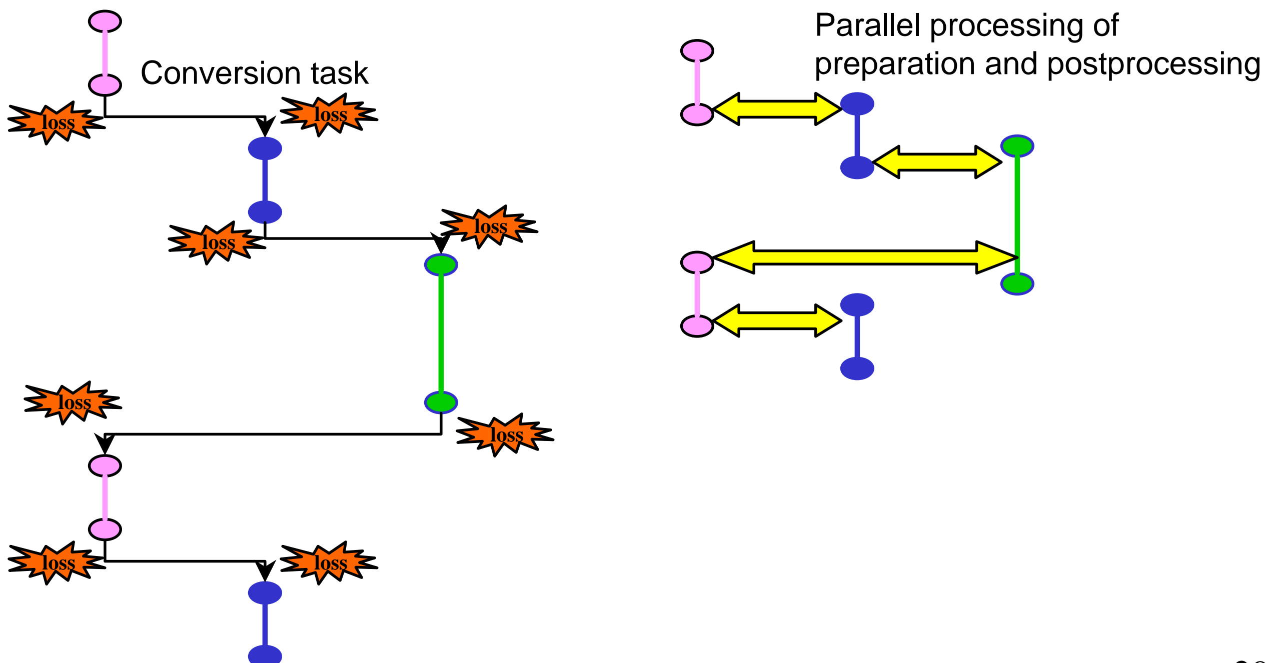


6) Cost

In order to reduce the cost for every reticle under small production of various products, it is necessary to eliminate every loss that is dispersed and generated in an extensive area and to obtain an integral effect. Not only that, it is necessary to establish standardization that is suitable for Internet technology in order to realize a wide information exchange inexpensively.

7) TAT

In order to make it contribute to ultimate product TAT realization, you should eliminate break and leakage in a total work flow. For that purpose, you should consider main stream design data that range from design to mask manufacture and to wafer manufacture. Not only that, you should include information that is information generated derivatively and consider possibility of wide reuse.

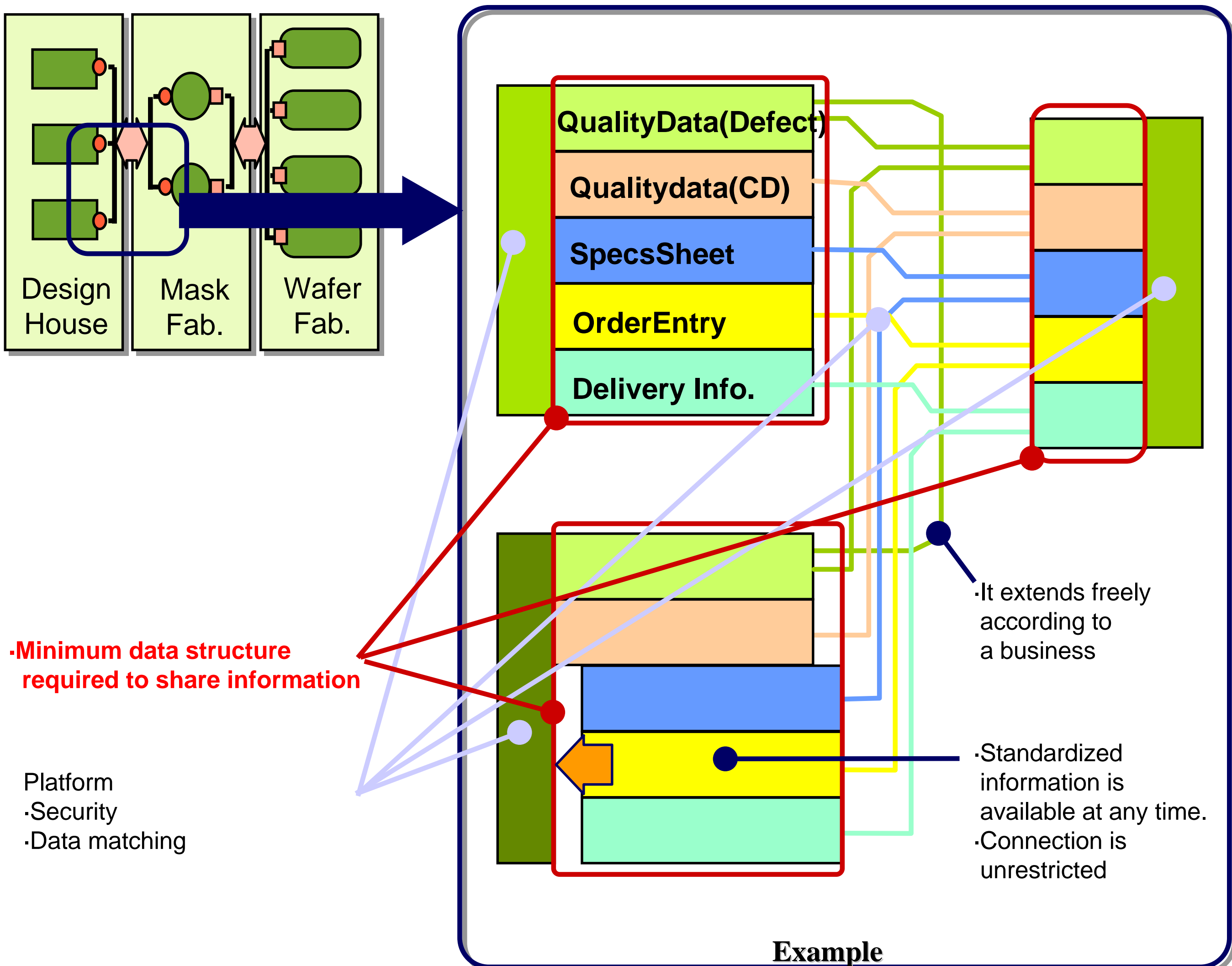


2. General guideline

2.1 Sharing of reticle data

The environment that can be utilized in common from design to wafer fab. must be established being fulfilled the following conditions.

Conditions :
1. Reticle data and reticle-related data must be correlated with a hierarchic configuration.
2. Reticle data and reticle-related data must be delivered in a standardized method at each interface.
3. Reticle data and reticle-related data must be defined clearly in their contents.
4. Reticle data and reticle-related data must be stored for each fab. so that the required data can be taken out whenever necessary.
5. Reticle data and reticle-related data must be protected by the reasonable security system.



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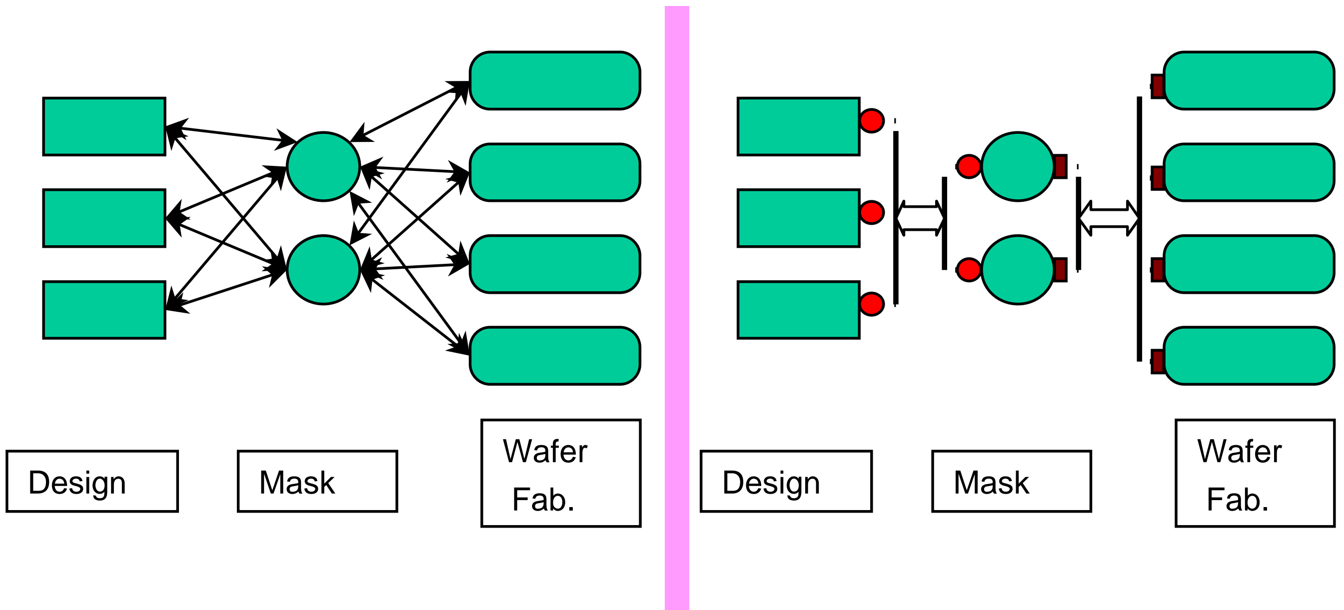
2.2 Outline of shared guideline covering design, mask manufacture and wafer manufacture

Interchange of various data that were explained above has been built by individual association at B to B until now. The left-hand figure shows continuing building of individual association, while the right-hand figure is based on standardization of processes that ranges from design of reticle data and reticle-related data to mask manufacture and to wafer manufacture. The individual know-how and the common data exchange are associated and controlled respectively, and overall complex processes can be simplified.



B to B	Shared data	Items for standardization	
		QC flow	Data handling
Design house ↔ Mask fab	Chip size Block configuration Reticle set mark CD (On wafer/reticle) Defect Orthogonality Shrink Alignment mark	Guideline for mask order-taking and ordering system and data handling (toward creation of standardization format) (ref: P10)	
Mask fab. ↔ Wafer fab.		Guideline related to frame data (exposure device mark, inspection device mark etc.) (toward creation of standardization format)	
Wafer fab. ↔ Design house.		Guideline for design (technology unit) and photolitho manufacture standard (wafer, reticle accuracy) (toward creation of standardization format)	

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3. Guidelines for Applications

3.1 Order-taking and Ordering of Mask

(1)Guideline for Order-taking and Ordering of Mask

Mask order-taking and ordering information must be shared from design to mask fab. and to wafer fab

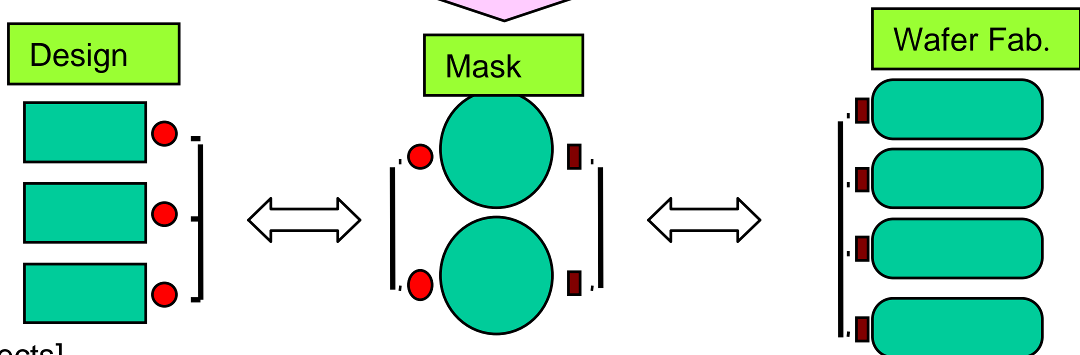
For data handling, a business model must be flexible enough to meet the requirements of both parties concerning various formats for drawing, text, GDS, Mebes etc.

The status report of each mask must be shared among order-taking, ordering, and production control of reticle database in order to report mask making progress report and forecast delivery it for customer. This mask supply is and will be a key for a fine patterned device. This will be an issue whether you produce a mask in-house or not.

[Common items for order-taking and ordering of mask]

1) Design data (drawing, GDS II, Mebes etc) (including frame data)
2) Manufacture request sheet (a masking name, new edition, revision, reprint, size, pellicle class, specified date of delivery, destination)
3) Manufacture conditions (manufacture data specification, exposure data arrangement
specification, manufacture specification, and inspection specification)
4) Progress
5) Specification (grade)
6) Quality (dimension, arrangement, defect, phase difference, transmittance)
7) Inquiry

Shared environment of order-taking and ordering



[Effects]

- You can service all customers more quickly than now
- You can reduce system development cost

(2) Mask Progress report and Delivery forecast program

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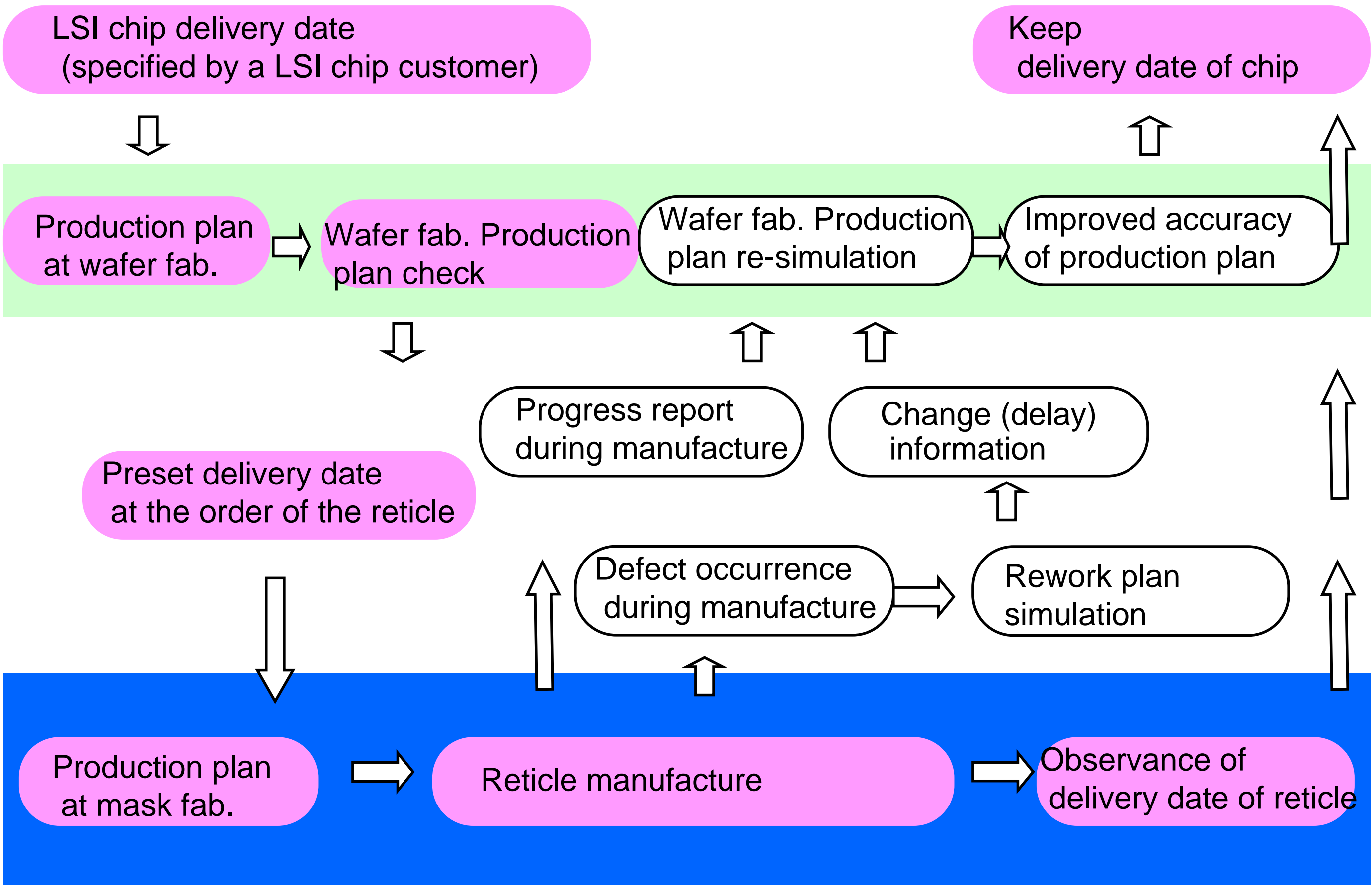
Mask fab. should offer wafer fab. the updated information including delivery schedule of rework of reticle manufacture. Both should offer the standardized interface.

Reticle data management —Just-in-time program

Timely prediction of delivery(● part) is added to the conventional B to B (○ part) in the standardization. Thus, B to B cooperation can eliminate waste that is observed by a customer.



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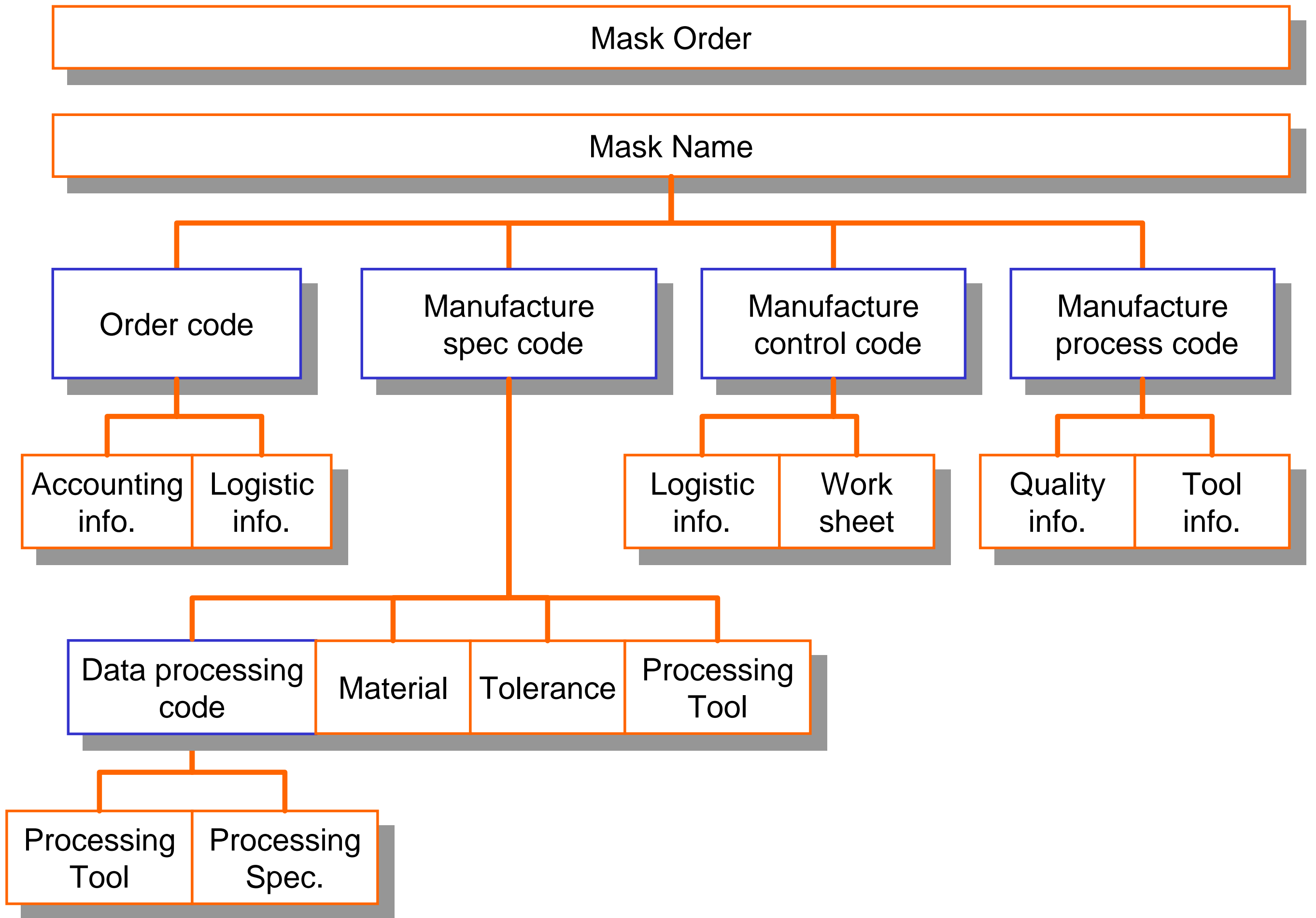
(3) Mask Ordering Data forXML (Structured Reticle Data for Order)



3.2 Increase in efficiency of analysis of reticle defect

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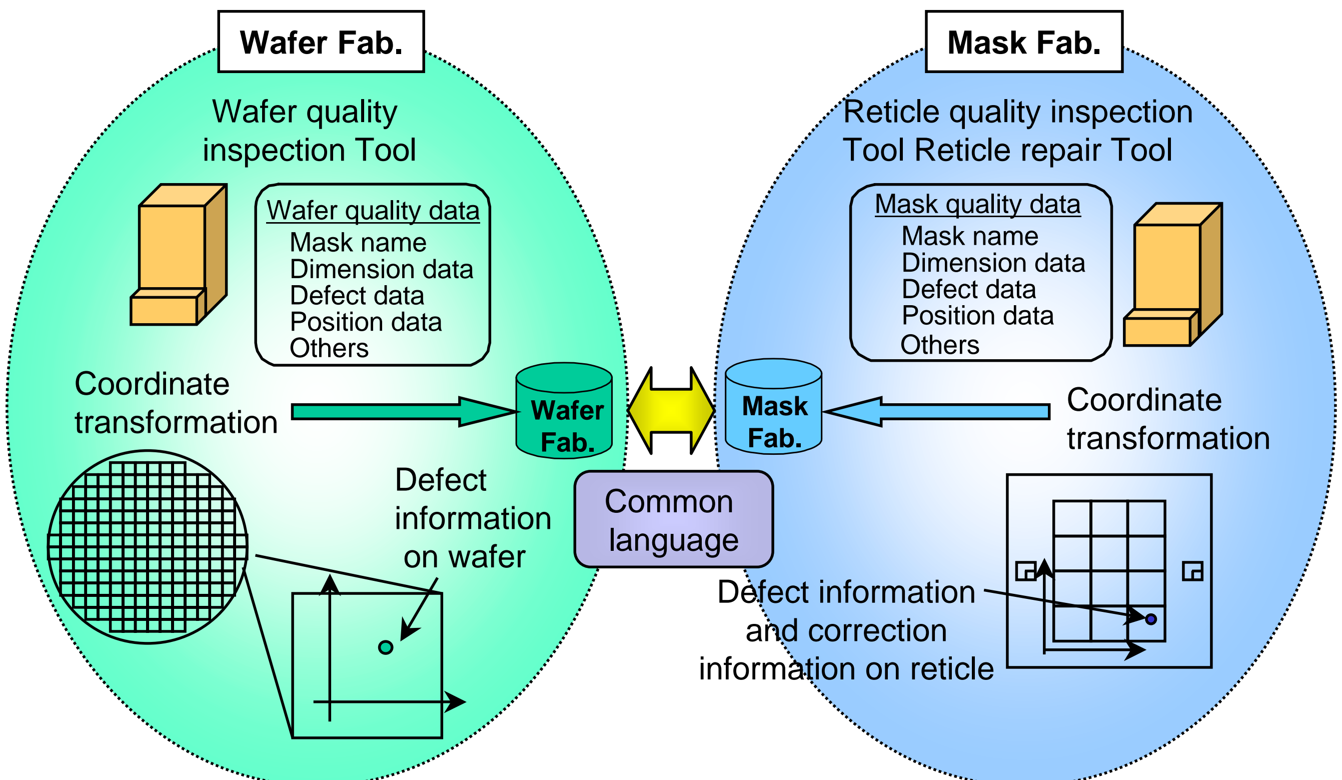
The reticle data and reticle-related data must be ready for wafer fab. to refer those for analysis of quality in wafer fab. (defect, dimension etc.) whenever necessary.

Example 1) You use the reticle data and reticle-related data so that you can judge whether the quality in wafer fab. originates in a reticle or not.

Example 2) You correlate quality information of a reticle with that of wafer so that you can increase efficiency of the process improvement of reticle manufacture.

[Examples of effects]
- You can improve the quality of mask
- You can increase efficiency of the quality analysis in wafer fab.
- You can clarify the criteria of quality, optimize mask production process, and reduce a manufacturing cost
- You can reduce the cost to develop a tool to analyze correlation between mask quality and wafer printing characteristics.

[Example of methods]
- You feed back the wafer printing result to the mask fab. and accumulate the data about correlation between mask quality and wafer printing characteristics
- You feed forward the quality information of mask manufacture process to the wafer fab. and utilize it for the quality analysis at wafer fab.



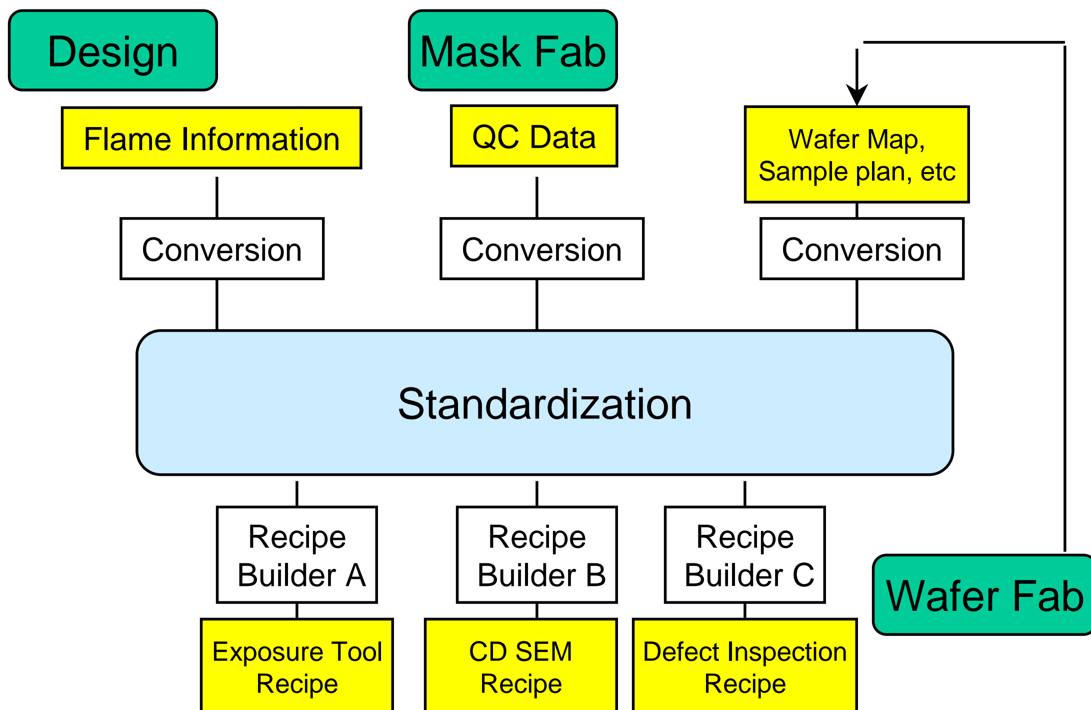
3.3 Increase in efficiency of recipe build in wafer fab

Guideline of Standardized Reticle design information and QC data to make reusable it for recipe build in Wafer Fab.

1) The data that are related to recipe build of systems, such as exposure tools, inspection tools, APC, MES, etc. are generated in various data sources throughout the design shop, mask fab. and wafer fab. In order to address various quality requirements in the future, you need a flexible method based on the common formats of data.

[Effects]
- The time of recipe building at wafer fab. will become quick.
- The cost for developing recipe build system will be minimized.

[Methods]
- Mask flame information, mask quality information, wafer map and sample plans are provided as standardized format data from each site. Recipe builders import these data and make recipe.



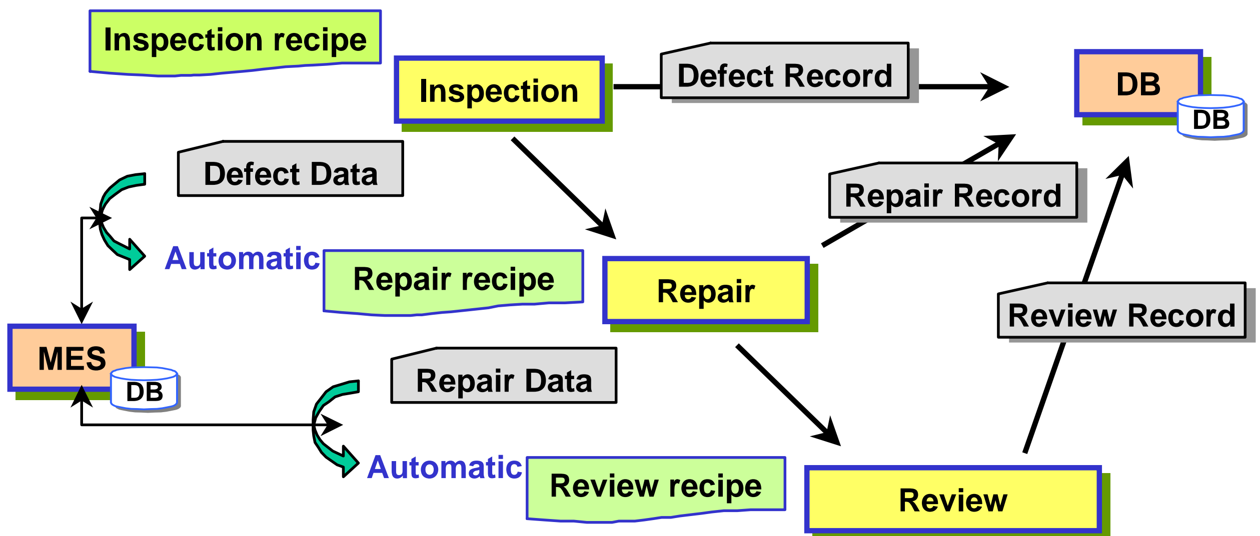
3.4 Data sharing within mask fab.

The data and information within Mask Fab.; inspection, defect correct and review tool, should be able to be shared for mutual reference of data as necessary.

1) Reticle defect correction process use many tools;inspection, defect correction and review. This correction will be efficient, if tools can share there results and recipe.

[Effects]
- Can shorten the time to create a recipe at the process of mask defect inspection, defect correction and review by reuse of information i.e. coordinates information etc.
- Can reduce the development cost of a recipe by preparing standard or flexible data format
- Can improve mask quality by integrate information related to mask defect.

[Methods]
- Collect, store, report and analyze the information about mask defect and processing information.
- Associate and integrate the information about mask defect at wafer manufacture process and the information at mask manufacture process.



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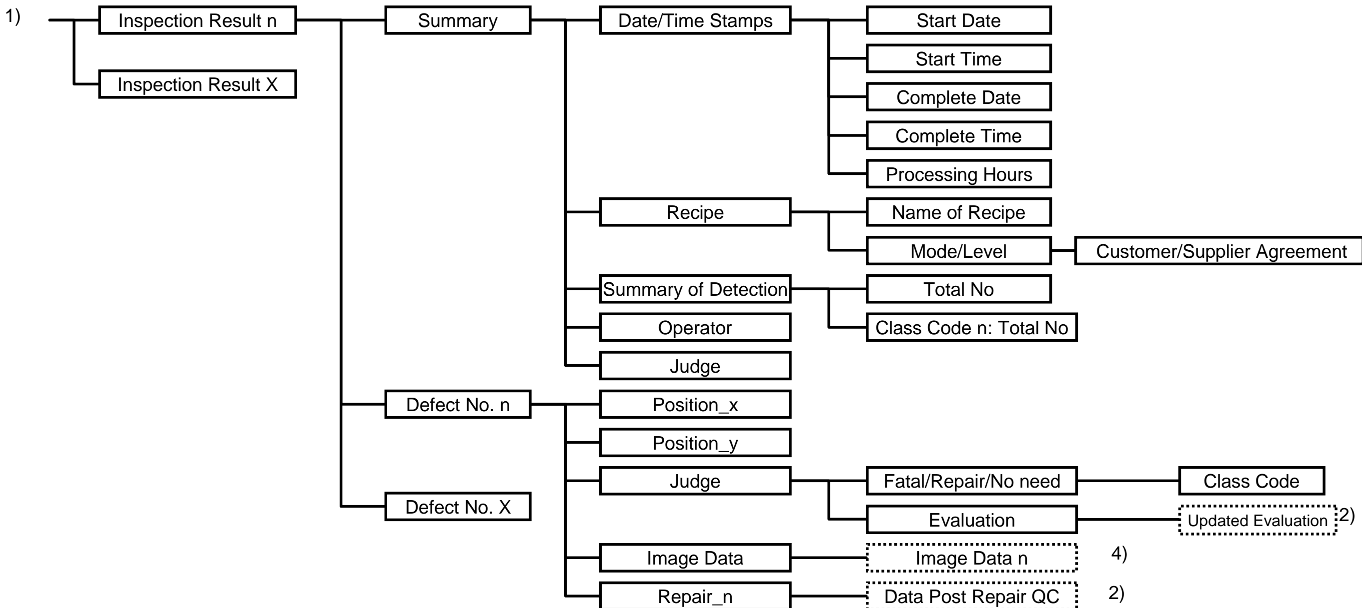
Example) XML Data Tree of Inspection Tool

Process No
Tool Information_n
Tool Information_X
Date/Time Stamps
Start Date
Start Time
Complete Date
Complete Time
Processing Hours
Basic
Reference Area DB
Basic Area DB
Tool_No
Coordinate Definition 3)
Date of Preparation
Date
Time
Operator of Preparation
Inspection Method
Data of Inspection Area
Inspection Area
Size_x
Size_y
Chip Number
Chip_n_x
Chip_n_y
Chip Size
Chip Size_x
Chip Size_y
Rotation
Mirror
Flip
Inspection Result_n 1)
Origin_n
Coordinate_x
Coordinate_y
Image Data 4)



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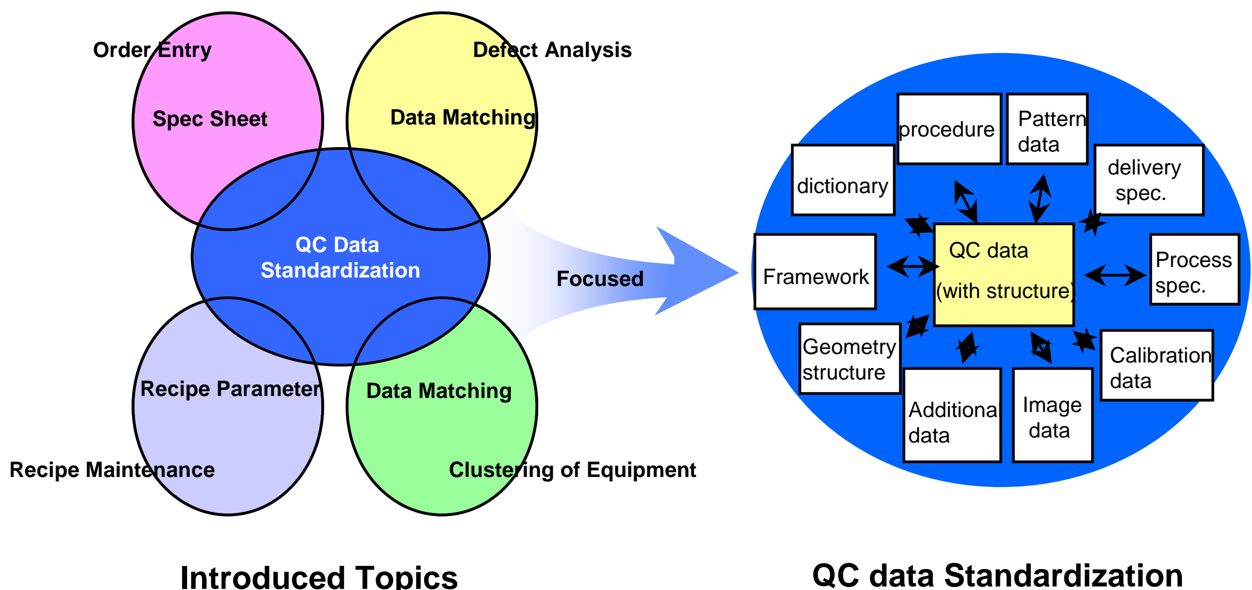
3.5 Reusable QC Data

At B to B, standards information should be exchanged in the standardized items.

1. Classification of information
   1) Wafer Fab. standards information
      - Order sheet - Spec sheet
   2) Mask Fab. standards information
      - QC sheet
2. Merit: Improvement of productivity and reduction of cost

Methods :
Expansion of reusability of QC information by standardization of different section
(definition and usage of QC data at Wafer, Mask and Design)
1) As to QC data, you standardize such components that can be stratified and shared. You should deal with data handling in a standardized method.
2) You should use classification and stratification for communalization. You should promote first the area that is easy to communalize, namely that is highly common or highly abstract.



Introduced Topics

QC data Standardization

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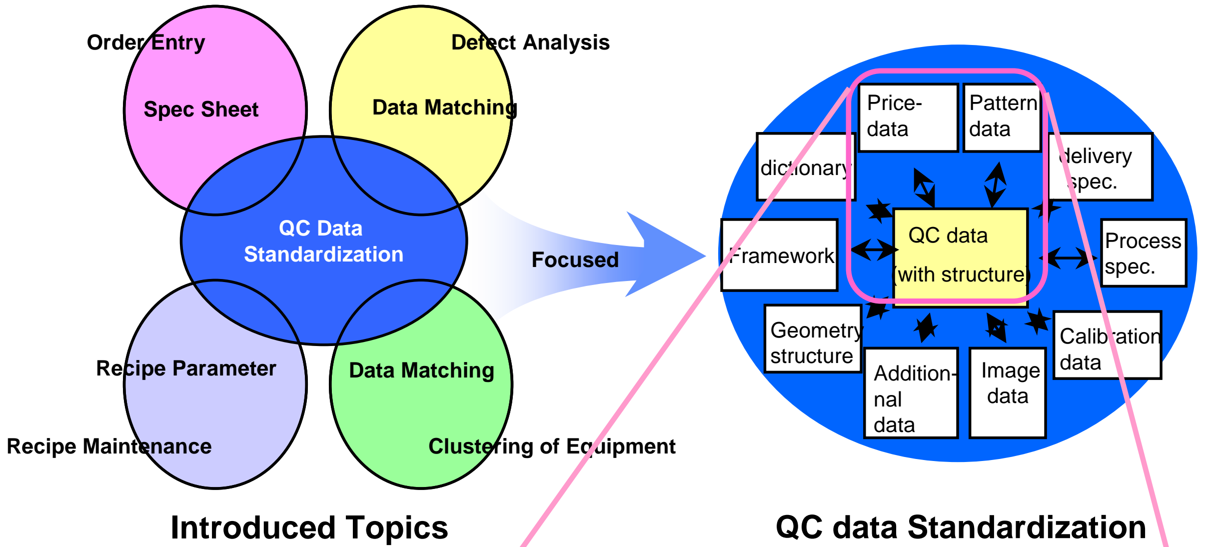
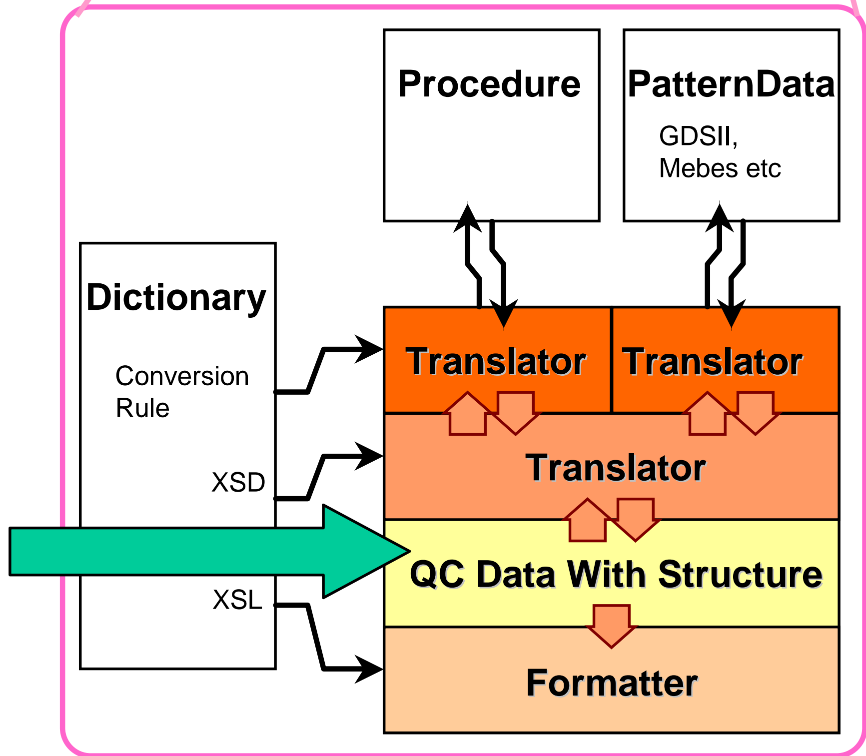
Examples of sharing of procedure and pattern data



Introduced Topics

QC data Standardization

Reticle Data Management Target



Example

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Example)
QC data of order-taking and ordering of mask

1) Shipped Mask Number
(for each type of product, each grade, each technology, each size,
 new edition, revision, reprint)
2) Just-in-time Delivery Reticle Ratio
3)TAT
4)Quality (CD:uniformity/mean to target, Distortion, Defect)
5)Tool (Tool Up Ratio, QC/Pre Maintenance result)
6)Failure data

* : Data must be read on a platform. Production control and quality contro
l should be shown daily, weekly, and monthly.
Those data must be updated to reticle production plan
and development plan.

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Contact JEITA Reticle Management Subcommittee Members

Role	Name	Company	Address
	Toshio Onodera	Oki Electric Industry Co.,Ltd. Silicon Manufacturing Company WP Business Div. WP Business Dept.	〒193-8550 550-1 Higashi-asakawacho Hachiouji-shi Tokyo TEL (0426)62-6234 FAX (0426)62-6709 E-M onodera021@oki.com
	Takashi Satoh	TOSHIBA CORPORATION Process & Manufacturing Engineering Center Advanced ULSI Engineering Dept. II	〒235-8522 8 Shinsugita Isogo-ku Yokohama-shi Kanagawa Yokohama Office TEL (045)770-3605 FAX (045)770-3570 E-M ta.sato@toshiba.co.jp
	Toshiharu Matsuda	SANYO Electric Co.,Ltd. Semiconductor Company LSI BU Engineering Dept.	〒370-0596 1-1-1 Sakata Oizumi-Machi Ora-gun Gunma TEL (0276)61-8043 FAX (0276)61-8836 E-M mats067701@sanyo.co.jp
	Michio Honma	NEC Electronics Corporation Corporate Strategic Planning Unit	〒211-8668 1753 Shimonumabe, Nakahara-Ku,Kawasaki Kanagawa TEL (044)435-1406 FAX (044)1870 E-M m-honma@cp.jp.nec.com
Sub-Leader	Norihiko Miyazaki	FUJITSU LIMITED Semiconductor Group Manufacturing Technology Development Div. MASK Technology Dept.	〒197-0833 50 Fuchigami Akiruno-shi Tokyo (Akiruno Technology Center) TEL (042)532-2158 FAX (042)532-2882 E-M miyazaki.norihi@jp.fujitsu.com
Leader	Nobuyuki Iriki	RENESAS Technology Co. LSI Manufacturing Unit Wafer Process Engineering Development Div.	〒312-8504 6-16-3 Horiguchi Hitachinakashi,Ibaraki-ken TEL (029)270-2185 FAX (029)270-1792 E-M iriki.nobuyuki@renesas.com
	Tadashi Imoriya	Matsushita Electric Industrial Co., Ltd. Semiconductor Company Corporate Manufacturing & Development Div. Design Support Group	〒601-8413 19 Nishikujokasugamati Minami-ku Kyoto-shi Kyoto TEL (075)662-7357 FAX (075)662-6154 E-M PAN84968@pas.mei.co.jp
	Masayoshi Mori	MITSUBISHI ELECTRIC CORPORATION ULSI Development Center ULSI Process Integration Dept.	〒664-8641 4-1 Zuihara Itami-shi Hyogo TEL (0727)84-7532 FAX (0727)80-2597 E-M Mori.Masayoshi@lsi.melco.co.jp