

Application Note 200308001 (Summary)

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Information management for MST cleanroom processes

1. Introduction

Documentation of the cleanroom activities is required to preserve the knowledge about the processes and the technologies involved; hence different users with different levels of expertise can obtain the relevant information easily.

However, a documentation for the micro's and nano's cleanroom processes is difficult to realize because of the diverse technologies involved¹.

The Process Flow Module in the PhoeniX Cleanroom Database is a tool to manage the documentation for the micro's and nano's cleanroom processes. It offers the flexibility to implement various processes and technologies affected. Nevertheless, its thoughtfully defined hierarchy and templates secure the communication standardization.

When the database is managed correctly, the available processes are accessible considerably. Furthermore, the quality improvement and most of the validation process will be automatically accomplished also.

PhoeniX ProcessFlowDB module can be extended to the OperatorDB module to incorporate the data digestion. The output data from the equipments can be registered as the input of the statistical process control for design iterations by using the simlink. Scripts can perform the statistical process control, and also can send an automatic warning message and email when a deviation is detected.

The purpose of this application note is to exemplify the development of an effective cleanroom database by using the PhoeniX Process Flow Module. The focus of this note is not on the technological issues, but on the documentation and the verification aspects.

The case study for this note, because of its well described technology, is the process flow of the optical core SiON by using the PECVD and RIE processes.

2. The Hierarchy Of The Process Flow Database

Each level of the hierarchy has a specific menu. Each menu contains unique templates. The menu and their templates function as a communication standard for knowledge management. This way the reuse, the quality improvement, and the validation of the defined processes can be realized.

The usage of the menu and templates inside the hierarchy, and the definition of the processes to develop a SiON optical core, will be briefly explained at section 3,4 and 5.

Section 3 will focus on the process development topic, while section 4 will bring up the issue about process validation. The quality improvement will be mentioned at section 5.

¹Proceedings COMS 2003 "Trends in micro and nano software" by [ir.N.Olij](#), [ir.A.F.Bakker](#), [dr.ir.H.H.van](#) den Vlekkert.

Phoenix Cleanroom Database Module : Process Flow Database					
Hierarchy	General description	Examples	Process validation	Quality improvement	Involved Expertises
Equipment	<ul style="list-style-type: none"> Define the cleanroom's equipment (1) 	<ul style="list-style-type: none"> Piranha bath. Hotplate. BLE gamma 60. 	<ul style="list-style-type: none"> Define the forbidden and the available materials (2) for the equipment. 	<ul style="list-style-type: none"> Create the new versions of the available equipment. 	<ul style="list-style-type: none"> Equipment managers.
Process Steps	<ul style="list-style-type: none"> Define the usage of equipment in the process step. 	<ul style="list-style-type: none"> The cleaning step by using the piranha bath. The baking step by using the hotplate. The exposure step by using the mask aligner. 	<ul style="list-style-type: none"> Validation of the materials and the equipment used in a process step. Define the required preceding steps and the forbidden proceeding steps. 	<ul style="list-style-type: none"> Update the version of the equipment used in a process step. Create the new versions of the available process steps. 	<ul style="list-style-type: none"> Equipment managers. Operators.
Process Blocks	<ul style="list-style-type: none"> Consist of a series of process steps to obtain a single development progress, e.g. a mask layer. 	<ul style="list-style-type: none"> The photolithography block to obtain the mask layer consists of several process steps : <ul style="list-style-type: none"> - the cleaning steps - the baking steps - the exposure step 	<ul style="list-style-type: none"> Validation of the relation among the process steps used in a process block. Define the required preceding blocks and the forbidden proceeding blocks. 	<ul style="list-style-type: none"> Update the version of the process steps used in a process block. Create the new versions of the available process blocks. 	<ul style="list-style-type: none"> Operators.
Process Flows	<ul style="list-style-type: none"> Consist of a series of process blocks to obtain a component, e.g. optical core SION. 	<ul style="list-style-type: none"> The Optical core SION flow is developed by several process blocks : <ul style="list-style-type: none"> - the deposit block - the photolithography block - the etching block - the measurement block 	<ul style="list-style-type: none"> Validation of the relation among the process blocks used in a process flow. Detail overview of the used processes. 	<ul style="list-style-type: none"> Update the version of the process blocks used in a process flow. Create the new versions of the available process flows. 	<ul style="list-style-type: none"> Designers.
Masks	<ul style="list-style-type: none"> Define the mask that is used by the process steps. 				

Notes :

(1) The equipment's categories and the equipment's parameters are defined in the Core DB.

(2) The materials, the material categories and the material's properties are defined in the Core DB.

Figure 2.1. The hierarchy of the process flow database.

The Development Of The Process Flow Database

The Re-usable And The Specifically Defined Process Steps

Although one would prefer to have the re-usable process steps, some steps may have to be specifically defined due to the specific purpose.

Below are the list of the available process steps to etch a wafer by using equipment RIE-Elektrotech Twin System PF340. Several etching gases for different purposes are available in this equipment. Thus, the process step to set the equipment parameters has to be specifically defined in accordance with the chosen etching gas.

ID	ProcessStep	Description	Equipment	Category	Version	Committed	BasedOn	MostRecent		
90	Etch, RIE, SF6, check/set/read parameters	Set temperature, pressure, gas flow rate, RF power	RIE-Elektrotech Twin System PF 340	Etching Equipment	1	0	90	90	New	Delete
81	Etch, RIE, low/rough vacuum mode	Load/unload the wafer, close the chamber.	RIE-Elektrotech Twin System PF 340	Etching Equipment	1	0	81	81	New	Delete
91	Etch, RIE, etching process	Start and finish the etching process	RIE-Elektrotech Twin System PF 340	Etching Equipment	1	0	91	91	New	Delete
80	Etch, RIE, venting	Open the chamber, load/unload wafer.	RIE-Elektrotech Twin System PF 340	Etching Equipment	1	0	80	80	New	Delete
92	Etch, RIE, minimize reflected RF power.	Should be between 3 until 6 watt.	RIE-Elektrotech Twin System PF 340	Etching Equipment	1	0	92	92	New	Delete

Figure 3.1. The etching process steps by using the RIE-Elektrotech Twin System PF340.

The Mathematical Expression

-- the communication among processes from different level of hierarchy --

The mathematical expressions interconnect the controls and the results from different levels of the hierarchy. The higher level controls can be used to specify the lower level controls. The results of the current level can be used to specify the consecutive controls, and also the results in the higher level.

This zoom dialog evaluates the expression you are building.

To save your result, please copy the "Checked Expression" into your original field and press update.

Expression

```
processflowresults[18].value/processblockcontrols[6][42].value
```

Current scope procflow=7,0,0
Result 0.166667
Checked expression processflowresults[18].value/processblockcontrols[6][42].value

Figure 3.2. The mathematical expression to define the etch rate as the etch depth (process flow result with ID 18) divided by the etching's duration time (process block control number 6 with ID 42).

4. The Process Validation In The Database

This section is dedicated to bring up the issue about process validation in FlowDB.

Phoenix Cleanroom Database Module : Process Flow Database			
Menu / Templates			
Validation			
Hierarchy	Material	Relation	Check (C)
Equipments	Define the forbidden and the available materials for the equipment.		
Process Steps	The forbidden and the available materials inherited from the equipment.	Define the required preceding steps and the forbidden proceeding steps.	
Process Blocks		Define the required preceding blocks and the forbidden proceeding blocks.	Check the relation among the process steps used in a process block.
Process Flows			<ul style="list-style-type: none"> - Check the relation among the process steps used in a process block. - Check the relation among the process blocks used in a process flow.

Note : (C) These tasks are automatically done by the software.

Figure 4.1. The menu/templates for process validation in Process Flow Database.

The Check Menu

This menu checks the materials used and the alignment of the process steps used in the process block. This action will be automatically done by the database only if the process validations at the equipment level and the process step level were defined.

Checking step dependencies

ID	Step	Name	Version	Message
91	4	Etch, RIE, etching process	1	is not preceeded correctly
92		Etch, RIE, minimize reflected RF power.	1	is a valid preceeder
92	5	Etch, RIE, minimize reflected RF power.	1	is not preceeded correctly
90		Etch, RIE, SF6, check/set/read parameters	1	is a valid preceeder

Figure 4.2. Warning messages when the process steps are aligned incorrectly, e.g. when the step "etching process" is set before the step "minimize reflected RF power".

The messages at figure 3.2 suggest that the step "minimize reflected RF power" should precede the step "etching process", and the step "check/set/read parameters" should precede the step "minimize reflected RF power". When the steps are alligned correctly, there will be no message.

5. The History

-- the quality improvement of the database --

The well-built equipment and processes are committed/saved hence they become a static part of the database; the committed versions cannot be edited or deleted anymore.

As the technology and the equipment evolve, the committed versions may however need some improvement in the future. The improvement is done by creating a new version of them, so that their contents, e.g. the variables and the expressions, can be adjusted.

The new version is assigned to evolve from the committed one, but it can also be created from the not-yet-committed version. This implies several committed and several not-yet-committed versions exist, and they are related to each other.

The database provides the service that tracks and keeps the history of the available versions, the evolution of each version, and the relation between each version of the processes and the equipment.

Phoenix Cleanroom Database Module : Process Flow Database				
Menu / Templates				
Quality Improvement				
Hierarchy	Commit	New	Versions ⁽¹⁾	Usage ⁽¹⁾
Equipments	Committed equipment cannot be modified/erased	Create the new version of the equipment.	<ul style="list-style-type: none"> - The available versions of an equipment. - The evolution / development history of each version of an equipment. 	The usage of a version of an equipment in the process steps & blocks & flows & batches.
Process Steps	Committed process steps cannot be modified/erased	Create the new version of the process step.	<ul style="list-style-type: none"> - The available versions of a process step. - The evolution / development history of each version of a process step. - The version of the equipment used in a process step. 	The usage of a version of a process step in the process blocks & flows & batches.
Process Blocks	Committed process blocks cannot be modified/erased	Create the new version of the process block.	<ul style="list-style-type: none"> - The available versions of a process block. - The evolution / development history of each version of a process block. - The version of the equipment & process steps used in a process block. 	The usage of a version of a process block in the process flows & batches.
Process Flows	Committed process flows cannot be modified/erased	Create the new version of the process flow.	<ul style="list-style-type: none"> - The available versions of a process flow. - The evolution / development history of each version of a process flow. - The version of the equipment & process steps & process blocks used in a process flow. 	The usage of a version of a process flow in the batches.
	Masks ⁽²⁾		Commit	Version
			Committed masks cannot be modified/erased	The version of the masks.

Notes : ⁽¹⁾ These tasks are automatically done by the software.
⁽²⁾ The mask's templates defines the masks that are used in the process steps.

Figure 5.1. The menu/templates for quality improvement in Process Flow Database.

6. Conclusion

The Process Flow Module in the Phoenix Clean Room Database is a tool to manage the documentation for the micro's and nano's cleanroom processes. It offers the flexibility but also the communication standardization to the various processes and technologies involved.

A properly managed database guarantees the accessibility of the available processes in the hierarchy. Also, most of the validation process will be able to be done automatically so that the confusion in process alignment and equipment contamination can be prevented. Finally, regular database update and maintenance will secure the continuous improvement of its quality.