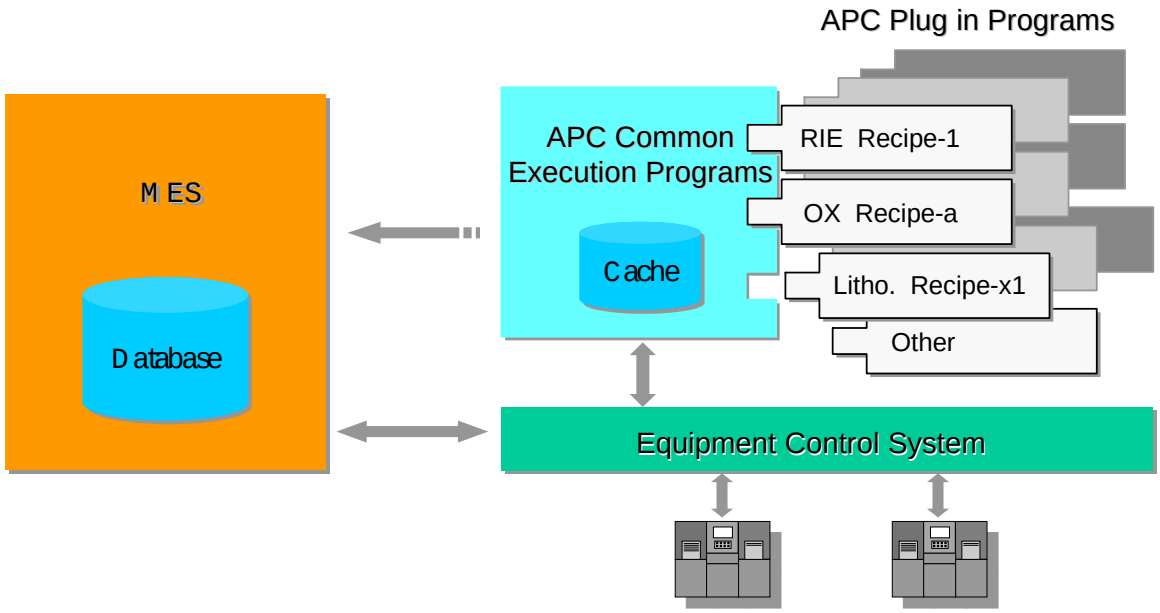
Use of APC in a Development Line

(APC in Toshiba)

Shoichi HARAKAWA

TOSHIBA Corp.

APC System



Control Pattern

- **Correction of process parameter uncertainty for individual equipment**
  - **–Feed Back Control**
- **Correction of process parameter uncertainty for an individual product**
  - **– Feed Forward Control**
- **Modification of a target for product specification**
  - **– Improvement of development line in adaptability**

Problems Specific to Development Line

- **Many kinds of layers**
- **Many kinds of Recipes**

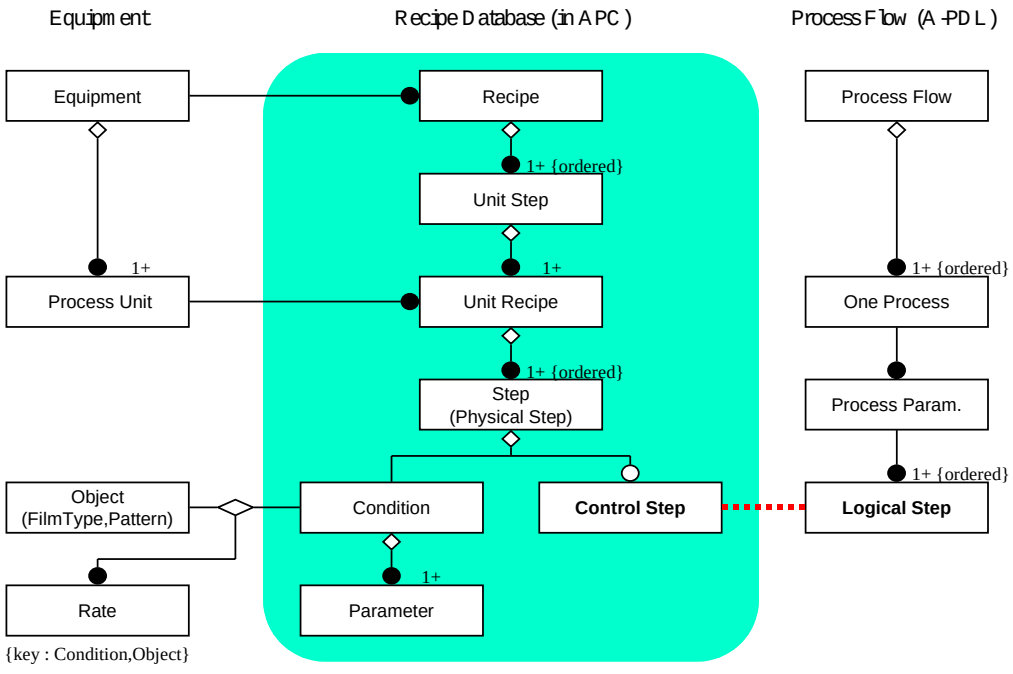
Model development is complicated for devices under development.

We have made development environment which raises flexibility of control models.

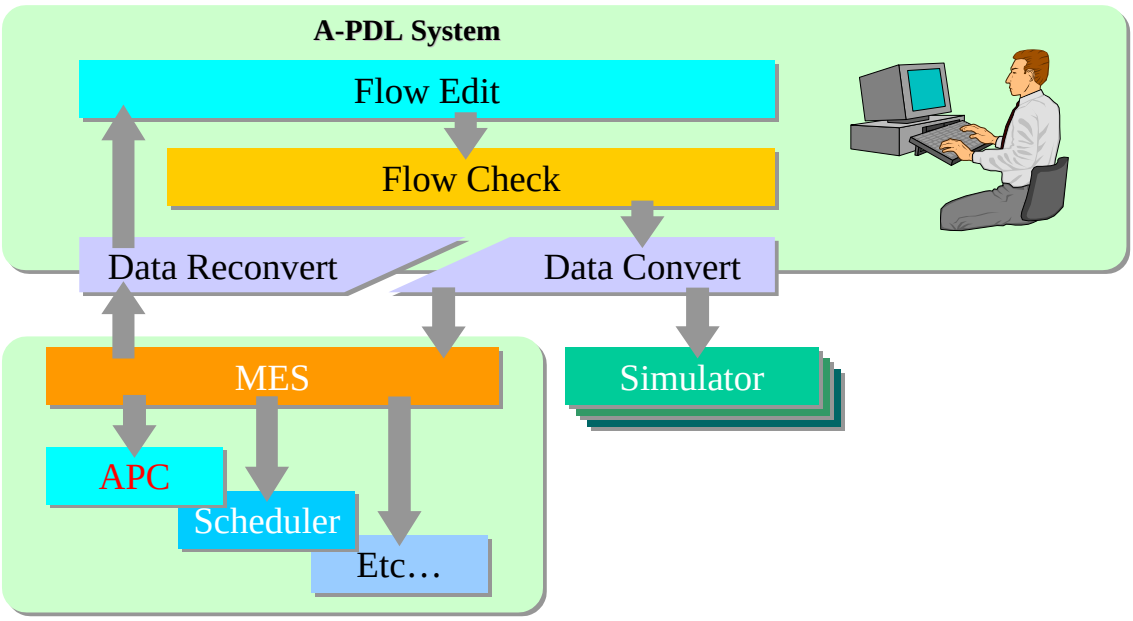
Making Environment for APC

- **It modeled relation between product specification and control step.**
- **Process Flow**
  - **Defines the parameter format of A-PDL system.**
- **Equipment Recipe**
  - **Build of recipe database in APC.**

Process Sequence Model



A-PDL System



Format Definition of A-PDL Flow Parameter

Clear description of a process step.

Deposition Process

2 Step Depositions

FILM=SIO2-SIN

THICK=300nm-200nm

Step	FILM	THICK
1	SIO2 (SiO_2)	300nm
2	SIN (Si_3N_4)	200nm

Etching Process

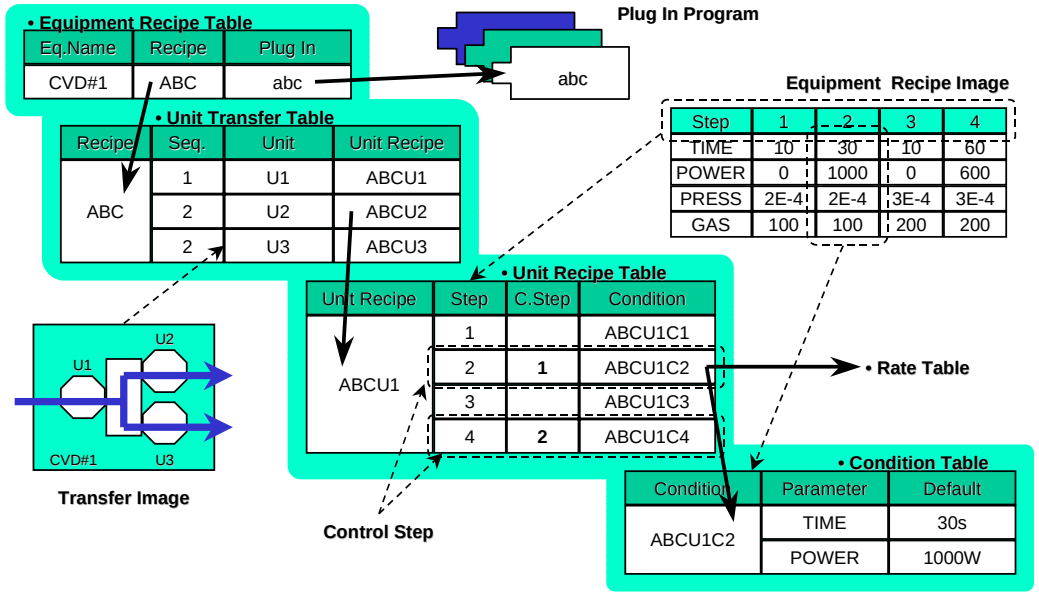
3 Step Etchings

STR=SIO2[300nm]+SIN[100nm]-POLY[200nm]-SIO2[100nm]

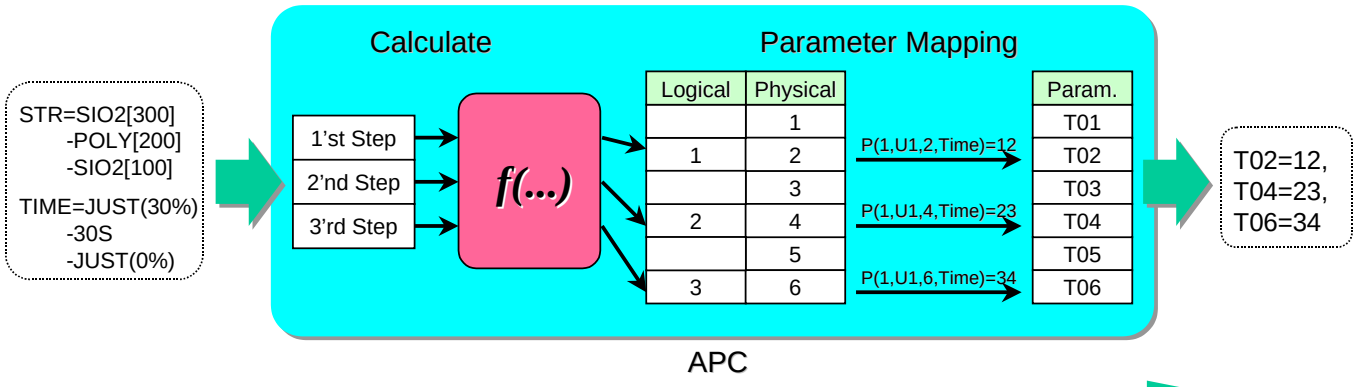
TIME=JUST(30%)-30S-JUST(0%)+10S

Step	STR	TIME
1	SIO2[300nm]+SIN[100nm]	JUST(30%)
2	POLY (Poly Si) [200nm]	30S
3	SIO2[100nm]	JUST(0%)+10S

Recipe Database Model



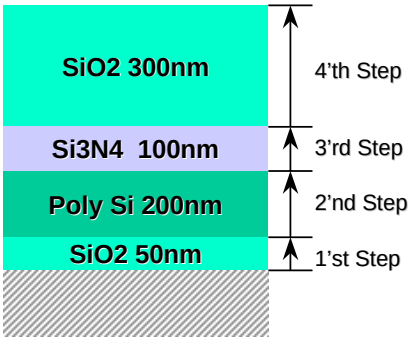
Flow of Processing



from Specification

to Equipment

Example of Deposition Process



A-PDL Parameter (Target Spec)

FILM=SIO2 - POLY - SIN - SIO2
THICK=50nm - 200nm - 100nm - 300nm
RECIPE=A1

Condition for Control Step (Recipe:A1)

Logical Step	1	2	3	4
Condition	Depo1	Depo2	Depo3	Depo4

Rate Table

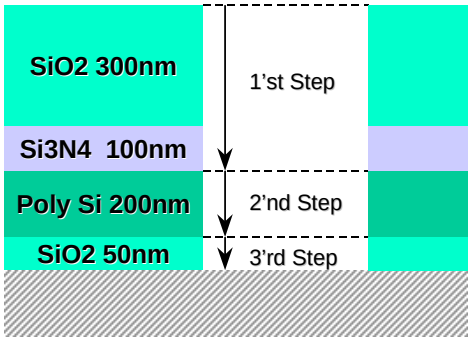
Condition	Depo1	Depo2	Depo3	Depo4
Rate(nm/min)	123.45	234.56	345.67	456.78

$$Time = \frac{Thickness(FilmType)}{DepoRate(Condition)}$$ **(Typical Formula)**

Example for Typical Calculation

Logical Step	1	2	3	4
TIME(sec)	50/123.45*60 =**24**	200/234.56*60 =**51**	100/345.67*60 =**17**	300/456.78*60 =**39**

Example of Etching Process



A-PDL Parameter (Target Spec)

STR=SIO2[300nm]+SIN[100nm] - POLY[200nm] - SIO2[50nm]
TIME=JUST(30%) - 50S - JUST(0%)+10S
RECIPE=B1

Condition for Control Step (Recipe:B1)

Logical Step	1	2	3
Condition	Etg1	Etg2	Etg3

Rate Table

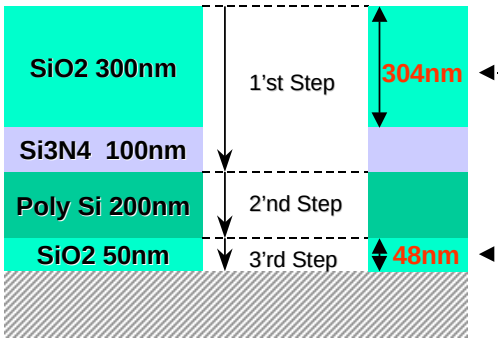
Condition	Etg1		Etg2	Etg3
Film Type	SIO2	SIN	POLY	SIO2
Rate(nm/min)	123.45	234.56	345.67	45.67

$$Time = \sum\left(\frac{Thickness(FilmType)}{EtchRate(FilmType, Condition)}\right)\cdot(1+Over(\%))+\sum AbsTime$$

Example for Typical Calculation

Logical Step	1	2	3
TIME(sec)	(300/123.45+100/234.56)*1.3*60 =**223**	Fixed Time =**50**	(50/45.67)*1.0*60+10 =**76**

Example of Application (Feed Forward Model)



Before Process (Metrology 1)

FILM=SIO2, SPEC=50nm(5nm)
PRCNAME=ABC

Before Process (Metrology 2)

FILM=SIO2, SPEC=300nm(30nm)
PRCNAME=DEF

Main Process (Etching)

STR=SIO2[DEF]+SIN[100nm] - POLY[200nm] - SIO2[ABC]
TIME=JUST(30%) - 50S - JUST(0%)+10S
RECIPE=B1

$$Time = \sum\left(\frac{Thickness(FilmType)}{EtchRate(FilmType, Condition)}\right)\cdot(1+Over(\%)) + \sum AbsTime$$

Example for Typical Calculation

Logic Step	1	2	3
TIME(sec)	(304/123.45+100/234.56)*1.3*60 =225	Fixed Time =50	(48/45.67)*1.0*60+10 =73

Example of Operator Console

Results

- **We expanded automatic calculation of a control parameter, without sacrificing flexibility of device development.**
  - **It has reduced the number of recipes by using general-purpose recipes.**
  - **It abolished fixed value specification of processing conditions.**
- **Customize of a model is unnecessary.**
  - **Development load and maintenance load of a model have been reduced.**

Problems

- **Product Specification**
  - **Is it possible to describe the parameter which contains a control model in product specification?**
- **Equipment Recipe Model**
  - **The structures of a recipe differ for every equipment maker and model.**
- **Others**
  - **At the process which needs the parameters (rate etc.) depending on a pattern, the parameter with consideration to all patterns cannot be offered.**

Examination Items

- **Further format should be standardized.**
- **General-purpose rate model**
- **Service to scheduler**
- **Correspondence to control by wafer**
  - **Correspondence with EES (EEC) models.**