Proceedings of the 17th World Congress
The International Federation of Automatic Control
Seoul, Korea, July 6-11, 2008

Cluster Tool for control of Semiconductor and FPD equipment

y.m.choi*, h.j.kim, i.s.jeon**, j.aiga*****

**Kornic Systems Corporation , Seoul, Korea*
(Tel:+82-43-261-4895; e-mail: ymchoi@kornic.co.kr).
***Kornic Systems Corporation, Seoul, Korea*
(e-mail:hjkim@kornic.co.kr)
***Kornic Systems Corporation, Seoul, Korea*
(e-mail:jsjeon@kornic.co.kr)
**** Kornic Systems Corporation, Seoul, Korea*
(e-mail:jaiga@kornic.co.kr)

Abstract: The manufacturers of the semiconductor and the FPD equipment attempt to lineup various equipments to increase the productivity. The manufacturers of the elements also expand their automatic systems for the visual controlling software and collection of the various data to increase the productivity. However, most manufacturers of equipments confront with the limit in following the controlling software technology for this requirement. Therefore, the companies are searching for the solutions already verified and optimized as the measure of improving the competitiveness through the various control of the equipments and shortening of the development lead time. This paper introduces the Easycluster as an alternative which is the Cluster Tool SW for equipment control already verified through the application in a line for mass production.

1. INTRODUCTION

There are a number of companies all over the world which produce the semiconductor and FPD equipment. Most companies lined up the control software using the restrictive programs such as PLC or DOS just a decade ago. For this reason, there were many restrictions on the collection of the data or the display of the status information and these restrictions have been more problematic according to the enlargement of the equipment from 200mm to 300mm. In addition, the conventional method has not been able to meet the increasing expansion of the host role. Therefore, big companies have met the requirements from the production line with operating an independent control team, but otherwise companies have come to search for the commercial solutions. The ratio of the companies which possess their own control solution in whole companies manufacturing the equipments is only under 30%. The remaining companies are propelling by the OEM not the individual development since they are in poor condition technologically and economically. Though there was, of course, a commercial solution for equipment control a decade ago as well, it has been kept in dead storage not meeting the requirements according to the enlargement of the equipment above mentioned. But, with the computer performance and the technology of the software being better and more companies coming to search for the commercial solution, many companies are being newly established again and the competition among them is being fiercer than before. And, only the good result of the production process was all that required before, but currently, the productivity including throughput, data collection, visual display, and automated host as well as the result of the production process are necessarily required to supply the equipments. That is, the control software has come to be more crucial than ever before. In fact, many manufacturers of the equipments are now increasing the number of backbones, loadlocks and robot arms to improve the throughput. Therefore, the shortening of the development term is required because the various scheduling and rapid development are needed to improve the competitiveness. And also, the factory automation based on only host and SECS was required before, but currently the factory automation based on EDA, APC, SPC and further SOAP like e-Diagnostic is required.

This paper considers above requirements and introduces the structure and the application cases of Easycluster which verified through the line for mass production with the semiconductor and FPD equipment applied with the control software.

2. EASYCLUSTER STRUCTURE

2.1 Design Object

Easycluster is software developed to control the semiconductor and FPD equipment. Thus, it was designed focusing on stability, convenience, and user development.

2.1.1 Stability

Easycluster was designed so as to minimize the troubles on the whole process, though some troubles are occurred on the specific module or function with applying the distributed control method to ensure the stability of the equipments. And also, under the distributed control method, it is possible to revise only the troubled function or GUI and reload it without

shutdown of whole program and therefore, the maintenance of the system is easy.

2.1.2 Convenience

The intuitive display enables the user to operate and to check up the status information more easily. In addition, it provides the utilities such as a plotter and a history log to enable the users to trace the status values of equipment, the result of a process, and a trouble more easily.

2.1.3 Development

It reflected the concept of developers sufficiently through the intuitive message flow and the open architecture interface to make the developers understand easily and enabled the users to make GUI easily through the script file. And also, it provides many libraries for the convenience of developers, and focused on the shortening of the development period with making the component already developed to be reused easily.

2.2 Products

Easycluster is largely divided into two groups of the product, one is for equipment control and the other is for host control. The equipment control consists of RCS, CTC, TMC, and PMC, while the host control consists of GEM, EES, and EDA. The system composition using the Easycluster in the line for mass production is shown in the below Fig. 1.

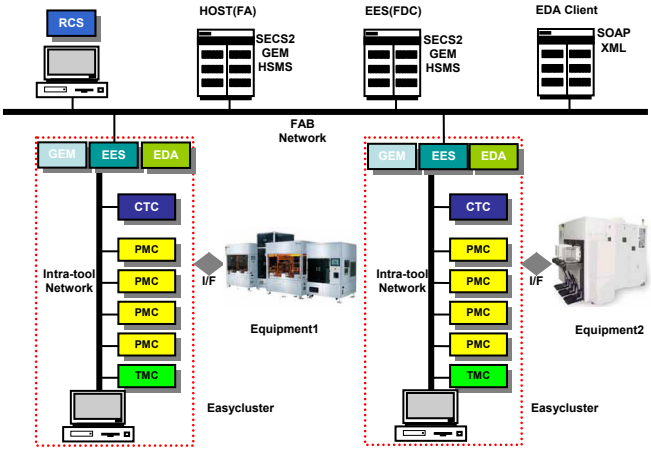

Fig. 1. System Composition

2.2.1 RCS(Remote Control Service)

This enables a user in a remote place to check up the same status information as displayed on the terminal of the equipments group and to control the equipments out of the factory. Therefore, it can reduce the loss of the man power and time. RCS can be configured as single RCS and multiple RCS. The maximum 5 equipments can be linked to the only one remote workstation for RCS in the single RCS system and the maximum 5 equipments for each workstation for RCS can be linked to the maximum 5 remote workstation for RCS in the multiple RCS system. Therefore, in the multiple RCS system, the user is able to monitor the equipments at different offices but to control the equipments at the only one place designated at the specific point of time.

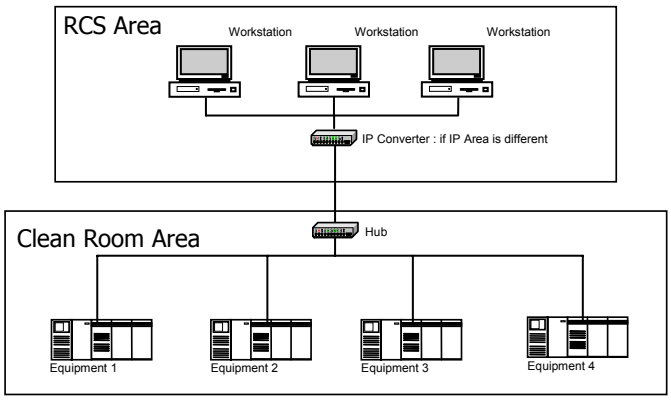

Fig. 2. Multiple RCS System Configuration

2.2.2 CTC(Cluster Tool Controller)

This enables a user to make a schedule so that the process for a substrate can be progressed through the optimized path according to the recipe designated by the user. The CTC carries out the message flow according to the TMC/PMC and a certain scenario of rules. Recently many companies line up the equipments of various concepts to improve the throughput. And also, the shortening of the development term is the most important of all things to improve the competitiveness. The Easycluser CTC has the various algorithms to meet these requirements and supports the user-defined option for optimized scheduling suitable for the characteristics of equipments. The key functions supported by the Easycluster CTC are as following;

- Maximum up to 64 PM
- Maximum up to 5TM
- Multi Finger Support(Single/Multi/Batch)
- Flexible LoadLock Scenario(Batch/Slots/InOut)
- Active and Passive Robot Transfer Support
- Serial and Parallel Chamber Process Support
- Layer Recipe Structure(Lot/Cluster/Process)
- Different Products Interface Support
  (Easycluster CTC <-> Other TMC/PMC)

2.2.3 TMC(Transfer Module Controller)

This is a module that controls the hardware relating to the transfer among equipments. The TMC hardware includes LoadPort, EFEM, Robot, Aligner, Cooler, LoadLock, and Backborn.

2.2.4 PMC(Process Module Controller)

This is a module that controls the hardware in a chamber to carry out a substrate process. The inner structure of the software of TMC/PMC consists of following five modules.

- IO Manager
- Sequence Manager
- Alarm Manager
- GUI Manager

- Remote Interface Module

The IO manager manages setpoint interlock and drivers. The status information or control of a device is managed by declaring the IO channel, and this IO channel communicates with the device through a driver. The IO Channel is able to define the specific events before transmission to a driver and it is not transmitted to a driver when these events are occurred. These events are called the Setpoint Interlock.

The sequence manager manages the sequence developed by a developer. This sequence can be requested to run by GUI or CTC Interface. The sequence has its own level and the lower level sequence is not able to request the upper level sequence to be carried out.

The alarm manager manages the alarm registered in a group of equipments. The alarm registration is declared with a script file and the interlock or the sequence is able to request it to be occurred.

The GUI manager manages the script file which includes the navigation of display and the information to be displayed in each display.

The remote interface module is a path between the CTC and TMC/PMC and conveys the order or information from the CTC to the TMC/PMC.

Fig. 3. shows the SW Structure of the TMC/PMC and Fig. 4. shows the interface structure between the CTC and the TMC/PMC.

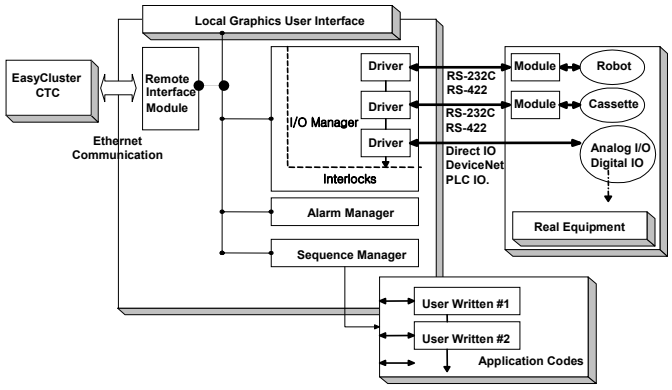

Fig. 3. TMC/PMC Software Architecture

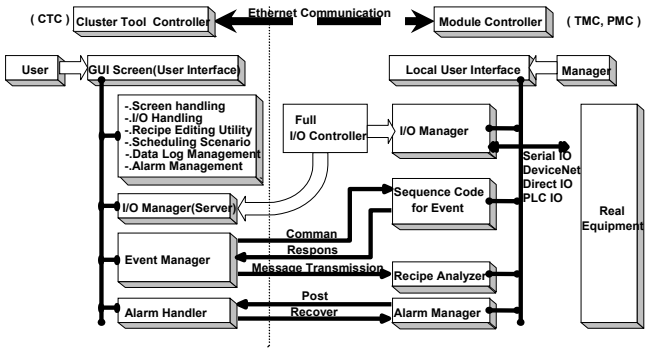

Fig. 4. CTC & TMC/PMC Interface Architecture

2.2.5 GEM(Generic Equipment Model)

This is software for automation to carry out the function of the status information and control between the host and the equipments. As a communication mode, it supports the SECS2 protocol and HSMS. As the equipments have come to be enlarged from 200mm to 300mm, the role of the human being is more reduced and the role of the host is more important. Moreover, the host monitors the great parts of equipment and makes a database to improve the productivity. The factory is suggesting many new specifications to minimize the loss through the forecasting and maintaining the result of process. Therefore, the result of process seemed to be important before, but currently the manufacturers might not sell equipment unless they meet the specifications for a host. The Easycluster GEM has been completed the CCS-Envoy Test and supports all specifications for 300mm. In addition, it provides the user option which is developed through an abundance of experience in setting up hosts of factories so that it can manage any equipment installed in any factory immediately. The following are the SEMI Standard basically supported by GEM.

- E5 : SECS2 Protocol Message(SECS2)
- E30 : Generic Equipment Model(GEM)
- E37 : HSMS Generic Service(HSMS)
- E39 : Object Service Standard(OSS)
- E40 : Process Job Management(PJM)
- E84 : Carrier Handoff Parallel IO Interface(PIO)
- E87 : Carrier Management Service(CMS)
- E90 : Substrate Tracking Service(STS)
- E94 : Control Job Management(CJM)
- E99 : Carrier ID Reader/Writer Standard
- E116 : Equipment Performance Tracking(EPT)

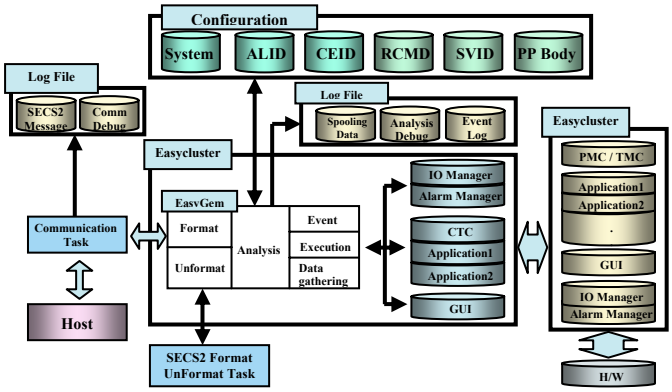

Fig. 5. GEM Software Architecture

2.2.6 EES(Equipment Engineering Service)

The purpose of this service is to collect the status information of equipment. Since the more and more data should be collected as the equipment come to be enlarged, using the only existing host can cause severe work load. So, the existing host is used to control equipment and the collection of data is carried out by the EES. The data include the recipe, the alarm, the event, and the FDC. The EES communication also uses the SECS2 Protocol and HSMS.

2.2.7 EDA(Equipment Data Acquisition)

The function of the EDA is same as the EES. That is, it also collects the status information of equipment. But it use the SOAP/XML as communication method. Generally, the factory uses the method of communication between a host and equipment as one to one. However, the EES is able to connect to and collect data from many clients simultaneously. The data include the exception, the event, and the trace. The SEMI Standard of the EDA is as following;

- E120 : Common Equipment Model(CEM)
- E125 : Equipment Self Description(EqSD)
- E132 : Equipment Client Authentication and Authorization
- E134 : Data Collection Management(DCP)

2.3 Main Function

Fig. 6. shows the equipment program architecture using the Easycluster. The gray-coloured parts which indicate the engine areas provided by Kornic are inaccessible, and the parts in the box outlined with a bold line are open to users so as to use the program provided by Kornic or the program developed by themselves at their discretion. The other parts are areas to be defined by users. The key functions basically used in developing programs are as following;

- GUI Management
- Recipe Management
- Plotting Management
- Alarm Management
- User Access Management
- Interlock Management

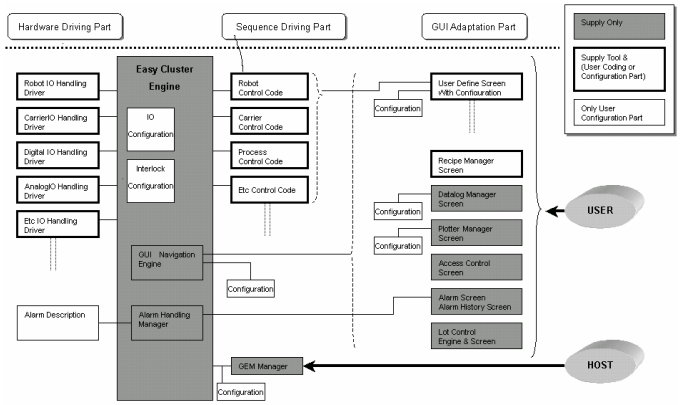

Fig. 6. Equipment Program Architecture

2.3.1 GUI Management

The each display of GUI has their respective GDF(Graphic Definition File). Users can define the display information in this GDF. Since the defined Items are the Object Oriented Component, users are able to drag it with a mouse on the GUI and it might be invisible or disabled according to the condition set to each item. In addition, users are able to define backgrounds and Images as well as Font/Palette/Text. Particularly, since users are able to reload just the GUI not the whole program when they revised the GUI, the maintenance of the GUI is convenient.

2.3.2 Recipe Management

The Recipe consists of 3 layers of Lot, Cluster, and Process.

Lot Recipe : determine the join of the Substrate in a process
Cluster Recipe: determine the PM path of the Substrate
Process Recipe: determine the process value of the Substrate

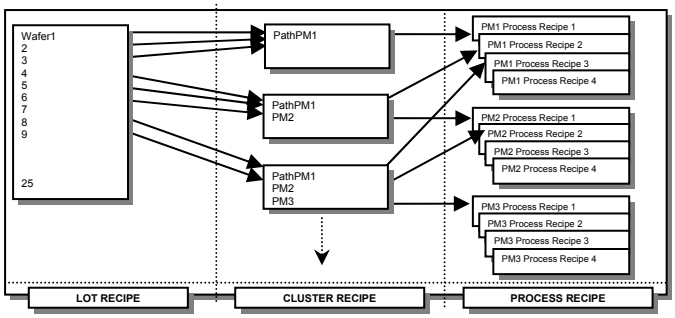

Fig. 7. Dynamic Recipe Level Structure

2.3.3 Plotting Management

This manages display and logging of IO values assigned in the equipment. Plotting Display IO and Logging IO are selected separately by a user. The minimum Logging Interval Time is 0.5 second and the maximum number of the Logging IO is 128. And, the maximum eight IO values can be displayed with Plotting Display.

2.3.4 Alarm Management

This manages the alarm information defined in alarm script file of a program and logs the alarm history. The user can check the logged alarm history with a viewer which has various searching condition such as time and module. When the alarm is occurred, the recovery type and the alarm message declared in the script file are displayed on the alarm GUI. The recovery types include the Retry, the Abort, the Ignore, and the Clear and a user can select the any recovery type among them.

2.3.5 User Access Management

This defines and manages group, ID, password for users login. The group level can be defined up to 9 levels and the users defined as level 9 are modify the user access information on the GUI. And also, the access to the system and control authority can be limited according to the level.

2.3.6 Interlock Management

The Interlock is divided into the Setpoint Interlock and the Value Interlock and is defined in each script file. The Setpoint Interlock locks off the control when the specific condition is satisfied and the Value Interlock monitors the condition declared in the script file at a interval of about 100msec. When the condition is satisfied, the declared action would be carried out.

2.3 System Requirement

The minimum system requirement for the Easycluster is as shown in Table. 1. When the CTC and the TMC/PMC PC is located apart, a LAN Card is needed. For development tool, the Microsoft Visual C/C++ 6.0 is used.

Table 1. PC Requirement

CPU	Pentium4	Graphic	16M
OS	WinNT/2000/XP	HDD	500M
Memory	128M	Language	Kor/Jap/Eng

2.4 Building Samples

2.4.1 Standard Building

This is the typical method that the controller is configured for each module separately. While the maintenance of the specific module is carried out, the process can be progressed with other modules and therefore the productivity is high because both the software and the hardware are separated.

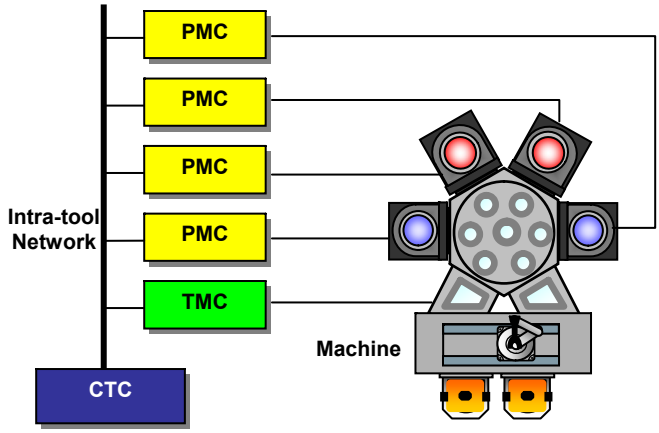

Fig. 8. Standard Building Sample

2.4.2 Economical Building

When the TM/PM is compact, there is no need of consuming the cost and space with many computers. Since this method combines several modules in only 1 computer in this case, it can improve economical effect.

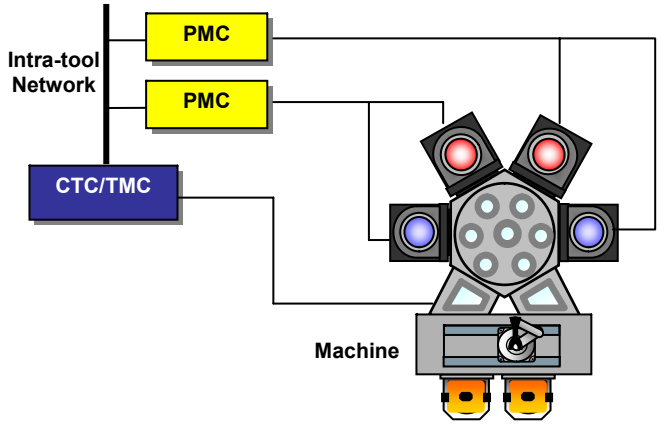

Fig. 9. Economical Building Sample

2.4.3 Standalone Building

This method can be used when only the PM exists without the TM or when it is possible to combine all modules in one computer due to the small scale of them though the both TM and PM exist.

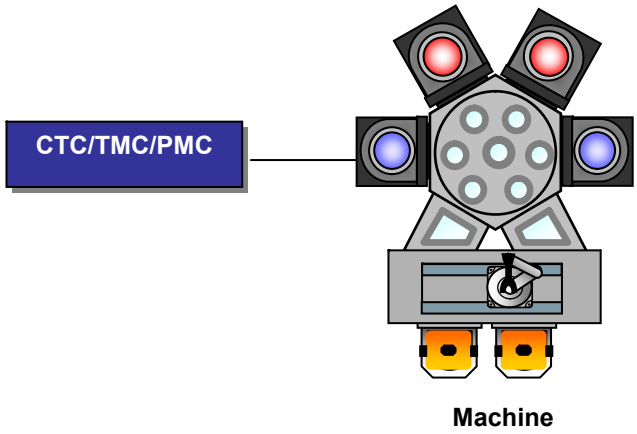

Fig. 10. Standalone Building Sample

3. SUPPLIED SAMPLES

3.1 Application Samples

This chapter introduces the cases which apply the Easycluster to development of equipment control program. The Easycluster has been applied to RTP, CVD, PVD, Etcher, Asher, Track, and CMP of equipment for whole process of semiconductor production and to LCD-Etcher, ODF of FPD equipment so far. Currently, a number of companies from Canada, Germany, Japan, Taiwan, and China as well as Korea are using the Easycluster in developing the equipment control programs.

Fig. 11 shows the case which applied to a track system with the multiple TM system. The robot on the final phase transmits the substrates to the Exposer connected with this equipment and progresses following process after the completion of the process of the Exposer.

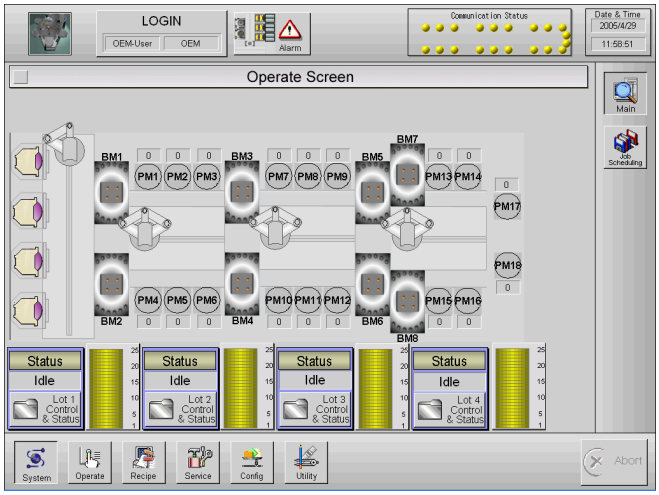

Fig. 11. Multiple TM System

Fig. 12 shows the case which applied to both Asher and CVD simultaneously with the double PM system. The TM Robot with 2 Finger carries out the supply and taking out of the substrate simultaneously.

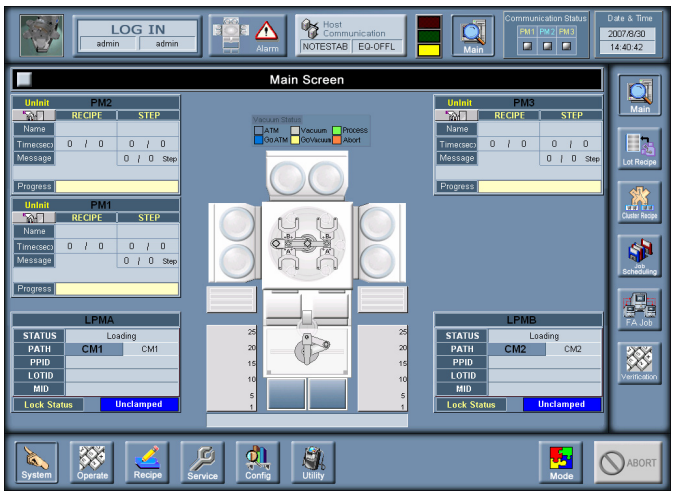

Fig. 12. Double PM System

Fig. 13 shows the case which applied to Furnace with the batch system. The number of Stocker Module is 16, the fingers of Substrate Transfer Robot are 5, and the Boat has 117slot.

Fig. 13. Batch System

Fig. 14. Double TM System

Fig. 14 shows the case which applied to CVD with the double TM system. This system has advantage in that though the one TM has some problems, the process can be progressed. The dummy in a buffer carries out the pre/post process for the lot or the substrate according to various conditions such as PM Process Count and Thickness.

3.2 Installed End User

Many domestic and foreign companies manufacture equipment with the Easycluster and supply it to end users so far. The end users supplied the equipment with the Easycluster include the cases of usage by themselves, laboratories or small-scale manufacturers of elements, and large-scale lines for mass production. Table 2 shows the end users of lines for mass production supplied the equipment with the Easycluster.

Table 2. Easycluster End User

Country	End User
Korea	Samsung, Hynix, DongBu
Japan	Epson, Rohm, Matsushita, Denso
Taiwan	Promos, Inotera, UMC, Nanya, PSC, Winbond, TSMC
China	Hynix Wuxi
U.S	Hynix US, Sematech, IBM
Singapore	Charded
Germany	Qimonda, AMD

4. FUTURE PRODUCTS

The shortening of the development term means right the competitiveness. Therefore, many companies want to complete the development more quickly and easily. And also, the software development tool has been more advanced and the .Net in which the languages are integrated comes into the spotlight now. To meet this requirement, we are planning to add the functions such as the EasyMHI, the .Net Interface, and the Project Builder. EasyMHI will support a user to develop the GUI more easily. Currently, for making GUI, a user has to create images and to declare the location and the function of the images in the GDF. However, EasyMHI will enable a user to create images in the tool and to create the GDF automatically through the declaring of the property for existing images. The .Net Interface will provide the interface for developing the Easycluster in the .Net Tool. The Project Builder will create basic programs automatically according to the user's choice on equipment types, hardware components and options.