UDC 628.511:697.94:621.382

ALL-ROUND PLANT ENGINEERINGS IN THE CLEAN ROOM FOR SEMICONDUCTOR AUTOMATIC MANUFACTURING LINES

Kazuo Shimazu

1 INTRODUCTION

In the semi-conductor industries, advancement of manufacturing equipment is remarkable, and automations of the manufacturing equipment have been rapidly proceeded because the increased diameter of wafer, pattern density and integration capacity have caused manual handlings to be difficult.

In response to the automation of manufacturing equipment, and in response to the advanced manufacturing process and process technique, idea of cleam rooms (hereinafter abbreviated to CR) and system are changing, requirements to the utility are becoming severer, and the total engineering which organically joins the manufacturing equipment, CR and utility has been unavoidably required.

Fuji Electric has experiences of total engineering of CR in the semiconductor field. Based on the experiences, this paper outlines trends of automations of manufacturing equipment, CRs and manufacturing equipment utilities.

2 TREND OF MANUFACTURING EQUIPMENT AUTOMATION IN SEMICONDUCTOR INDUSTRIES

A number of young women workers were employed in the semiconductor industries and manual operations were conducted up to about 15 years ago. In or about 1974, full automatic wire bonder was adapted in the semiconductor assembly process which needed man hands mostly, accomplishing a great labor saving, and the center of the present equipment rationalization has moved from the assembly process to wafer process. This is a result of the advanced semiconductor process technique, and typical examples are (1) Increased wafer diameter, (2) Finer pattern, (3) Shallower joint, and (4) Multiple layers. (*Table 1*) In response to the developments of these new process technologies, developments of semiconductor manufacturing equipment are also remarkable, and individual manufacturing equipment and machines have been automated.

On the other hand, in the side of semiconductor manufacturing enterprise, manpower saving, improvement of yielding point, improvement of quality, reduction of inventory assets, etc. are becoming a large target for the purpose of reduction of semiconductor manufacturing cost and improvement of profit rate. And as a method to accomplish these targets, employment of machine and automation are becoming important theme of product developments and strategy of the enterprise. (*Table 2*)

Now, when the wafer process which needs the auto-

Table 1 Trend of a wafer fabrication development

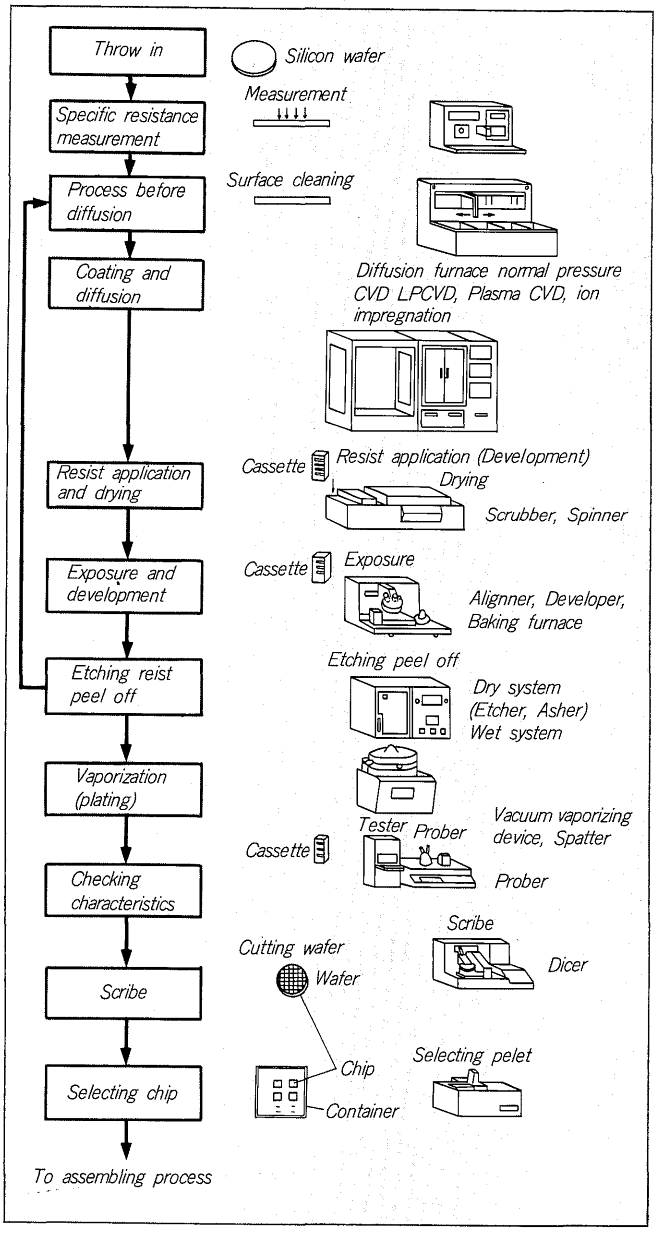
Process development target	Problem point	Countermeasure
Enlargement of water bore	· Increased size of equipment · Handling difficulty · Evenness and perfectness of material	· Process automation · Low temperature process (fault suppression) · Development of new system, device and process
Finer pattern	· Limit of optical technique · Control of pattern shape (Transferring accuracy)	· Projection exposure, reduced projection exposure · Dry process (development, etching, resist elimination) · Highly sensible resist material · Mask manufacturing by electron beam
Shallower joint	· Limit of diffusion · Redistribution of impurity · Relationship with electrode formation (reliability) · Control of fault	· Application of ion driving technique · As diffusion · Low temperature process · New electrode construction
Multi-layer	· Flatness of the surface · Reaction of metal against insulation film · Current capacity · Contamination and damage	· Flatening by LOCOS · Glass flow and resin coating · New passivation technique · New wiring material

Table 2 Wafer fabrication process and needs for automatic fabrication

Process \ Need	Labor saving	Yielding	Product quality	Process length
Crystal process	○	○	◎	△
Wafer process	○	◎	◎	◎
Assembling process	◎	○	◎	◎
Testing process	◎	○	○	△

(NOTE) ◎ Strong ○ Ordinary △ Weak

Fig. 1 Wafer fabrication process



mation mostly is developed and this process is combined with semiconductor manufacturing equipment, it appears as shown in *Fig. 1*.

Trends of these semiconductor manufacturing equipment are;

(1) From individual automation to in-line
(2) From contact type mask aligner to Contact proximity to Mirror projection to Reduction exposure equipment to Electron beam illustrating equipment
(3) Diffusion furnace to Ion impregnator (Medium to Pre-deposited type)
(4) Normal pressure CVD to Low pressure CVD, Plasma CVD
(5) Vacuum vaporization to Spattering
(6) Wet etching to Dry etching (Reactive ion etching) to Ion beam etching

These changes are because of the higher integration of semiconductor, finer pattern and other needs such as improvement of film quality.

Table 3 shows the present trend of automations of semiconductor manufacturing equipment. As the next step, automation of wafer carriage from one automated equipment to another is considered.

3 AUTOMATION OF LINE AND TREND OF CR

The fundamental form of CRs is shown in *Fig. 2*. Out of various forms, No. 2, 3 and 4 CRs have been used in the semiconductor industries.

Conventionally, a clean booth or clean bench was installed in a conventional type CR (Class 1,000 to 10,000, No. 2 or 3 CR in the *Fig. 2*) by each semiconductor manufacturing equipment. However, because of the higher integration of semiconductors, improvement of yielding point and improvement of quality, level of cleanliness of CRs was increased, and in many cases, a clean bench has been installed in a down flow type CR (Class 100, No. 4 CR in the *Fig. 2*) by each equipment.

On the other hand, level of integration per chip has been increased in the ratio of a double per year, and in 1980 and thereafter, it is estimated that the increase ratio will be a double per every two years. Further, in response to the increased integration level, the minimum treating line width is becoming finer. This pattern size change is due to the advancement of the process technologies and improvement of aligner performance, and such a need as further finer pattern drawing is causing the system to change from optical type to electron beam pattern drawing type.

In response to these higher density and finer pattern size, requirement of cleanliness of CRs for semiconductors is rising, size of the objective particles is reducing, 0.1 μm particle size is becoming to be a problem for 1 μm pattern size, and HEPA filters which eliminate 0.1 μm particle has already been developed.

In addition, requirements for temperature and humidity fluctuation widths are also becoming severer, and to maintain cleanliness, and temperature and humidity fluctuation widths within a constant level, power consumptions required for the air conditioning are becoming extremely great.

The system in which clean benches or clean booths are spread within a conventional CR has such an advantage as that the layout can be changed comparatively freely. On the other hand, however, even unnecessary space is air-conditioned. Further, aisles are made in everywhere within the CR and dust is likely to be generated. In addition, in many cases, air flow within the CR was considered separately from the clean bench, air flow is not diffused because blow out port of the CR is located near the clean bench intake port, causing the cleanliness to reduce, and the equipment or clean bench often closes the intake port on the floor.

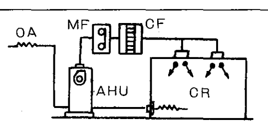
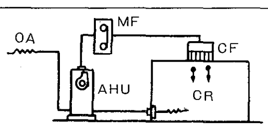
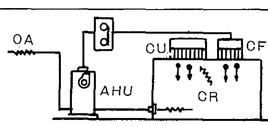
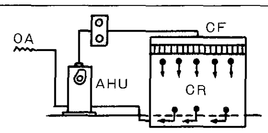
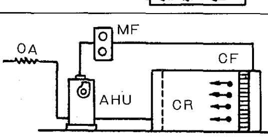
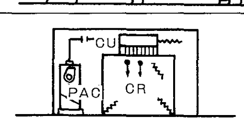
On the other hand, automation of manufacturing equip-

Table 3 Existing state of manufacturing equipment automation (wafer process)

Name of process	Name of equipment	Level of automation			Batch or one sheet process	Problem points
		Cassette-Cassette type	Process	Process monitoring		
Oxidizing heat process	Electric furnace	△	○	○	Batch	Replacement of wafer into quartz board
Thin film formation	Low pressure CVD	△	○	○	Batch	Replacement into quartz board
	Normal pressure CVD	○	○	○	Batch	
	Plasma CVD	○	○	○	Batch	
	Spattering	○	○	○	Batch	
	Vaporization	△	○	○	Batch	Wafer load/unload system
Introduction of impurity	Medium current	○	○	○	One sheet process	
	High current	△	○	○	Batch	Wafer load/unload system
Dry process	Etching	○	○(△)	○	Batch/ one sheet process	End point judgement
	Asher	△	○	○	Batch	Replacement of wafer into quartz board
Wet process	Etching	○	○(△)	○	Batch/ one sheet process	End point judgement Chemical supply
	Washing	○	○	○	Batch	Chemical supply
	Acid process	○	○	○	Batch	Chemical supply
Lithography	Resist application and and development	○	○	○	One sheet process	
	Light exposure	○	○	○	One sheet process	
	EB exposure	△	○	○	One sheet process	

(NOTE) ○: Automation accomplished △: Technically possible

Fig. 2 Standard form of clean room

No.	Standard form	Practical cleanliness	Features and usage point
1		Class 100,000	· Effective depending on how to use it. · Room itself can be constructed easily. · Care should be exercised on the duct between CF and CR · Entrance control is the point.
2		Class 1,000~ 100,000	· Standard CR · Entrance control is important for maintaining cleaness
3		Class 1,000~ 10,000	· Clean booth or clean bench is used with the standard CR · Range of class 100 can be made as required.
4		Class 100	· Cleanliness is always constant toward the entire range at the upper stream of the dust generating source · Entrnace control is comparatively easy.
5		Class 100~ 10,000	· Cleanliness is always constant toward the entire range at the upper stream of the dust generating source. · Cleanliness change is remarkable in between the upper and lower streams.
6		Class 10,000~ 100,000	· Installed in an ordinary air-conditioned room · CR of prehabricated type · When heat generation is large in the CR, air conditioners must be added.

NOTE) CR: Clean room, AHU: Air conditioner, MF: Intermediate filter,
CF: Final filter (HEPA filter), CU: Clean unit, PAC: Package type air conditioner.

ment and in-line system caused the dispersed individual layout to change to a line layout for the manufacturing convenience, and energy saving of CR has become an important theme. Thus, such a system as that fluctuation widths of high cleanliness, temperature and humidity are reduced for only the minimum required space has been used.

Consequently, because of these requirements, it is

Fig. 3 Annual transition of number of elements per chip and future forecast

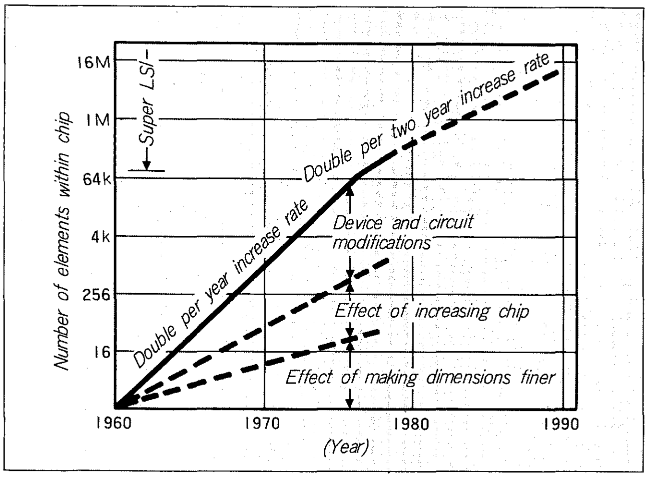


Fig. 4 Transition of integrated density and minimum pattern size

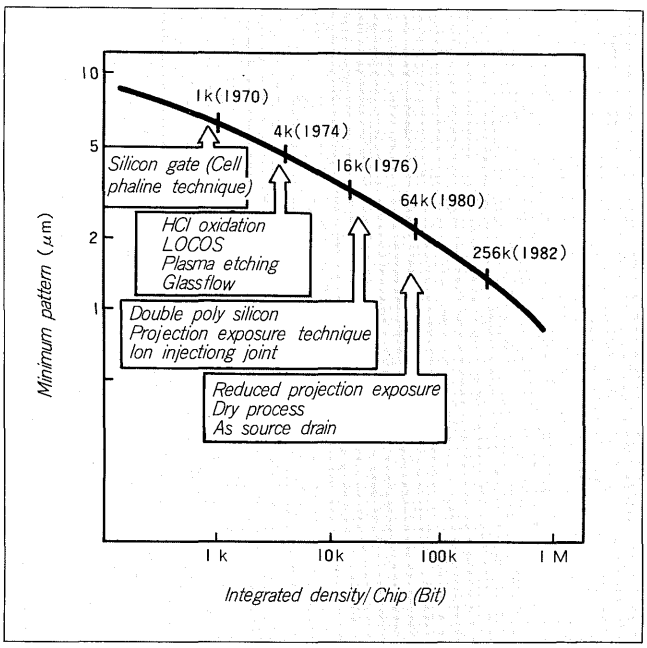


Fig. 5 Transition of semiconductor integrated circuit technique

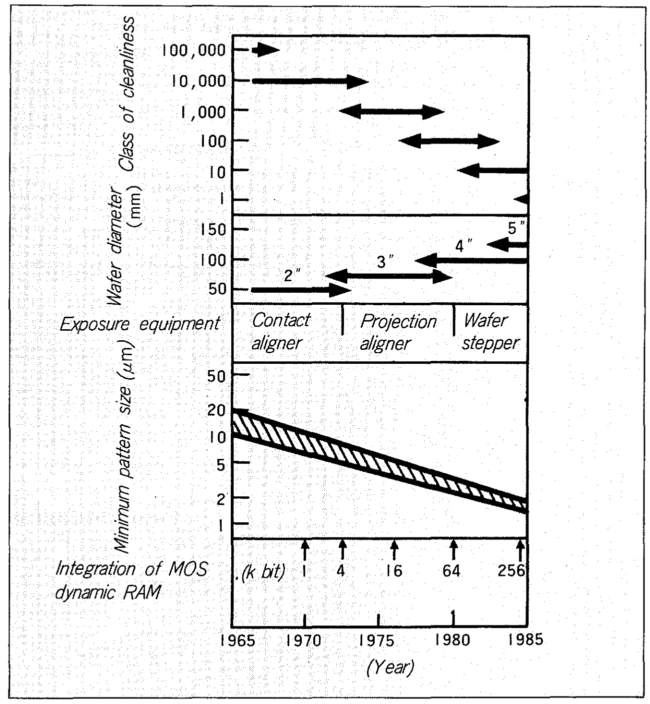


Table 4 Comparison of air conditioning energy

Class	Temperature (°C)	Humidity (%)	Power consumption (kW/m²)
100,000	24±3	50±10	0.1~0.2
10,000	24±2	45±10	0.3~0.6
1,000	22±1	40±5	0.8~1.2
100	22±0.1	40±1.5	1.2~1.8

important to combine a CR with a clean booth or manufacturing equipment to be a system. This system is called "Clean Tunnel type CR" and this system will be the main stream of CR for manufacturing semiconductors.

For this system, there are (1) bay system, (2) aisle system and (3) star system, and the bay system is becoming the main stream in VLSI factories.

In this system, the utilities such as gas, coolant water,

Fig. 6 Various systems of clean tunnel type clean room

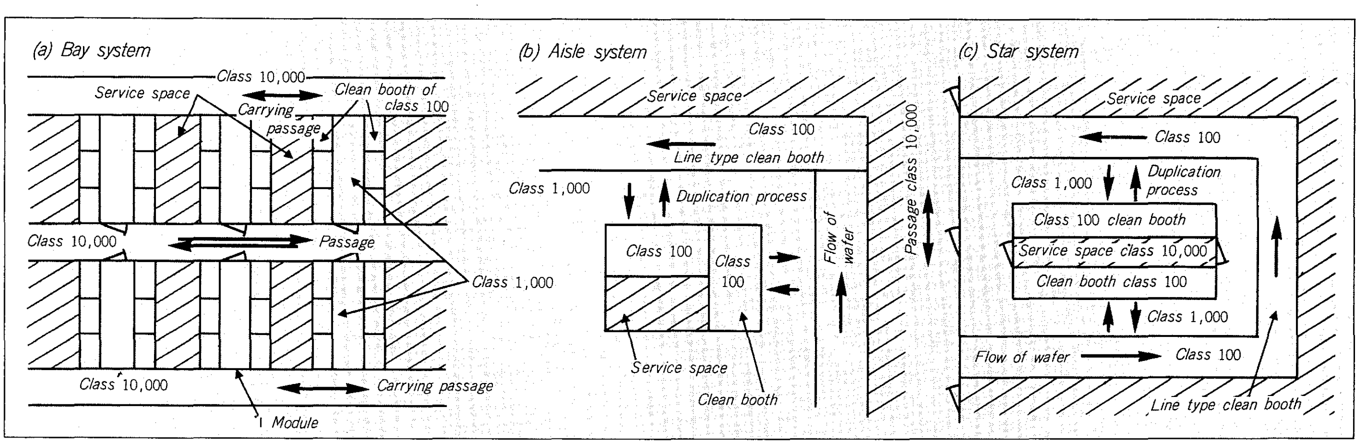
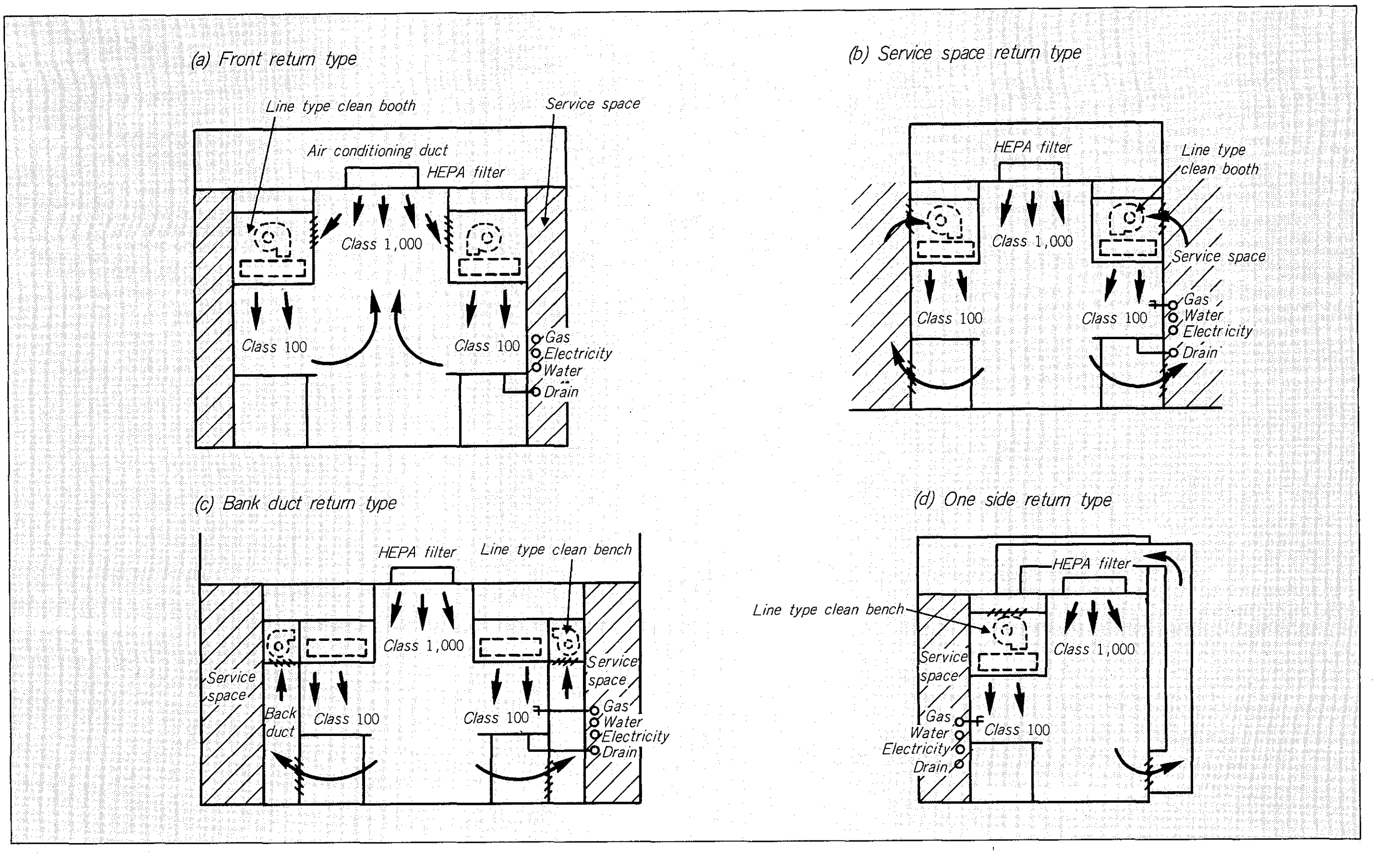


Fig. 7 Various systems of air flow for clean tunnel type clean room



exhaust, drain and power required in manufacturing semiconductors are centerized in the service space, and without ceasing the semiconductor manufacturing, maintenance can be made within the service space.

For the air flow systems in the clean tunnel and passage portions, various types shown in *Fig. 7* are used, and they are:

(1) The front return type installs the intake port on the top of the front face of the clean booth. Therefore, a part of clean air blown out to the CR from the clean booth becomes a rising air stream within the CR and is directly sucked into the clean booth, causing cleanlinesss of the CR to drop. As long as air flow structure, this type is not desirable.

(2) The service space return type is used in a bay system. The air within the CR is sucked into the service space located behind the clean booth and is circulated to the clean booth.

(3) The back duct return type installs a circulation duct on the back of the clean booth. The air within the CR goes through the circulation duct and is circulated to the clean booth.

(4) The one side return type installs the duct in the opposite side of the service space. The air within the CR is sucked into the duct and circulated. This type is most effective when the space is limited.

Further, for requirements on temperature and humidity, only those such as a mask aligner which require temperature fluctuation width within ±0.1 to ±0.5°C are installed in a constant temperature/humidity equipment such as a thermal clean booth and thermal clean cube, and CR itself is kept in such fluctuation widths as that the temperature is within ±1 to 2°C and humidity is within ±5%, saving energies.

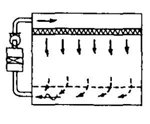
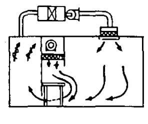
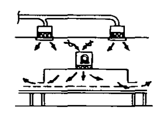
When a comprehensive automation of the process line is executed in the future, a CR of clean tube type (The process line which required a super high cleanliness is isolated from the surrounding spaces and only the process line is kept in the super high clena space.) will be achieved. With this type, the process line can be protected from dust generated by workers and other surrounding contamination sources and very high cleanliness can be obtained. In addition, volume of blown air can be reduced, which is effective in saving energy, and this type will be introduced next to the clean tunnel type CR.

Table 5 compares the vertical laminar flow type, clean tunnel type and clean tube type CRs.

4 UTILITY OF MANUFACTURING EQUIPMENT

For utilities of a semiconductor manufacturing equipment, pure water, gas, exhaust, drain, compressed dry air, vacuum, coolant water, power, etc. are required, and level utility requirement differs depending on each manufacturring equipment. *Table 6* shows the requirement levels by

Table 5 Comparison of down flow type clean tunnel type and clean tube type clean rooms

Item	Vertical laminar flow type	Clean tunnel type	Clean tube type
Air flow state			
Features and application	The overall area within the CR is maintained in the highest cleanliness. Since generated dust is flowed to the down stream immediately, it is seldom to affect other areas. Unless otherwise dust is generated in the upper stream of the significant work area, no contamination will result. Many of this type are employed in wafer process of IC and LSI plants, and in some cases, there are of a large size exceeding 1000 sq.m.	Mainly employed in IC and LSI manufacturing process. The process of mask, wafer, etc. which requires an especially high cleanliness is arranged in tunnels. Since the products are isolated form the workers, super high clean space could be realized easily. Since class 100 is limited within tunnel only, in comparison with the totally vertical laminar flow type, both the equipment and operation costs are less.	When products flow within an automatic manufacturing line, the space within the fense may be cleaned. Since products are isolated from workers and circumferencial dust generation, high cleanliness can be obtained by a small volume of air supply. Automation which does not require man hand is essential, and this type is indispensable for the future super LSI manufacturing line. Further, in view of the energy saving, this type will be used more popularly in the future.
Cleanliness	Class 100 (entire range)	Class 100 within tunnel	Class 100
Number of ventilation	300 to 500 times per hour	500 to 1000 times per hour within tunnel	100 to 300 times per hour
Blow out wind velocity	0.25~0.5 m/s	0.3~0.5 m/s	–
Pressure	About 0.5 mmH_2O	0.5~1.0 mmH_2O	1.0~3.0 mmH_2O
Construction cost	High	Medium	Low
Operation cost	High	Medium	Low
Flexibility	Easy	Difficult	Difficult
Maintenance	Easy	Easy	Difficult
Noise	High	Medium	Low

each process and manufacturing equipment.

These utilities are mutually related, and they must be examined totally. If each of them is examined independetly, unexpected failure may result. For example, pure water is closely related with drain system, air conditioning is closely related with exhaust system and gas is closely related with exhaust system, and therefore, it is important to plan these systems by taking the mutual relationships into consideration. Especially for the relationship between the air conditioning and exhaust system, if these systems are unbalanced, such problems as that the differential pressure between rooms cannot be balanced, volume of air processed by air conditioning regulator is greatly deviated from the processed energy, control level of the room temperature cannot be within the rated value and the rated cleanliness cannot be obtained will occur, and special care is required.

4.1 Pure water equipment

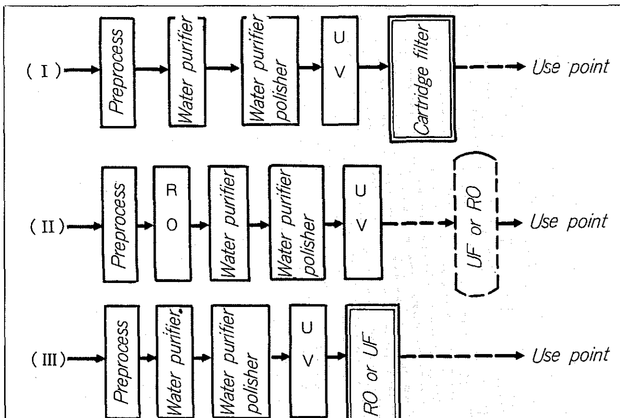
When manufacturing semiconductors, super pure water of 15 MΩ·cm at 25°C specific resistance is used.

Not only the specific resistance, but also number of fine-grains and number of microorganisms contained in the super pure water are limited because they affect the yielding point of the products. *Table 7* shows examples of water quality presently required in the semiconductor industries.

When planning a pure water equipment, it is necessary to plan an economical system suited to the nature of the source water after thoroughly understanding the quality of the source water, temperature change, number and change of fine-grains, and quality and source of microorganisms. *Fig. 8* shows a typical system flow.

In the semiconductor industries, the circulation piping is made to always obtain clean pure water, surplus water in the use point is returned to the reservoir tank and filteration and sterilization are executed. *Fig. 9* shows these processes. Further, if water stays in a part of the piping route, CO_2 gas is melted into the water, microorganisms are propagated and piping material is melted into the water, causing water quality to reduce. Therefore, it is important to plan the system and piping route so that water does not

Fig. 8 Flow diagram of water purifier



Process type	Advantage	Disadvantage
(I) Water purifier + Cartridge filter	○ Low initial cost ○ Simple system	○ Fine particle cannot be eliminated completely. ○ Cannot correspond to water source fluctuation ○ Replacement of filter is troublesome
(II) RO + Water purifier	○ Low running cost ○ IER load is reduced. ○ Maintenance control is easy.	○ High initial cost ○ Fine particle leaks.
(III) Water purifier + RO	○ Fine particle, miroorganism and organism can be eliminated completely. ○ Water source fluctuation can be suppressed.	○ Medium initial cost ○ High running cost ○ RO collecting rate must be raised.

Table 6 Utilities for semiconductor manufacturing process

Process	Name of equipment	Pure water	Gas	Exhaust	Drain	Compressed air	Vacuum	Coolant water	Electricity
Process before diffusion	Wafer linsing equipment	○	–	○ (Acid system exhaust)	○ (Fluoroacid system drain) (Acid system drain)	–	–	–	–
Coating and diffusion	Ion impregnation	–	○ (P, B, AS, N_2, LN_2)	○ (Ordinary exhaust)	–	○ (6 kg/cm²)	–	○ (18~23°C)	○
	CVD	–	○ (SiH_4, B_2H_6, PH_3, H_2, O_2, N_2, Freon, Ar, LN_2)	○ (Ordinary exhaust)	–	○ (6 kg/cm²)	–	○ (Temperature equivalent to well water and city water)	○
	Diffusion furnace	–	○ (B_2H_6, N_2, O_2, H_2)	○ (Ordinary exhaust)	○ (Ordinary drain)	–	–	○ (Temperature equivalent to well water and city water)	○
Resist application and drying	Scrubber	○	○ (N_2)	○ (Ordinary exhaust)	○ (Ordinary drain)	○ (6 kg/cm²)	○ (For wafer suction)	–	○
	Spinner	–	○ (N_2)	○ (Organic system exhaust)	○ (Organic system drain)	○ (6 kg/cm²)	○ (For wafer suction)	–	○
Exposure · Development	Aligner	–	○ (N_2 for driving)	○ (Ordinary exhaust)	–	–	○ (For wafer suction)	–	○
	Developer (spray type)	–	○ (N_2)	○ (Organic system exhaust)	○ (Organic system drain)	○ (6 kg/cm²)	–	–	○
	Developer (Dip type)	○	–	○ (Organic system exhaust)	○ (Organic system drain)	–	–	–	–
	Baking furnace	–	○ (N_2)	○ (Ordinary exhaust)	–	–	–	–	○
Etching resist peel off (in case of wet)	Etching device	○	–	○ (Acid system tem exhaust)	○ (Fluoroacid system drain) (Acid system drain)	–	–	–	–
	Resist peel off	○	–	○ (Organic system exhaust)	○ (Organic system drain)	–	–	–	–
	Rotary dryer	○	○ [N_2 (For drying)]	○ (Ordinary exhaust)	○ (Ordinary drain)	–	–	–	○
Etching resist peel off (in case of dry)	Etcher	–	○ (N_2, O_2, CF_4)	○ (Ordinary exhaust)	–	–	–	–	○
	Asher	–	○ [N_2, O_2, (CF_4)]	○ (Ordinary exhaust)	–	–	–	–	○
Vaporization (plating)	Processing device before vaporization	○	–	○ (Acid system exhaust)	○ (Fluoroacid system drain) (Acid system drain)	–	–	–	–
	Vacuum vaporizing device	–	○ (N_2, LN_2)	○ (Ordinary exhaust)	○ (Ordinary drain)	○ (6 kg/cm²)	–	○ (Temperature equivalent to well water and city water)	○
	Spatter	–	○ (N_2, LN_2)	○ (Ordinary exhaust)	○ (Ordinary drain)	○ (6 kg/cm²)	–	○ (Temperature equivalent to well water and city water)	○
	Placing device	○	–	○ (Acid system exhaust)	○ (Fluoroacid system drain) (Acid system drain)	–	–	–	○ (For heater)
Checking characteristics	Prober	–	○ [N_2 (for suction)]	–	–	–	–	–	○
Scribe	Dicer	○	○ [N_2, (for suction and air curtain)]	○	○ (Ordinary drain)	○ (6 kg/cm²)	–	–	○

Fig. 9 Piping diagram for purified water

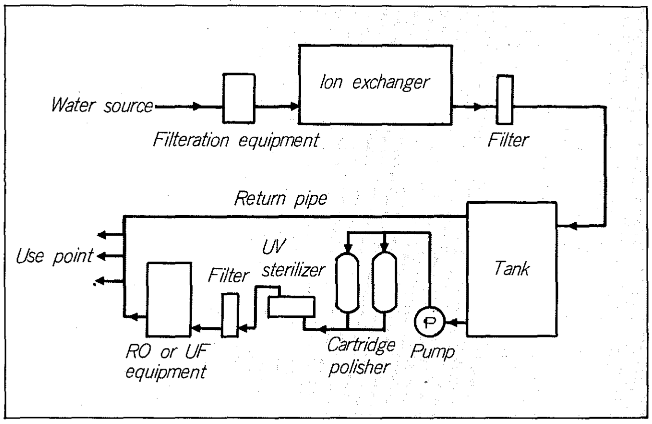


Table 7 Example of required quality of purified water for semiconductor manufacturing in Japan

Item	A	B	C	D	E	F
Specific resistance (MΩ · cm at 25°C)	>18	>16	>16	>15	>16	>15
Number of fine particles (0.2 μm or larger particles/ml)	<100	<300	<300	<40	<90	<200
Microorganism (pieces/ml)	<1	<5	<5	<2	<0.05	<1
Organic matters (mgC/l as TOC)	<0.5	<0.5	<1	–	<1	<1

(NOTE) For fine particles and microorganism, there is a slight difference in the measuring method.

Table 8 Systems and treatment of exhaust gas

System segment	Processing method
Non-organic exhaust	Wet type
Organic exhaust	Dry type
Special exhaust	Wet type
Miscelaneous exhaust	Wet type
Heat exhaust	Wet type

stay in the pipe line.

4.2 Drain equipment

In the semiconductor industries, the most drains are from the wafer process. Since various chemicals are used in this process, water cannot be drained as they are but it must be discharged after treating it so that it is recovered to the rated level.

Care must be exercised to separate drain pipings by chemical systems, allowing a drained water treatment at the preceded stage because various chemicals such as organic chemical, non-organic chemical and hydrogen peroxide are used in the semiconductor manufacturing process. (For details, refer to the paper under a separate cover.)

4.3 Exhaust equipment

In the semiconductor manufacturing equipment, chemicals and gases used in the process are exhausted, and

Table 9 Use and required quality of gas for semiconductor manufacturing

Process	Used gas		Purity (%)	Dust (Pieces/l)
	Balance gas	Special gas		
Oxidation	O_2, N_2, H_2		99.99999	
		HCI (for cleaning)	99.999 (present status) H.C. 1ppm or less	
Diffusion	O_2, N_2, Ar		99.99999	
		PH_3, B_2H_6	99.999	
Ion impregnation	N_2 (for chamber purge)		99.999	
		AsH_3, PH_3, BF_3	99.999	
CVD	O_2, N_2, He		99.99999	3~4
		SiH_4, PH_3 SiH_2Cl_2, N_2O NH_3	99.99	
Epitaxial	N_2, H_2		99.99999	
		SiH_4, AsH_3 SiH_2Cl_2, B_2H_6, Hcl	99.999	
Etching	O_2 N_2 (for chamber purge)		99.999	
		CF_4 (Polysilicon nitriding film)	99.999	
		C_3F_8 (Oxidizing film) C_2ClF_3 (Anisotropy polysilicon)	99.9	
Others(Gas for purging, etc)	N_2		99.999	

since these chemicals and gases contain harmful substances, they must be adequately treated before discharging into the air. The method of treatment differs by kind of the chemical and gas, and therefore, mixed exhaust using same duct system is not allowed. As shown in *Table 8*, the exhaust system must be divided into five kinds. (For the details, refer to the paper under a separate cover.)

4.4 Coolant water equipment

For the coolant water used by semiconductor manufacturing eqipment is classified into two systems. One if low temperature coolant water which must be maintained within 18 to 28°C throughout the year, and the other is an ordinary coolant water equivalent to the city or well water. The low temperature coolatn water is used and circulated by a refrigerator and the ordinary coolatn water is supplied from a city water system or well, and drained after use or recirculated by a cooling tower.

It must be noticed that temperature level of coolant water differs by each semiconductor manufacturing equipment.

4.5 Special gas equipment

For gases used for semiconductor manufacturing lines, there are two types. One is special gases such as silane, phosphine and freon, and the other is the balance gas used to purge a gas after reactions.

Since O_2, H_2 and N_2 used as a balance gas is used in a large quantity, a central supply system from a gas tank yard is employed, and for special gases, a gas cylinder box is installed near the manufacturing equipment and the gas is supplied from the cylinder because volume of used gas is less.

There are requirements on purity and contained dust for each gas, and *Table 9* shows the required values.

The balance gas of the central supply system is further refined by using a refiner at the entrance or inside the CR, and the refined gas is supplied to each equipment.

As for the gas pipings, stainless steel pipe is used. For the piping from a balance gas tank to the gas refining equip-

Fig. 10 Gas piping diagram in a semiconductor manufacturing factory

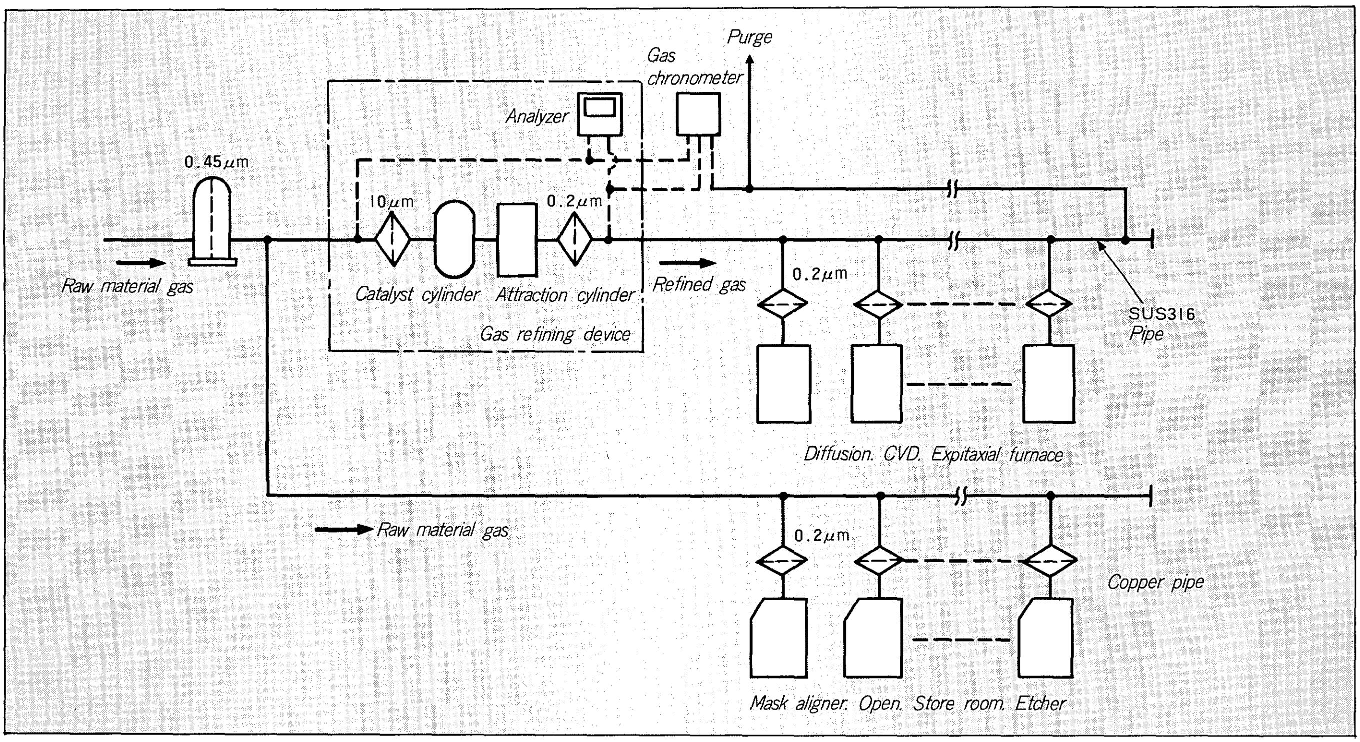


Fig. 11 Example of prevention systems for vibration of equipment

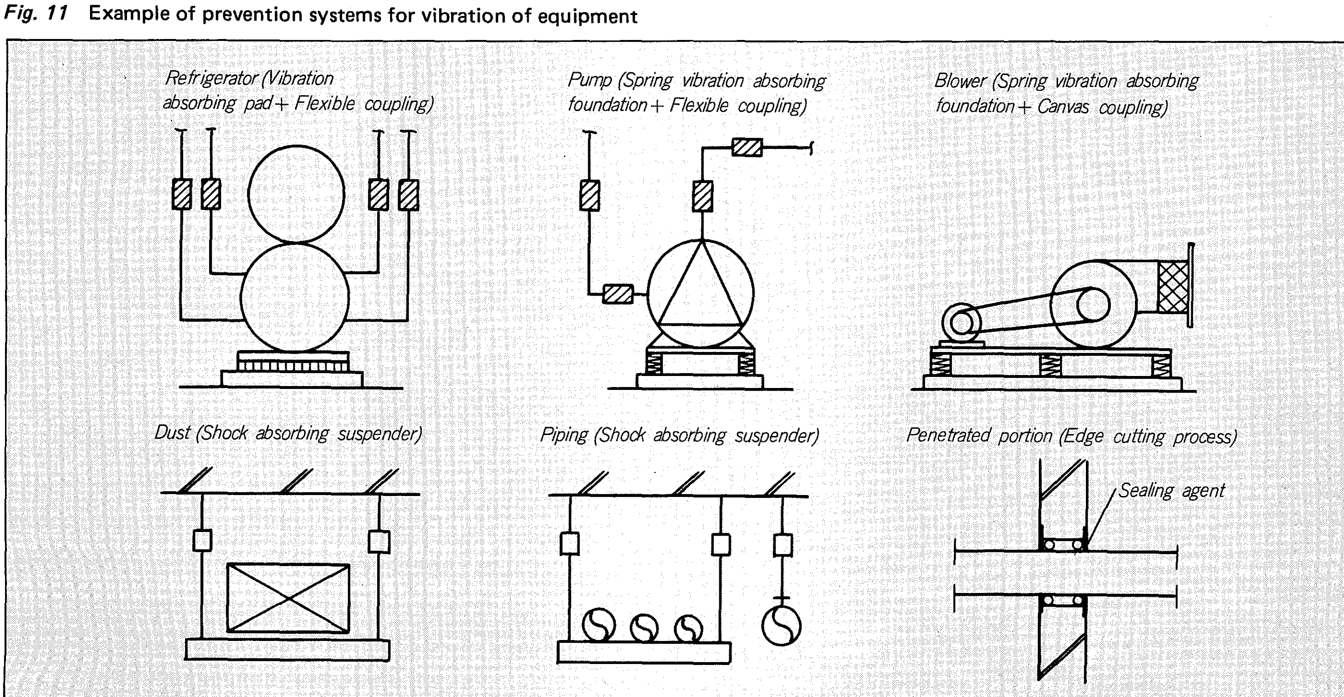
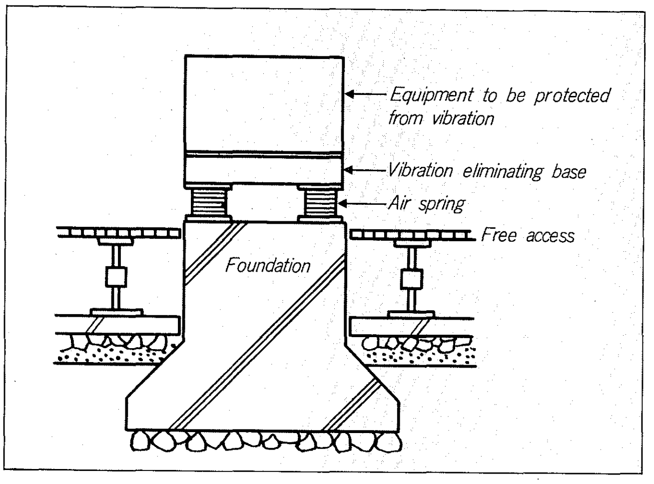


Fig. 12 Separated foundation



ment, in many cases, copper pipes are used. *Fig. 10* shows an example of balance gas piping within a factory.

4.6 Manufacturing equipment and vibration preventing countermeasures

As semiconductor patterns are becoming finer and multiplied, even a very minor vibration greatly affects the yielding in the exposure process.

Aligners and inspecting equipment prevent propagation of vibrations from the floor with a vibration preventing equipment using air springs. When pattern size is 3 μm or less, vibration of the floor itself must be limited.

Floor vibration required in an exposure process must be limited to 1 μm, 1 gal or less against 5 to 50 Hz vibration frequency for all frequencies, and when pattern size is 2 to 1.5 μm, it must be limited to 0.3 μm or less.

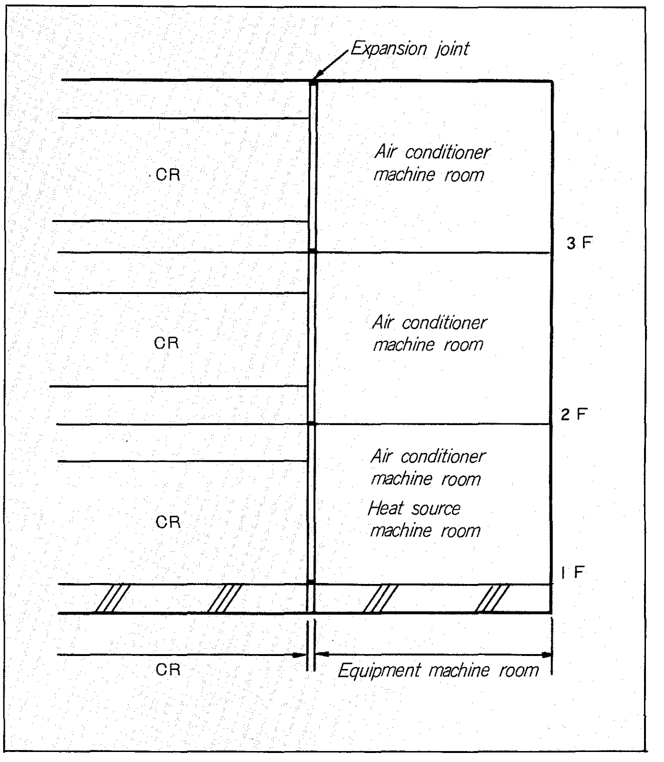
It may be said that these very small vibrations should be prevented at the time of building construction rather than the equipment installed in the building. However, it is difficult to take countermeasures only at the time of building construction, and prevention of vibration must also be taken into consideration carefully at the equipment side.

The equipment which require vibration preventions are air conditioners, pumps, refrigerators, fans, ducts and pipings. *Fig. 11* shows examples of these vibration preventing devices.

As for actions to prevent vibrations taken at the time of building construction, a vibration avoiding device is installed on the independent foundation (*Fig. 12*), or the equipment machine room is separated from the foundation of the building, and the machine room and building are joined through an expansion joint (*Fig. 13*).

Further, a rotary pump, clean bench, clean booth, etc. attached to the semiconductor manufacturing equipment within a CR are also vibration sources, and individual vibration preventions are required.

Fig. 13 Separated machine room system



5 POSTSCRIPT

Trend of the automation of manufacturing equipment, CRs and utilities in the semiconductor industries were outlined. How to combine manufacturing equipment depending on the type of manufactured semiconductor, scale of production, etc. is a knowhow of each semiconductor manufacturer, and the combination is not limited to a certain kind.

Also for the utilities, each equipment has an independent system, and combined utility equipment, its performance and capacity differ depending on the combined semiconductor manufacturing equipment.

An air conditioning equipment is closely related with the exhaust equipment, so is it between water purifying equipment and drain treating equipment and between an exhaust system and gas system. And, it is important to take a mutual balance between them, and to proceed the equipment plan with a flexibility for the future provided.

To trace these point, a well balanced total engineering will be essential.

Fuji Electric has accumulated thousands of experience and knowhow of CR and utility required for the total engineering based on many equipment and systems actually delivered into the semiconductor industrial fields. Many of the details are confidential matters for the CR owners, and they cannot be announced to the outside, and therefore, they were just outlined. We hope this paper can be used as a reference for the people concerned.