Development of DWCCS for Chemical Temperature Control of Semiconductor Manufacturing

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Abstract

In the semiconductor manufacturing process, many factors lead to lower transference numbers and DT. Especially, this occurs due to the temperature changes of essential chemicals such as acid and solvent and the rate is constantly increasing. Thus, it is required to develop equipment to improve transference numbers and DT properties and the work efficiency of process engineers by maintaining constant temperature of chemicals used in the manufacturing process and by controlling multiple circulators. This study developed DWCCS which engineers operate by remote control with multiple facilities and which maintains constant temperature of chemicals used in semiconductor device manufacturing facilities and processes.

Keywords: *Chemical Control, DWCCS, Down Time, Semiconductor process*

1. Introduction

This study develops leak detection algorithm to automatically detect the amount of deionized water inside circulators, to automatically supply or supplement deionized water if there is a lack of deionized water, and to detect the leak of deionized water inside circulators at an early stage in order to maintain constant temperature of various chemicals used in semiconductor wafer manufacturing facilities and processes. Also, it is to decrease down-time (DT) of process facilities and failure due to temperature changes of chemicals in wafer processing processes by sending alarms to equipment engineers working in a distance, in case leak of deionized water inside circulators is detected. This study developed DWCCS (Deionized Water Circulation Control System); its control system collects deionized water samples from circulators and measures their concentration by programmed routes according to measuring cycles set by engineers. It automatically processes the deionized water clean process, if the concentration is higher than the standard turbidity. Also, this may be easily applied to existing semiconductor manufacturing lines.

2. Semiconductor Manufacturing Process

Semiconductor manufacturing process consists of wafer manufacturing, circuit design, mask fabrication, assembling, and inspection. Among these semiconductor manufacturing processes, the wafer processing processes have various processes: oxidation which oxidizes wafers, photo resist process which apply photoresist after oxidation, exposure which expose patterns, development, etching, ion implantation which implants ion, chemical vapor deposition (CVD), and metalization process. Table 1 shows major equipment and materials used in detailed processes of wafer processing [1, 2].

Table 1. Wafer fabrication process and Major equipment, Primary material

Process	Detailed process	Major equipment	Primary material
Wafer fabrication	▪ Oxidation ▪ Photo resist ▪ Exposure ▪ Development ▪ Etching ▪ Ion implantation ▪ Chemical vapor deposition ▪ Metalization	▪ Tray system ▪ Stepper ▪ Etcher ▪ Asher ▪ CVD ▪ Gas cabinet ▪ Wet station ▪ Gas purifier ▪ Chiller ▪ Scruber ▪ Spinner	▪ PR ▪ Process Gas ▪ Chemical

3. Deionized Water Circulation Control System

In case a wafer turns out bad due to inefficiency of wafer processing processes, it has to be discarded or reworked. Failure to decide the wafer quality results in decreasing transference numbers. Moreover, with the increasing demand of consumers and the development of semiconductor-related technology, sizes of semiconductor wafers are dramatically increasing. As costly large-sized wafers emerge, it is now essential to conduct constant research and development to increase transference numbers in manufacturing processes and research on control system for process improvement.

Therefore, this study developed DWCCS with advantages; it is easily applied to existing semiconductor producing lines and is easy to be converted to LCD producing lines. Also, an engineer may control a maximum of nine circulators in a distance through one DWCCS by remote control; losses in each process may decrease near to zero and losses and failure due to temperature changes in chemicals may be prevented. When development was completed, application test was carried out on DWCCS against producing lines [3, 4].

Figure 1 shows a conceptual diagram of DWCCS, the system for which this study aims. The advantages of Deionized Water Circulation Control System (DWCCS) are as follows and Table 2 shows the development range.

1) Nozzle D.I Water Leak early alarm system

This may detect leak of constant-temperature water which occurs in each circulator system as soon as it takes place, send alarms and stop spinner system. Also, DWCCS conducts detailed analyses on the amount of D.I water which is supplied to each circulator, finds circulators which may have leaking problems and generates corresponding alarms at an early stage.

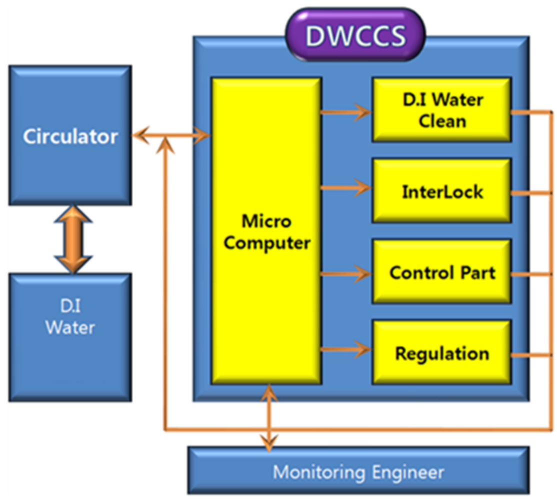

Figure 1. Conceptual diagram of DWCCS

2) Automatic cleaning function is equipped according to the analysis on the concentration of circulating water inside circulators

This function is equipped to automatically measure the concentration of pollutant of circulating water in each circulator according to the cycle set by users. If any factors which disrupt circulation of bacteria occur in circulators, automatic cleaning is implemented to remove pollutants so circulating water flows normally and process failure factors such as temperature anomaly are removed.

3) Automatic supplementing function of circulating water inside circulators

Decrease of circulating water in each circulator is measured in real time. When constant-temperature water level drops, DWCCS detects it immediately for automatic supplementation.

4) Thorough triple water overflow prevention devices are equipped.

As supplied water leaks lead to serious damages to devices. Thus, this system is equipped with triple safety devices.

-. First stage: main sensor detects and blocks regular flow.

-. Second stage: In case of continuous supply, overflow occurs. Overflow is blocked with S/W interlock time.

-. Third stage: limit sensor blocks overflow at a final stage. If overflow occurs constantly, leak sensor detects it and blocks the system. Also, manual valves and regulators in the IN part of MAIN water blocks water supplied at an early stage.

5) In case of serious problems, it notifies facilities.

This system is equipped with functions which generate alarms to facilities in case of water leak, nozzle leak of constant-temperature water, and supply time overflow. (These may be set by users)

6) Water pressure device is designed in the system (to prevent leak in the device)

In this system, electronic solenoid valves in D.I. Input part prevent internal pressure increase. This increases safety of components built in water circulators. In case of high pressure design, components may be damaged early due to increased internal pressure.

DWCCS developed in this study is designed and fabricated as shown in Figure 2 and 3, 4 to automatically supply and supplement D.I water in order to complement increased facility down time due to direct and indirect evaporation of circulating water in constant-temperature controlling system in the producing lines of semiconductor manufacturing processes and increased process failure due to inconsistency of constant-temperature controlling capability in case of circulation. Figure 5 shows a internal image of D.I gauge and regulator unit.

Figure 2. Control unit of DWCCS

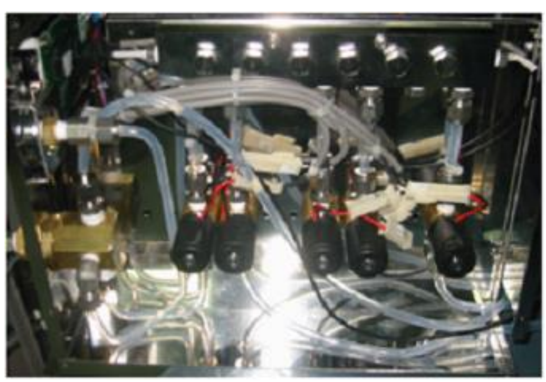

Figure 3. Sensing and chemical clean unit

Figure 4. D.I gauge and regulator unit

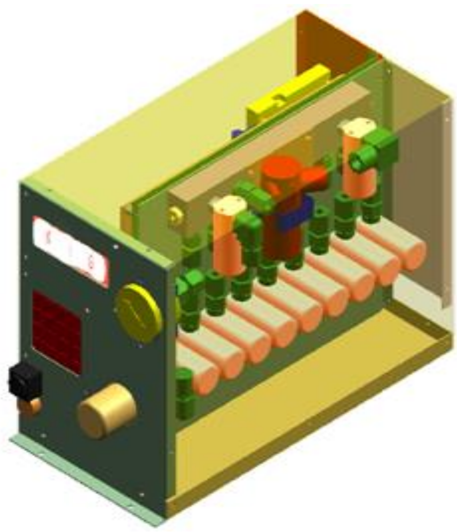

Figure 5. Internal image of D.I gauge and regulator unit

Figure 6 shows a diagram of concentration measuring part of D.I water. As for concentration measuring part, according to concentration cycle set by users (turbidity measuring cycle for circulating water), the controller collects circulating water and puts it in to concentration measuring unit for concentration measurement according to programmed order. If its turbidity exceeds the turbidity set by users, circulating water cleaning process is automatically operated.

Water supply system consists of concentration measuring part/supply and collecting drain part, system controlling part, interlock, and external support part. When supply signals are input in level sensor, concentration measuring part/supply and collecting drain part supplies water from supply and collecting drain part until it reaches the target water level.

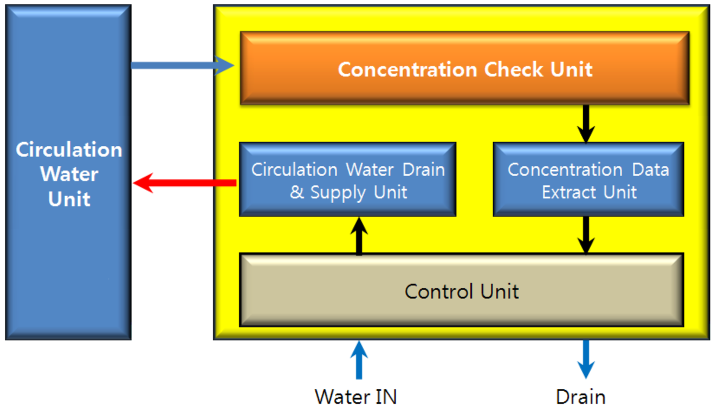

Figure 5. Concentration measuring unit for concentration measurement

When supply signals are input on external sensors (water level sensor, water level interlock sensor, concentration measuring sensor, and leak sensor), system controlling part first controls automatic water level controlling function of circulating water and safety blocks related to turbidity tests of circulating constant-temperature water and system leak safety. It also saves and adjusts automatic operating factors of the system. Also, it is equipped with a function to send early alarms for decrease of circulating water due to deficient devices.

Interlock part consists of leak detecting bath part and water valve interlock part. In case water leak occurs in concentration measuring part/supply and collecting drain part due to DWCCS system problems, firstly the water stays in water collecting bath at the bottom of the system and secondly highly sensitive sus type leak detecting sensor implements emergency handling process (four-layer interlock system) to prevent accidents due to leak.

External support part consists of level sensor unit, supply/collecting & drain part, and main power supply part. Stop/start sensor for water supply has a function of maintaining circulating water level automatically. Overflow interlock sensor implements a function of blocking the system in case the water level constantly increases due to system problems. Table 2 shows the specification of DWCCS developed in this study.

4. Conclusion

This study developed DWCCS to improve transference numbers and DT properties and the work efficiency of process engineers by maintaining constant temperature of chemicals used in the manufacturing process and by controlling multiple circulators. This equipment is easily applied to existing semiconductor producing lines and is easy to be converted to LCD producing lines; losses and failure due to temperature changes in chemicals may be prevented. Constant research should be conducted on the development of probe units which sets power automatically in connection with DWCCS output and pattern signals.

Table 2. Specification of DWCCS

No.	ITEM	SPEC.
1	Control Port No.	Max 9 Circulator
2	Used fluid	D.I Water
3	Power	110-220 AC
4	Case	ALL SUS304BA
5	Leak Sensor	SUNX-FX-F71
6	D.I Regulator	CKD-Brass-BODY
7	Level Sensor	SPX613
8	Cooling System	FAN
9	Solenoid Valve	CKD-USB3-24V
10	Power Supply	24V S/W Regulator
11	CPU	PIC16F877-2
12	Main Memory	64k Byte
13	Data Memory	32k Byte
14	I/O Port	34 I/O
15	Clock Frequency	20MHz
16	Data Use EEPROM	32k Byte
17	8 bit A/D Channel	8 Ch
18	12 bit A/D Channel	2 Ch
19	LCD Display	20T x 4F
20	CPU(Display)	PIC16F877-2

Acknowledgments

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