Development of Multi-Chemical Supply System for Semiconductor Wafer Cleaning Station

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Abstract: A multi-chemical supply system is developed and applied to a wet station, which uses the multi-chemical process in one bath. To control the concentration of two chemicals, control logic of a supply pump is programmed using the programable logic controller (PLC). By using the multi-chemical supply system, wet station with single bath is applied to cleaning process using multi chemicals such as buffed oxide etchant (BOE) and standard clean 1 (SC-1). The concentration of each chemical is measured in the bath to verify the multi-chemical supply system. The control range in the each chemical concentration is measured to 1.33weight% in NH4OH and 0.23weight% in H2O2. The multi-chemical supply system can be movable and usable as an independent module of fixed wet station. By simply midifying the PLC, a multi-chemical supply system can be developed for a wet station.

Keywords: multi-chemical supply system, cleaning station, programmable logic controller, ladder diagram

1. INTRODUCTION

Wet clean/etch process in the semiconductor manufacturing industry is used to remove the particle or defect on the wafer by cleaning or etching using high pure chemicasl [1]. There are pre-cleaning before diffusion, photo, and chemical vapor deposition (CVD), strip, etching, polymer treatment, cleaning and spin scrubbing as the wet clean/etch process. Cleaning process is conducted before or after the main technologies of semiconductor wafer process. The particles and defects on the wafer are generated during the super large scale integration (LSI) manufacturing process. The control of particles and defects on the silicon wafer is a main target to increase the packaging yield. In semiconductor manufacturing process, removal of particle is only possible by the cleaning process. From this perspective, cleaning process is repeatedly appeared in the main manufacturing process flow. With a smaller pitch of circuit patterns and higher density of large-scale integration (LSI), effect of particle and micro-contamination on the wafer has been studied to increase the packaging yield [2]. Wet station for wet clean/etch process is configured with wafer loader/un-loader, chemical bath, over flow rinse bath and dryer. Depending on the purpose of cleaning process, chemical and rinse bath has multi configuration to supply several chemicals. The cleaning process in a multi-bath wet station is conducted sequentially according to combination of each chemical at each bath for removal of cleaning object. By combination of multi-bath layout, the station has large footprint. By an increase in the wafer size from 8inch to 12inch, the space occupied by the station is dramatically increasing. Therefore, a single bath systems using multi-chemical in one bath is increasingly demanded [3].

In this paper, multi-chemical supply system is developed and applied to wet station, which is using the multi-chemical process in one bath. The multi-chemical supply system has two chemical bottles, pneumatic system, two supply pumps, capacitance sensor, chemical analyzer, and programmable logic controller (PLC) unit. To control the concentration of two chemicals, supply pump control logic is programmed using the PLC.

The developed multi-chemical supply system was applied to a wet station with single bath for cleaning process using multi chemicals such as buffed oxide etchant (BOE) and standard clean 1 (SC-1), respectively. The concentration of each chemical was measured in the bath to verify multi-chemical supply system.

2. BATH CONFIGURATION OF WET STATION

Fig. 1 shows one of the bath configurations using in the Sankyo wet station, where 100:1 dilution hydrofluoric (DHF) chemical and de-ionized (DI) water are supplied to the bath [4]. DHF chemical is used for pre-diffusion cleaning, pre-oxide stripping, and oxide etching. The bath is made of polytetrafluoroethylene (PTFE) material and filter is used to filter the particle of chemical. Bath temperature is controlled by an inline heater. In this bath configuration, only one chemical is used for cleaning process.

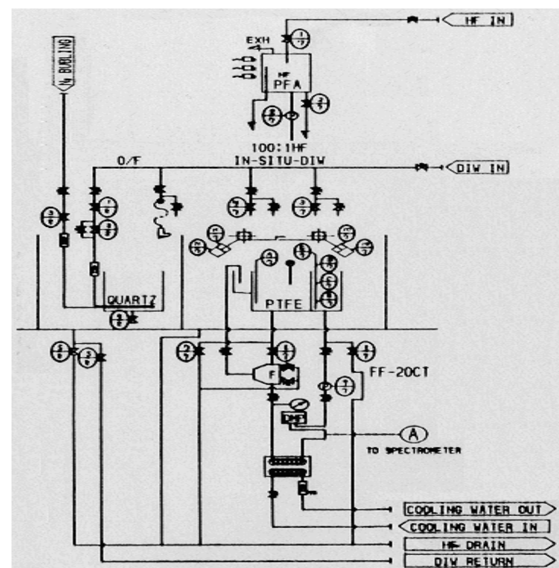


Fig. 1 Bath configuration of Sankyo wet station

For the cleaning process to use multi-chemicals, the bath needs a multi-chemical supply system. The bath of Sankyo

wet station is modified to supply the multi-chemicals. Fig. 2 shows the bath configuration modified to have the multi-chemical supply system, which is described with box having dotted line. The multi-chemical supply system can be supplied with two chemicals, separately.

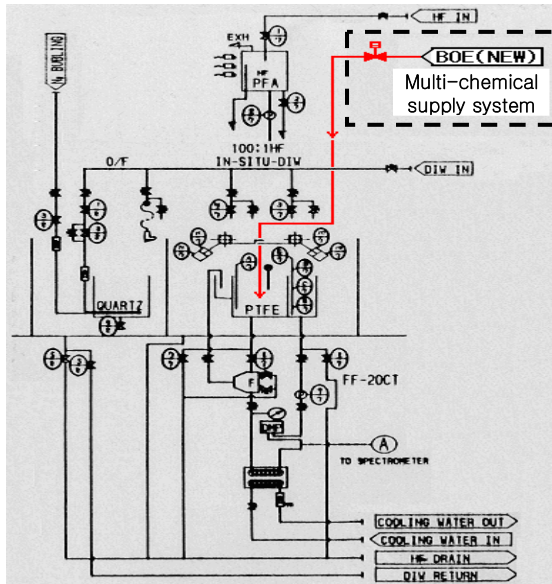


Fig. 2 Bath configuration modified to have a multi-chemical supply system

3. DEVELOPMENT OF MULTI-CHEMICAL SUPPLY SYSTEM

A wet clean process using multi-chemical in one bath is required according to an increase in the wafer size. A multi-chemical supply system is developed for wet clean process in one bath of Sankyo wet system. The operation procedure of multi-chemical supply system is shown in Fig. 3. By a power switch operation signal, the chemical supply system is checked. By a chemical supply start signal, a supply pump is operated to supply chemical to the chemical bath. The chemical supply is completed by a feedback signal from a flow meter and a chemical analyzer. The PLC ladder diagram following the operation procedure was constructed with given tool [5]. This diagram uses simple scheme for sensing of concentration and controlling of supply pump.

The chemical supply can be conducted with one chemical or multi chemicals, respectively. In this study, two kinds of chemicals are used. The control diagram of multi-chemical supply system is showed in Fig. 4, where the main components are consisted with CPU, input unit andoutput unit:

- CPU

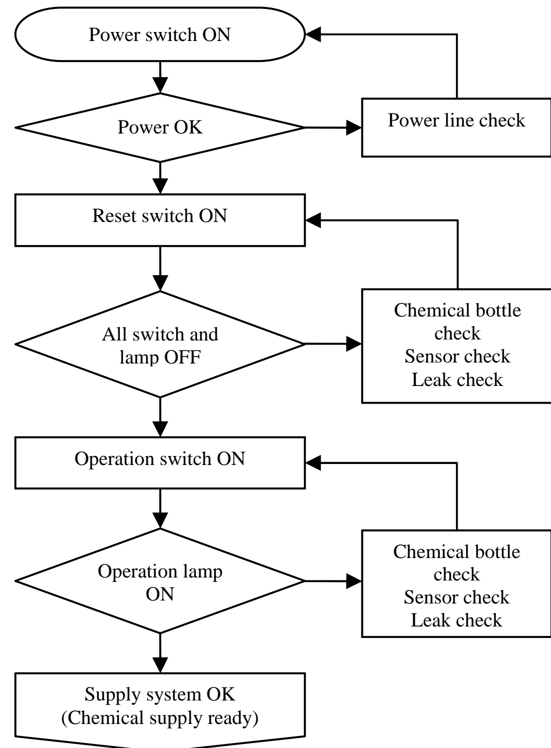
8 Bit (C200H-RT202/Omron)

- Input unit

The chemical analyzer (Ace-II/Kurabo) as feedback sensor, capacitance senor (E2K-X4ME1/Omron) as limit switch, and switches are used as input unit.

- Output unit

The bellows pump (FF10H/Iwaki) and spike pump (PZ-10/Nippon Pillar) as chemical supplier, solenoid valves (P5136M6/CKD) as air controller, and lamp as alarm indicator are used as output unit.



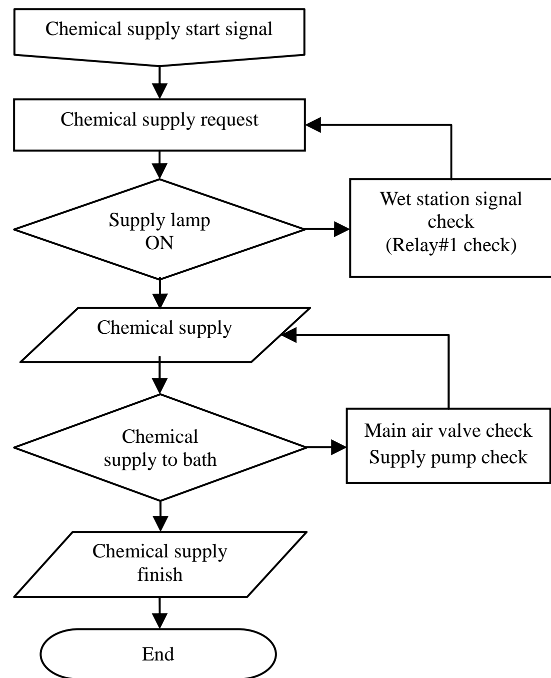


Fig. 3 Operation procedure of multi-chemical supply system; (a) Chemical supply system check (b) Chemical supply operation

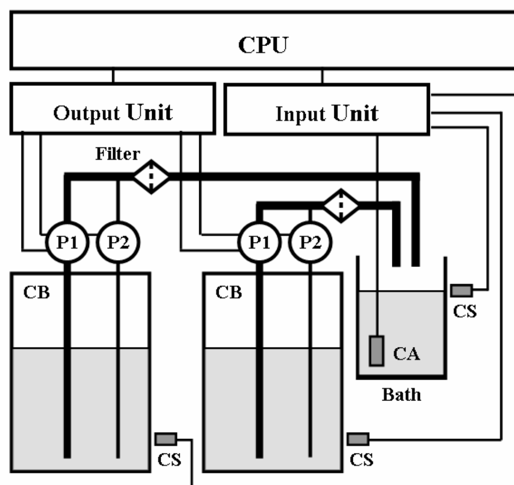


Fig. 4 Control diagram of multi-chemical supply system; where, P1: Bellows pimp, P2: Spike pump, CS: Capacitance sensor, CA: Chemical analyzer, CB: Chemical bottle

In Fig. 4, the chemical supply is conducted with bellows pump and spike pump for fast (by bellows pump) and precision (by spike pump) pumping. The amount of supplied chemical is measured by limit sensor configured in the outside of chemical bath. The chemical concentration is measured and feedback by chemical analyzer in chemical bath. In this chemical supply system, two chemical bottles are used as chemical sources.

The specifications of multi-chemical supply system are listed in Table1, where the settling time of chemical supply is required as less than 10minutes with 5wt% of concentration deviation, which is defined as deviation from nominal value in weight percent.

Table1. Specifications of multi-chemical supply system

Item	Nominal value	Unit
Supply rate	166.7	ml/sec
Analyzer resolution	±0.05	wt%
Bath capacity	25000	ml

The developed multi-chemical supply system is showed in Fig. 5. This system can be movable and usable as independent module of fixed wet station. Also, it can be usable for single chemical supply to the bath, which has not chemical supply line.

4. EXPERIMENTAL RESULTS

The performance of the multi-chemical supply system is evaluated in the wet station with a quartz bath using the SC-1 chemical, consisted with

$NH_4OH + H_2O_2 + DIW = 1:4:20$ (in volume ratio)

$NH_4OH + H_2O_2 + DIW = 1:5:113$ (in wt% ratio)

at 25℃±5℃, (1)

where, NH_4OH is 29% solution, H_2O_2 is 30% solution and DIW is de-ionized water.

Fig. 5 Developed multi-chemical supply system

Fig. 6 shows the concentration transient trend of SC-1 chemical as a fuction of chemical supplying time. From Fig. 6, NH_4OH and H_2O_2 are settled in 10minutes with a concentration deviation of 1.33wt% and 0.23wt%, respectively. In the bath using SC-1 chemical, chemical supply is conducted in the sequence of DIW, NH_4OH, and H_2O_2. The concentration deviation is dependent on the chemical analyzer resolution and spike pump flow rate. The measured data are sufficient for required specification of bath concentration control value, which is recomended as less than 10minutes with 5wt% of concentration deviation.

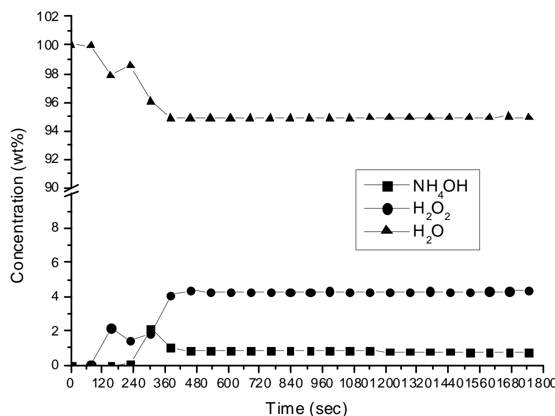


Fig. 6 Concentration transient trend of 300:1 BOE chemical measured in the PTFE bath

5. CONCLUSIONS

The developed multi-chemical supply system was applied to a wet station with single bath for cleaning process using multi chemicals such as SC-1. The concentration of each chemical was measured in the bath to verify multi-chemical supply system. The concentration control range was measured to be 1.33weight% in NH_4OH and 0.23 weight% in H_2O_2. Developed multi-chemical supply system can be movable and usable as an independent module of fixed wet station. The presented multi-chemical supply system can be easily extened to incorporate numerous chemicals by simply modifying the PLC.

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