Intelligent Monitoring System for High Precision Balance Of Chemical supplying system in the Wet Station

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1. Introduction

As semiconductor device geometries continue to shrink and die sizes grow, micro-contaminants such as particles, metallic impurities, and trace organic contaminants will have an ever-increasing detrimental impact on device yield and reliability[9]. Every wafer process step in ULSI manufacturing is a potential source of such contaminants, which may lead to defect formation and device failure. Scrupulous maintenance of clean wafer surfaces throughout the wafer-processing cycle is essential to obtain high yields. Rigorous wet cleaning is known to be effective in reducing the presence of these contaminants on the wafer surface, making it the most frequently repeated step in any LSI manufacturing sequence[10].

Wafer-cleaning chemistry has remained essentially unchanged over the past 30 years. Hydrogen peroxide-based chemistry is the most prevalent cleaner in the semiconductor industry worldwide. Most notably, it is used to perform RCA standard cleans, in which wafers are sequentially immersed for several minutes in an $NH_4OH-H_2O_2-H_2O$ mixture (SC-1) and an $HCl-H_2O_2-H_2O$ mixture (SC-2) at elevated temperatures, and then in dilute HF at room temperature. In immersion-type wet chemical cleans, even if ultra-pure chemicals are introduced and then disposed of after each wafer-cleaning treatment, contaminant-removal efficiency is compromised by impurities brought into the fresh solution by incoming wafers[11].

In order to m increase stringent wafer-cleanliness requirements, single-wafer spin cleaning process has been introduced, in which fresh chemicals are continuously supplied to the wafer[11]. Using single-wafer spin cleaning in the wet etching of films on silicon substrates is better for etch uniformity. Single-wafer cleaning equipment has a much smaller footprint than a conventional wet bench and is the most suitable tool for short-cycle-time minifab operations for system LSI production. The tool's throughput, however, must be increased and its chemical consumption reduced. To solve these problems, the best approach is to develop ways to use alternative cost-effective

chemicals that react more rapidly and use fewer chemicals than those used in conventional RCA cleans. The implementation of new chemistries will also reduce the volume of effluents generated during the cleaning process.

Meanwhile, one automatic wet station has several single-wafer spin cleaning systems. It needs high precision balance for exact supplying of chemicals to each system. High precision balance is electronic measurement system, which consists of load-cell and the microelectronic circuits. Often it occurs differences actual weight between measuring weight. This trouble by malfunction of load-cell causes serious problems better than other problems (power failure, be broken, etc) in cleaning process.

To solve this problem we have designed load-cell trouble diagnosis system. That is an intelligent monitoring system, which is stored information of a load-cell expert. By the fuzzy logic algorithm, it realized decisive knowledge of expert and diagnosed trouble of load-cell [1].

In particular, this paper shows developed hardware of intelligent monitoring system to diagnose load-cell's troubles and its operating software that was programmed using Microsoft-Visual C++.

2. Intelligent Monitoring System

2.1 Basic concepts of Single-Wafer Spin Cleaning

Single-wafer spin cleaning uses ozonated water and dilute HF without any additives or megasonic aids. As shown in Figure 1, the system functions by alternately applying ozonated water and dilute HF onto a wafer surface for a few seconds, a cycle that can be repeated as many times as necessary until the surface attains the required level of cleanliness. Following the last dilute-HF treatment, either DI water is applied to the wafer to obtain a hydrophobic silicon surface or ozonated water is applied to obtain a hydrophilic silicon surface. Then spin drying takes place in a nitrogen atmosphere to prevent spot formation on the patterned wafers.

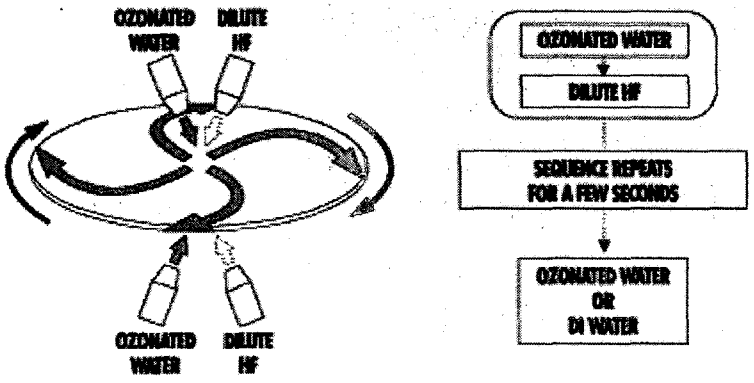

Figure 1. Schematic diagram showing the repetitive use of ozonated water and dilute HF in the Single-wafer spin cleaning process.

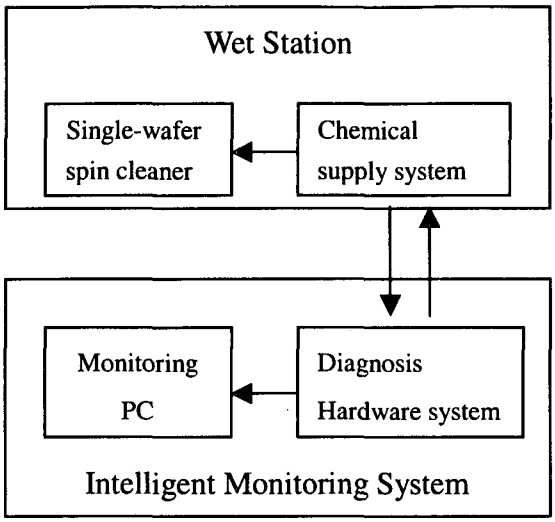

Figure 2. Diagram of Intelligent Monitoring System

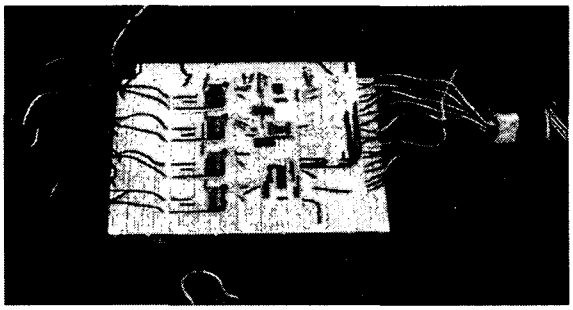

Figure 3. Hardware System

The system's short-time- cycle cleaning can efficiently remove particulate and metallic contaminants, as well as trace organic contaminants, without increasing the microroughness of the silicon surface[9].

2.2 Diagnosis system

The chemicals are measured the top of the load-cell plate[2]. Automatic calculator calculates the weight. Load-cell is include strain-gage that located center of load-cell inside and transforming resistance to voltage. That is Wheatstone-bridge by elasticity of strain-gage. If increase the weight, than increase the voltage product [4]. To diagnose the load-cell's trouble, input voltage from the load-cell make load-cell's state data and send to PC through Port address 0x379 IBM standard rule after A/D converting[5].

This system used 3-wire type of Communication protocol which is standard 24bit serial data-communication. Converting resolution for 1bit is 0.3 [uV] but real resolution is 2.3[uV] because of oscillation of load-cell's output voltage. Control-signal is send to PC through LPT port in PC. Port address is 0x378 of IBM standard rule. Table 1 shows the control signal.

Table 1. Control Signal 0x378 Port

Pin	2	3	4	5	6	7	8	9
LC1	0	0	X	X	0	0	0	0
LC2	1	0	X	X	1	0	0	0
LC3	1	0	X	X	0	1	0	0
LC4	1	0	X	X	0	0	1	0
LCA	1	0	X	X	0	0	0	1

LC 1 ~ 4 : Load-cell ID Number.

LCA : All Load-cell of system

1 : High bit , 0 : Low bit, X : Not Used (Option)

The load-cell's states are monitored on PC screen in real time after inference by intelligent monitoring algorithm using fuzzy logic.

2.2 Fuzzy logic algorithm

For our fuzzy logic algorithm, the isosceles triangle method was used as a fuzzifier. Mamdani's Max-Min compositional rule was used for fuzzy approximate reasoning [6].

As the fuzzy input variables (FI_1), Vi and Vr were used. Vi is load-cell's initial voltage near to Zero. And Vr is load-cell's measuring voltage with Load. Fuzzy input variable (FI_2) used Vnr. Vnr is variation of load-cell(Δ V). Linguistic Variables are defined in Table 2.

Table 2. Definition of linguistic variable used in the FLC

Variable	Definition	Variable	Definition
VL	Very Low	N	Normal
L	Low	SD	Small Difference
S	Stable	VD	Very Difference
O	Over	OD	Over Difference
VO	Very Over	AL	Alert
CH	Change	GS	Good Stable

Examples for the fuzzy inference example are as follows [7] and rule base is like Table 3.

Table 3. Rule Base

FI_1₩ FI_2	VL	L	S	O	VO
N	AL	GS	GS	GS	AL
SD	AL	AL	GS	GS	AL
VD	CH	AL	AL	AL	CH
OD	CH	CH	AL	CH	CH

" IF FI_1 is N and FI_2 is N Then OUT is GS ",
" IF FI_1 is O and FI_2 is VD Then OUT is AL ",
- - - - - - ,
" IF FI_1 is VO and FI2 is VD Then OUT is CH"

In figure 4, monitoring screen is shown load-cell's state of chemical supplying system for Wet Station with several single-wafer spin cleaner. This intelligent monitoring system shows high correctness above 90 %(average percentage of 100 times).

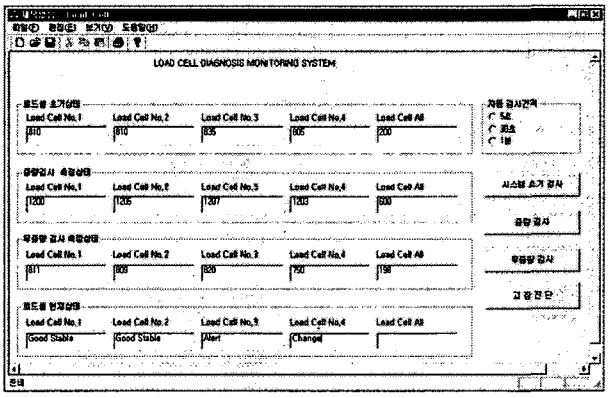

Figure 4. Monitoring Screen

3. Conclusion

A growing trend in broadband-networked digital consumer electronics has led to paradigm shifts in semiconductor manufacturing toward shorter cycle-time minifab operations, where single-wafer cleaning is desired. Especially Wet Station needs high precision balance for supplying of exact chemical. In this paper, we developed an intelligent monitoring system to diagnose the load-cell using fuzzy logic algorithm. This system shows good accuracy and will be utilizing the fabrication line.

Acknowledgments

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