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Research Paper

Pre-particle filtration and moisture control by efficient purging in various inlet and outlet of a 450 mm wafer front-opening unified pod

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Abstract

The trend toward narrower line width in semiconductor manufacturing has made contamination control more and more important. The presence of moisture in wafer containers, such as front opening unified pods (FOUP), can lead to the native oxide residues growth, metal corrosion, and thin film cracking on wafer surfaces. Accordingly, decreasing contamination methods and improving factory efficiency are continuously researched. Single or multi-layer particulate shields on top of wafers in FOUPs may be used to prevent pollutant accumulation. In addition, point-of-use (POU) filtration may also been used to control particle contamination in FOUPs during wafer transformation and storage. The demand for stricter filtration led to the usage of 0.10 and 0.20 μm membranes to control the contamination. However, with the introduction of finer membranes end users may have concerns about deleterious remainders on wafers from undergoing filtration. There are a total of 25 pieces of wafers in the FOUP and the arrangement is from the bottom (wafer No. 1) to the top (wafer No. 25) with arising manner. Purging FOUPs to expel moisture vapors with Clean Dry Air (CDA) is one of the most popular methods.
There was no previous research for investigating the purge performance on new-generation 450mm FOUPs. This research aims to study main factors influencing the performance of the purge system on 450mm FOUPs, including moisture concentration, CDA flow rate, and filter pressure.

Keywords: *Front Opening Unified Pod (FOUP); Purge System, Moisture Control; Particle Filtration.*

1. Introduction

To involute semiconductor manufacturing is extending as ICs goes on the shrinking feature sizes scale. From the involution, nanosize particles contamination control methodologies are growing more critical while fabricated process increasingly. The International Technology Roadmap for Semiconductors (ITRS) sponsored by five leading chip manufacturing associations those have cited the removal of particles 14 nm as critical for advanced semiconductor devices.
The feature sizes reduce to 14 nm or smaller that has led to supply tighter membranes ensuring the removal of particles reduce yield in Table 1. In an opened wafer fab or inside a process tool, the wafers are kept clean by a filtered air of vertical laminar flow. However, the interior of a front opening unified pod (FOUP) is a very contrary environment, which involves no flowing air. Once the air flow into the process tool is at the higher pressure than that of the circumjacent fab typically, the interior of a FOUP is not vigorously pressurized during the door closed. The atmosphere interior of the FOUP includes of primary air that runs into from the process tools while wafer transfer steps, together with some air that gets through a breather filter while pressure equalization of the closed FOUP. [1] The application of point-of-use filters have been joined into the dispense systems and assure the removal of undesired particles from the

photo resist users to prevent the deposition of unwanted particles into the wafer surface while the semiconductor chips fabricate. The removal of particles that are slighter than the feature size is necessary to prevent IC failure.
In our survey, we were not able to locate any article that could be used for investigating pre-filtration and purging performance of a FOUP by challenging particle and moisture. Therefore, the objective of this study is to study the key parameters, including moisture concentration, CDA flow rate, and filter pressure, which influence the performance of the pre-filtration and purge system under the challenging conditions.

Table 1: Yield Enhancement/Wafer Environment Contamination Control (ITRS 2013 Edition)

Year of Production	2013	2015	2017	2019	2021	2023	2025	2028
Logic Industry "Node Name" Label"	"16/14"	"10"	"7"	"5"	"3.5"	"2.5	"1.8"	
Logic ½ Pitch (nm)	40	32	25	20	16	13	10	7
Flash ½ Pitch [2D] (nm)	18	15	13	11	9	8	8	8
DRAM ½ Pitch (nm)	28	24	20	17	14	12	10	7.7
FinFET Fin Half-pitch (new) (nm)	30	24	19	15	12	9.5	7.5	5.3
FinFET Fin Width (new) (nm)	7.6	7.2	6.8	6.4	6.1	5.7	5.4	5
6-t SRAM Cell Size(um2) [@60f2]	0.096	0.061	0.038	0.024	0.015	0.01	0.006	0.003
MPU/ASIC HighPerf 4t NAND Gate Size(um2)	0.248	0.157	0.099	0.062	0.039	0.025	0.018	0.009
4-input NAND Gate Density (Kgates/mm) [@155f2]	4.03E+03	6.37E+03	1.01E+04	1.61E+04	2.55E+04	4.05E+04	6.42E+04	1.28E+05
Flash Generations Label (bits per chip) (SLC/MLC)	64G /128G	128G /256G	256G /512G	512G /1T	512G /1T	1T/2T	2T/4T	4T/8T
Flash 3D Number of Layer targets (at relaxed Poly half pitch)	16-32	16-32	16-32	32-64	48-96	64-128	96-192	192-384
Flash 3D Layer half-pitch targets (nm)	64nm	54nm	45nm	30nm	28nm	27nm	25nm	22nm
DRAM Generations Label (bits per chip)	4G	8G	8G	16G	32G	32G	32G	32G
450mm Production High Volume Manufacturing Begins (100Kwspm)				2018				
Vdd (High Performance, high Vdd transistors)[**]	0.86	0.83	0.8	0.77	0.74	0.71	0.68	0.64
1/(CV/I) (1/psec) [**]	1.13	1.53	1.75	1.97	2.1	2.29	2.52	3.17
On-chip local clock MPU HP [at 4% CAGR]	5.5	5.95	6.44	6.96	7.53	8.14	8.8	9.9
Maximum number wiring levels [unchanged]	13	13	14	14	15	15	16	17
MPU High-Performance (HP) Printed Gate Length (GLpr) (nm) [**]	28	22	18	14	11	9	7	5
MPU High-Performance Physical Gate Length (GLph) (nm) [**]	20	17	14	12	10	8	7	5
ASIC/Low Standby Power (LP) Physical Gate Length (nm) (GLph)[**]	23	19	16	13	11	9	8	9

*** Note: from the PIDS working group data; however, the calibration of Vdd, GLph, and I/CV is ongoing for improved targets in 2014 ITRS work*

2. Method

The schematic diagram of the FOUP-CDA purge system is shown in Figure (1). A mass flow controller with an operational range of 6–18 L/min was used to control the inlet CDA volume. RH sensors were installed for monitoring the relative humidity on the surfaces of the 1st, 7th, 13th, 19th, and 25th wafer within the FOUP. The specifications of the Temperature and Humidity Date Logger (DICKSON TK150) were: measurement range of −20 to +70 °C, measuring precision of ±1 °C. The specifications of the temperature and humidity Date Logger (DICKSON TK150) were: measurement range of −20 to +70 °C, measuring precision of ±1 °C. A multi-point laser particle counter (Model: Pacific Scientific Model Met One 2100.10, Ashtead Technology) was used to monitor particle concentration within the test chamber and the specification was shown in Table 2. A pressure gauge (0~100 psi) was used to monitor the pressure of CDA line before the FOUP. In all the experiments, the FOUP door was modified to obtain a better tightness. The need for the delivery of CDA to the FOUP has resulted in the implementation of CDA delivery systems within FOUP. The CDA delivery systems are used to transport CDA to FOUP. The Point-of-use (POU) filter installed at FOUP plays a critical role in the delivery of CDA, as the filter is the last chance to remove particulate contamination prior to CDA entering FOUP and coming into contact with the wafer. The filters were the 0.05 and 0.1 μm filters. These POU filters are constructed of PTFE hydrophobic membrane with high-density polyethylene support, drainage and hardware (Model J100A047A). The measurement setup for particle filtration is shown in Figure (2).

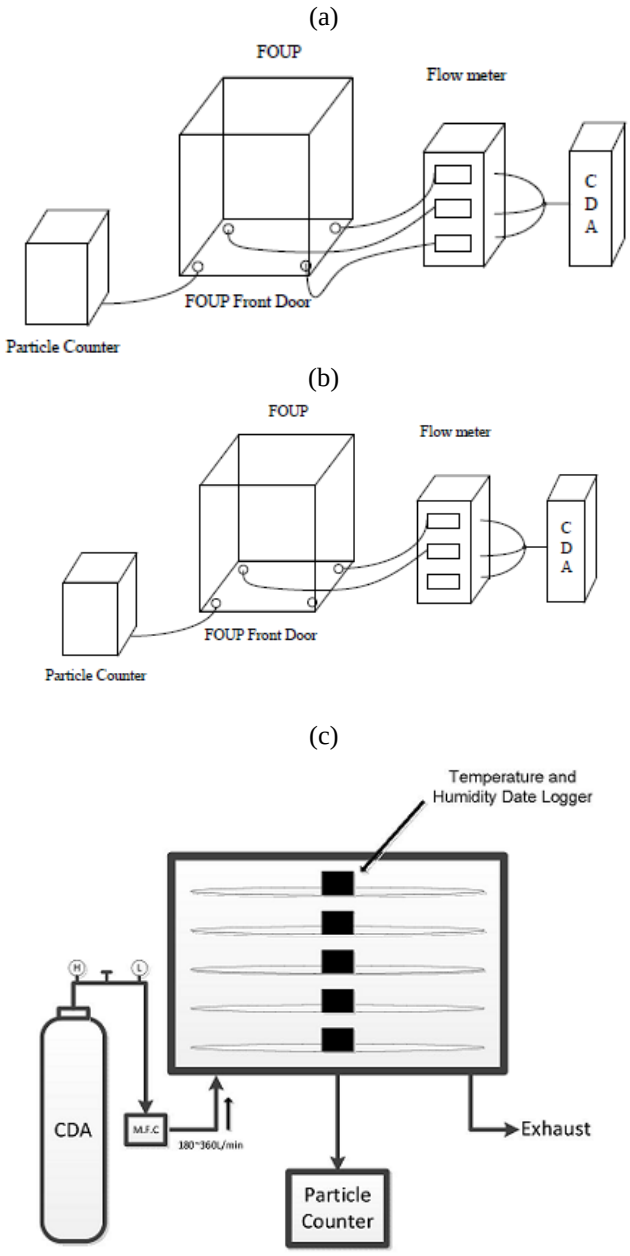


Fig. 1: Schematic Diagram of the FOUP with the Inlets and Outlets for the Purge Experiments. (A) 3in/1out, (2) 2in/2out, and (C) Setup of a Relative Humidity Measurement System.

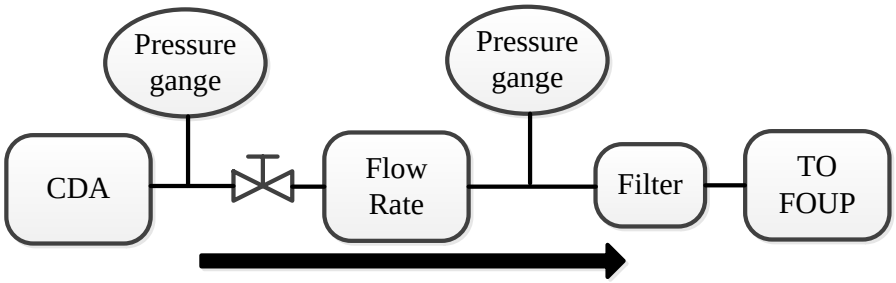


Fig. 2: Schematic Diagram of the Connections for the Particle Filtration at the Purge Station.

Table 2: Specifications of the Multi-Point Laser Particle Counter.

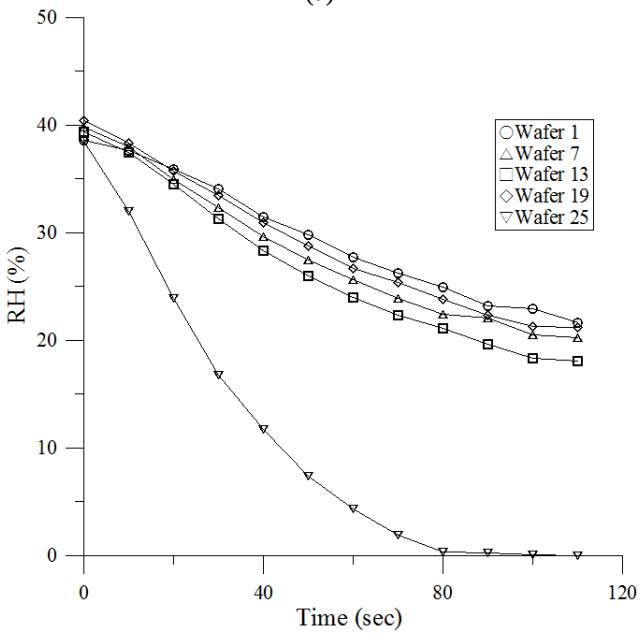
Title	Value
Size Channels	0.1, 0.2, 0.3, 0.5, 0.7, 1.0 µm
Flow Rate	1 Cfm
Sample Time	1 Second To 24 Hours Automatic, Or Manual Start And Stop
Hold Time	1 Second To 24 Hours
Data Logging	500 Samples
Output	Built-In Printer, RS-232 Port
Power	115V
Dimensions	178 X 343 X 559 Mm
Weight	19 Kg

3. Results and discussion

3.1. Effect of moisture content on the performance of the purge system

We examined the time-dependent humidity depletion in an experiment with different wafer locations and various holes inlet and outlet. Figure (3) shows the differences of the relative humidity on the surfaces of the 1st, 7th, 13th, 19th, and 25th wafer. The depletion of humidity on the 1st wafer was specially slow. The depletion of relative humidity on the 25th wafer was fast, and the equilibrium purge times declined from 110 sec at three inlet and one outlet to 80 sec at two inlet and two outlet of purging rate of 180 LPM. These results are in agreement with Hu et al [2]. (Testing flow rate of 0.25–2.4 L/ minimum at 300 mm PC wafer FOUP). Figure (4) shows the moisture content in the test set up monitored as a function of time for various CDA flow rates from 180 to 360 LPM. The moisture content decay was faster with higher CDA flow rates at three inlet/1 outlet and two inlet/2 outlet FOUP systems. The CDA purging time for moisture is inversely proportional to the purging gas flow rate as shown in Figure (4) [3].

(a)



(b)

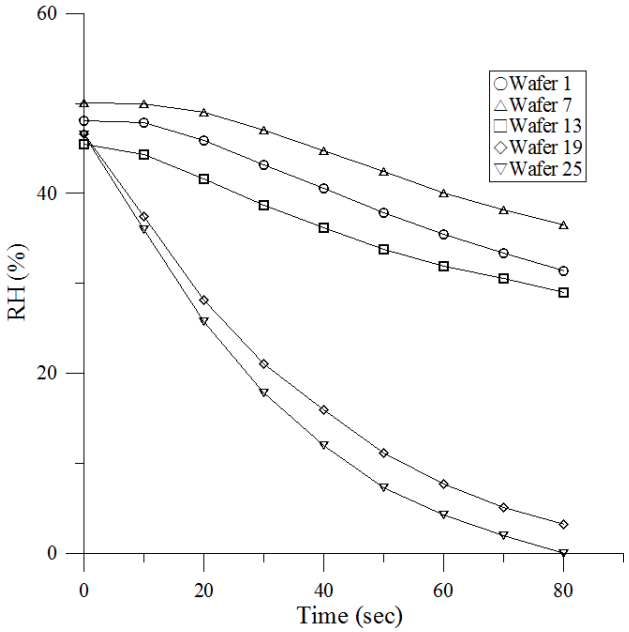


Fig. 3: The Depletion of the Relative Humidity on the Different Wafer Surfaces.

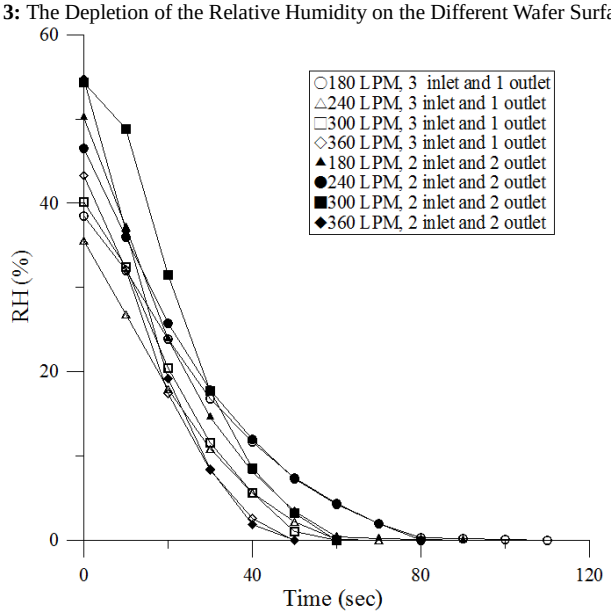


Fig. 4: Moisture Content as A Function of Time for Different N_2 Purging Flow Rates.

3.2. Effect of purge time on the purging gas flow rate

The purging time for moisture content is inversely proportional to the purging gas flow rate as shown in Figure (5) [4] To decrease purging time that need a large volume of gas flow, which demonstrates that 360LPM is the most efficient flow rate. However, too rapid gas flow creates undesirable results, such as exiting promote contamination by releasing moisture from wafers and interior surfaces of the FOUP. It is again superior to decrease the consumption of purging gas to reduce the cost. (Testing flow rate of 0.25–2.4 L/min at 300 mm PC wafer FOUP) [5].

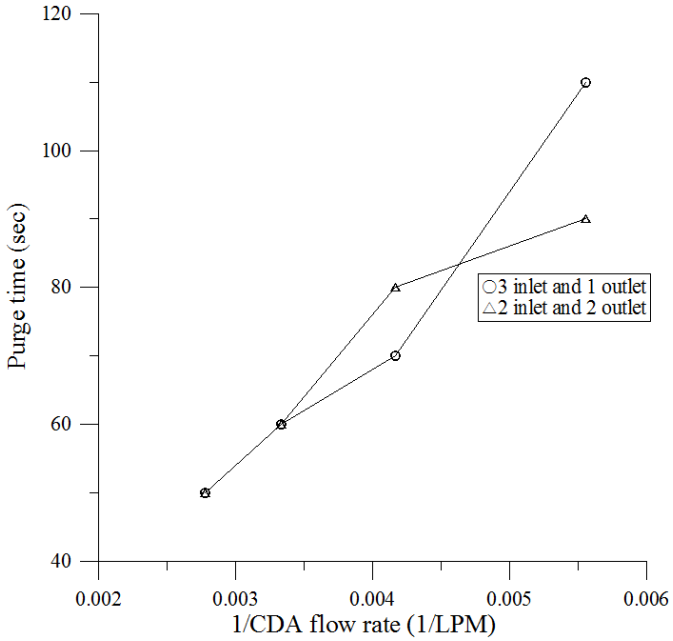


Fig. 5: Purging Time for Moisture Content as a Function of Flow Rate.

3.3. Effect of filter pressures on the air flow rate

Actually, a seal need to execute superior at a negative pressure condition that occurs while the contaminated air run into the pod potentially than the condition of a positive pressure. [1] Figure (6) presents the flowrate relates to the pressure for the FOUP that acts a door seal that has been specially designed to supply negative pressure. We plugged the PTFE filter to obtain these data to promote FOUP conductance valves representing only seal conductance. In this experiment, the conductance was kept constant at 190 LPM that all round the monitoring range at the positive pressure, but the data came off linearly at 48 PSI highest negative pressure. [1] The 0.2µm PTFE filter has a lower pressure drop than 0.1µm PTFE filter at the same airflow rate by 20-80%. Installed 0.1µm PTFE filter at FOUP, the defectivity is reduced further compared to 0.2µm PTFE filter.

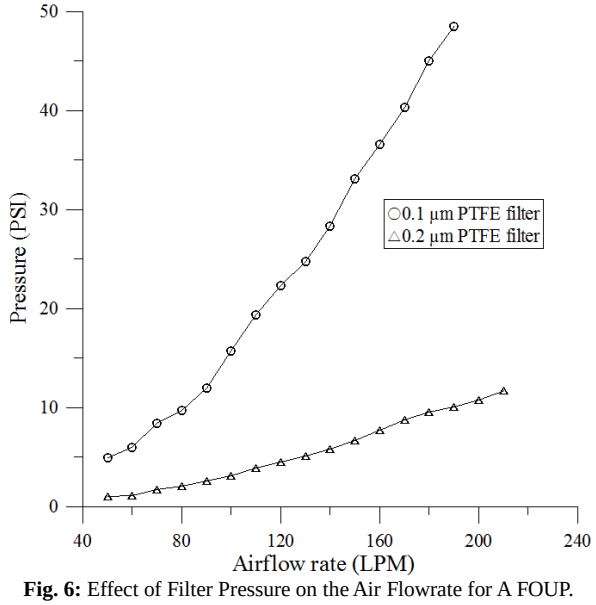


Fig. 6: Effect of Filter Pressure on the Air Flowrate for A FOUP.

4. Conclusion

We have applied the extremely good properties of the advanced resin on the next generation 450 wafer FOUP system. The advanced resin FOUP has the best moisture dry down characteristics. The moisture quantity approach to zero from the special resin FOUP was 110 sec and 80 sec at three inlet and one outlet and two inlet and two outlet of 180 LPM purging rate, respectively. We will efficiently transfer and stock the wafer without exposing to contaminated clean room

air by virtue of moisture. The purge efficiency was even more useful than that of 360 LPM flow rate. The relative humidity (RH) in the FOUP can be approached to 0% within 50 sec.

References

[1] Mikkelsen, K. and Niebeling, T. "Characterizing FOUPs and evaluating their ability to prevent wafer contamination, Micro. (March 2001), pp. 10.

[2] Hu, S.C. and Wu, T.M. and Lin, H.C. and Hsu, K."Design and evaluation of a nitrogen purge system for the front opening unified pod", Applied Thermal Engineering, Vol. 27, No. 8-9 (2007), pp. 1386-1393. http://dx.doi.org/10.1016/j.applthermaleng.2006.10.028.

[3] Hu, Y.Z. and Tay, S.P. "Monitoring and purging dynamics of trace gaseous impurity in atmospheric pressure rapid thermal process", J. of Vac. Sci. & Techn. Vol. A21 (2003), pp. 676- 682. http://dx.doi.org/10.1116/1.1564023.

[4] Genco, R. and Pitts, J. and G. Gallager, "Control microcontaminants with wafer cassette purging", Semiconduct. Int., April 1997, pp. 91-96.

[5] Hu, S.C. and TSAO, J.M. "Purge of a Front Opening Unified Pod (FOUP) with Nitrogen for 300 mm Wafer Manufacturing", Jap. J. of Appl. Phys. 45(6A), Vol. 175 (2006), pp. 5269-5271.