

Virtual yield indicator using in situ particle monitor

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The particle check using the test wafer is executed as a technique for regularly monitoring the particles generated in the semiconductor manufacturing process. It is usually a sampling inspection about once a day. However, the number of particles contaminating on a wafer often varies. For instance, the particles generated in one lot (25 wafers) by the plasma etcher varied from about 10 to about 100 particles according to the experiment by Umehara et al. [1] They also reported it varied from about 70 to about 700 particles in the condition that the particle is generated easily.

Therefore, the particle management by the sampling inspection only observes the situation at the moment. Sugimoto proposed the logarithm technique for plotting the number of particles on the wafer as a technique for observing the trend of the particle generation. [2] When the inclination of the particle transition becomes negative after maintaining the chamber, the particles are originated by the insufficient dryness of chamber parts according to this technique.

On the other hand, *in situ* particle monitor (ISPM) is developed as a technique for real time monitoring the particle. However, it was reported that the ISPM count did not have the correlation with the particle on the wafer with the plasma etcher according to reports of Takahashi et al. [3] It is also reported that the ISPM even with etching equipment by using specific sequence is able to use for monitoring between run and run of the wafer processing. [4]

This time, ISPM was installed in the mass production 300-mm plasma etcher. The ISPM count throughout one cleaning cycle and the correlation with the mass production yield were investigated. ISPM was installed in a part of the bypass exhaust line (diameter 25mm) connected with a dry pump as shown in Figure 1. Polystyrene latex polymer (PSL) particle is used as shown in Figure 2, and the sensitivity of ISPM used in this experiment is more than diameter 0.25 μ m and a detection efficiency of about 50%. It executed between

25 wafers processing as shown in Figure 3, the main valve was shut to the turbo pump, and the particle measurement by ISPM was executed in the bypass line. At this time, the particles are dispersed by impressing a shock wave, an electromagnetic stress respectively, and gas viscosity transports them into ISPM. Figure 4 shows the flow of purge sequence for the particle measurement. [5]

Figure 5 shows the ISPM count after maintaining the chamber and the transition of the number of particles on the wafer. As for the number of particles on the wafer, the tendency cannot be admitted by Sugimoto's technique. [2] On the other hand, the ISPM count takes the decreasing tendency immediately after maintenance. It steadies almost though it is uneven after the day second. Then, it approximated to exponential each transition before the second day and after the day second. As it approximates to $y = 142e^{-1.98x}$ and $y = 4.89e^{-0.015x}$ as shown in Figure 6 and Figure 7, the coefficient is greatly different.

The production yield processed with the etching equipment used to experiment is shown in Figure 8 and Figure 9 for a period the above-mentioned respectively. The initial yield shown in Figure 8 is approximated linearly to $y = -2.0x + a$ (a is arbitrary), and the yield has fallen with the repeated etching processes. On the other hand, the yield at latter term approximated to $y = 0.3x + b$ (b is arbitrary), is constant regardless of the repeated etching processes. From these results, it has been found to be able to monitor the yield decrease by managing the logarithmic index of the ISPM count.

References

- [1] S. Umehara et al., Proc. ISSM (2002), p. 429
- [2] M. Sugimoto, Proc. ISSM (2008) PC-P-033
- [3] K. M. Takahashi et al., J. Vac. Sci. Technol. A 14 (1996) 2983
- [4] R. Burghard et al., Proc. ISSM (2006), p.7
- [5] T. Moriya et al., IEEE Trans. Semicond. Manufact., 18 (2005) 477

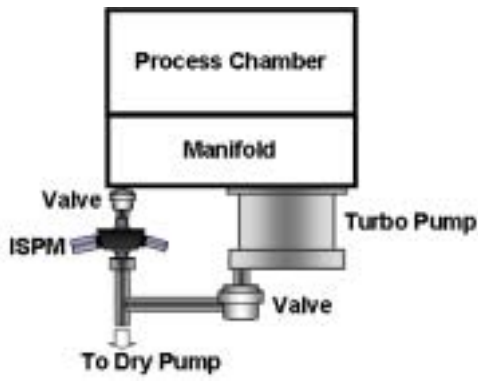


Fig. 1 Experimental setup

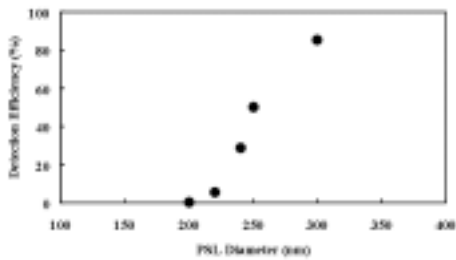


Fig. 2 Sensitivity of ISPM

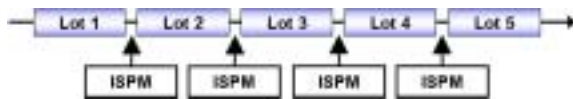


Fig. 3 ISPM measuring timing

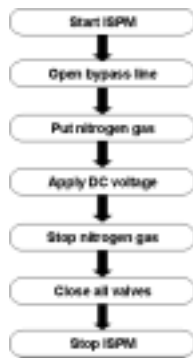


Fig. 4 Sequence for measuring

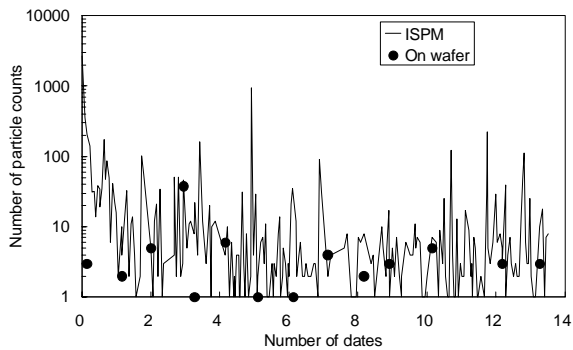


Fig. 5 Trend for ISPM count and number of particles on a wafer

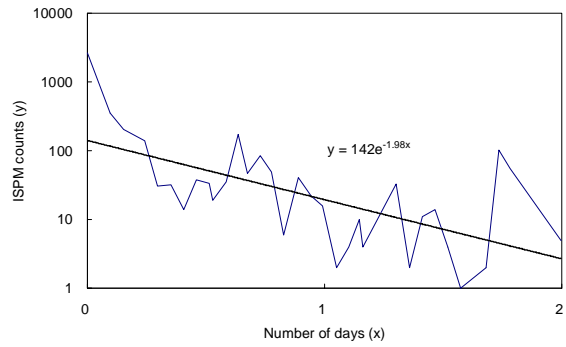


Fig. 6 Approximation result (initial 2 days)

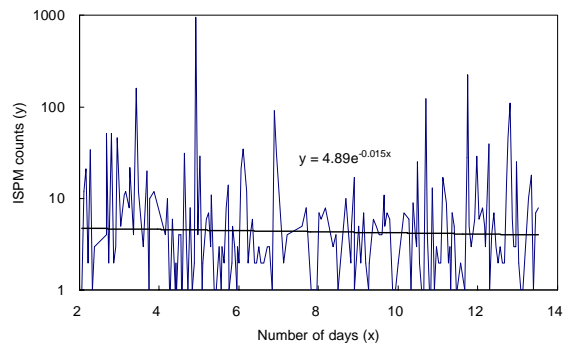


Fig. 7 Approximation result (after 2 days)

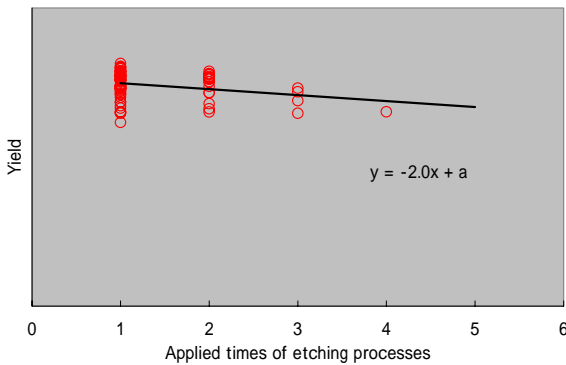


Fig. 8 Yield corresponding to applied times of etching processes (initial 2 days)

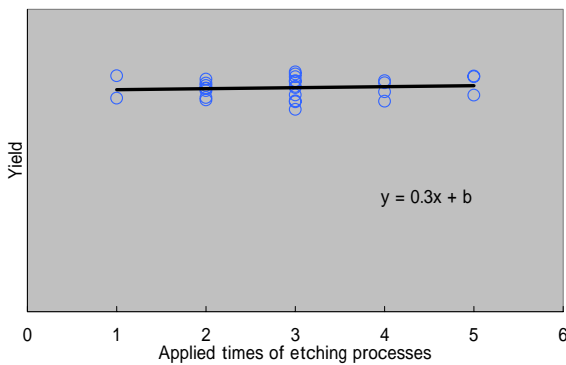


Fig. 9 Yield corresponding to applied times of etching processes (after 2 days)