# Optimization of a Brush Scrubber for Nano-Particles

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## INTRODUCTION

To ensure high device yields, wafer surface contamination and defects must be monitored and controlled at several points in the semiconductor manufacturing process. Wafer scrubbers are among the tools used to achieve such control. This article describes the evaluation and optimization of a brush scrubber for the removal of nano-particles. $SiO_2$ particles on nitride substrates is chosen as a model system. To measure nano-particles on wafers, we investigated the haze instead of the individual LPD of high density particles based on a linear relationship between the amount of particles and average haze on wafers.

## EXPERIMENTAL

Wafers are 200mm p-type, monitor, <100> with 150nm nitride layer on 15nm pad-oxide. After IMEC-clean, wafers were intentionally contaminated with Clariant Klebosol PL30S25 $SiO_2$ slurry particles ($\phi$=35±10nm) using an immersion based contamination procedure (approximately $4\times10^4$ #/wafer, by measuring long tail of particles at $\phi_{LSE}$ = 0.1-0.2 µm with KLA-Tencor SP1 [TBI]). Contaminated wafers were processed using standard brushes followed by a Lineagoni [TM] dry on Damasclean [TM] tool from STEAG MicroTech. The effect of different factors of brush scrubber such as brush speed, wafer speed, brush-wafer distance, *pH* and cleaning time upon Particle Removal Efficiency (PRE) was evaluated using a Design-Of-Experiment software with a linear design. The effect of loading the brushes with particles was also assessed by running wafers with extremely high contamination levels (approximately $4\times10^6$ #/wafer, $\phi_{LSE}$ = 0.1-0.2 µm).

## RESULTS & DISCUSSIONS

The haze signal and number of LPDs are proportional to particle concentration in the liquid solution (Figure 1), which results in a linear relationship between haze and LPDs on wafers. Therefore, without knowing the absolute calibration factor, nano-particles on wafers can be determined by haze measurements. As Figure 2 shows, brush-wafer distance is the most critical factor and is becoming more and more important as the particle size becomes smaller. Its further optimization is depicted in Figure 3. A brush-wafer distance below –2.2mm is thought to be optimal. By running highly contaminated wafers, the effect of brush loading was investigated (Figure 4). When processing with UPW, the PRE decreases drastically as a function of the number of wafers processed. However, this loading problem can be eliminated greatly by using diluted $NH_4OH$ during the processing, especially when very small particles (haze signal) are concerned.

## CONCLUSIONS

The haze can be used to monitor the deposition of nano-particles on wafers. Brush-wafer distance is shown to be the most important factor of brush scrubber and it becomes more critical when smaller particles are concerned. As already discovered, brush scrubber clean is a mechanical friction process. There exist serious loading problems when highly contaminated wafers are processed, which can be eliminated greatly when right chemicals, such as diluted $NH_4OH$, are used during the processing.

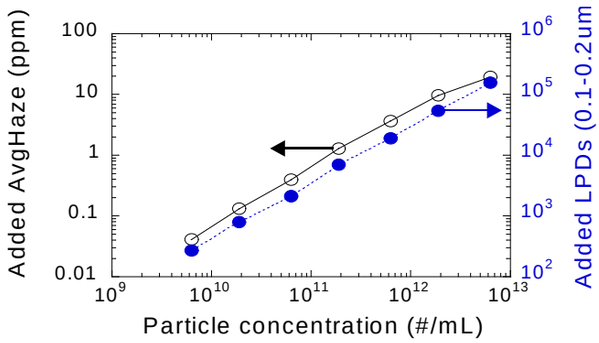


Figure 1: Added average haze and added LPDs (0.1 - 0.2 µm) on nitride wafers contaminated with $SiO_2$-Clariant slurry particles as a function of particle concentration in a contamination bath (measurements: KLA-Tencor SP1 [TBI], oblique incident bean, wide angle detector).

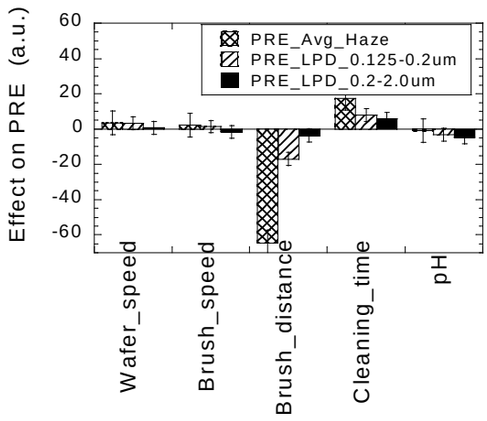


Figure 2: Results of the Design Of Experiment analysis performed on the brush scrubber.

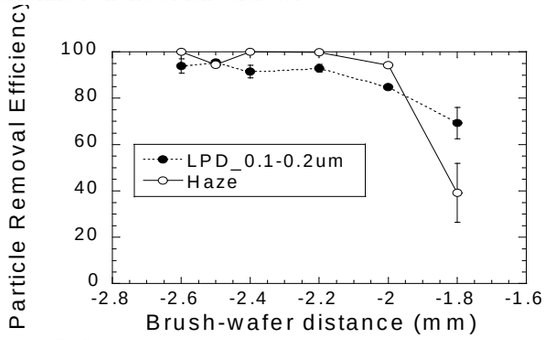


Figure 3: Particle removal efficiency calculated using haze and LPDs after brush scrubber clean as a function of brush-wafer distance.

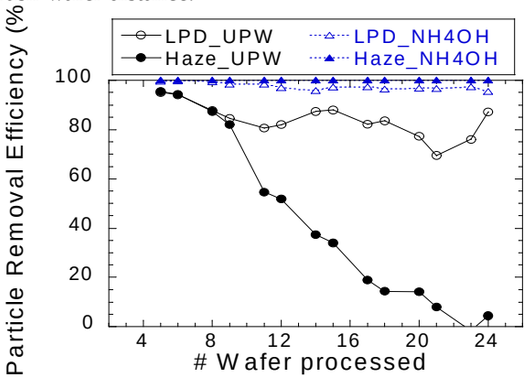


Figure 4: Effect of the number of wafers processed on the particle removal efficiency for highly contaminated wafers after brush scrubber clean using UPW and diluted $NH_4OH$.