Ceria CMP Slurry Monitoring

AccuSizer® Mini FX

OVERVIEW

Chemical mechanical polishing/planarization (CMP) is a process widely used in the microelectronic industries to smooth surfaces with the combination of chemical and mechanical forces. This process uses an abrasive and corrosive slurry to help planarize the surface of a wafer. The particle size distribution of the slurry is a critical parameter controlling the success of the planarization process. Cerium oxide (ceria) based slurries are becoming more widely used in a variety of CMP applications for integrated circuit (IC) manufacturing. This application note documents the ability of the AccuSizer® Mini FX to accurately measure the size and concentration of ceria CMP slurries, and determine the presence of tails to the distribution.

INTRODUCTION

The CMP process and CMP slurries are widely used for polishing during microcircuit manufacturing. The health of the CMP slurry is crucial to maximize device yields, requiring regular measurement of the particle size distribution (PSD) of the slurries. In addition to the mean size of the PSD, the monitoring technique should ideally be sensitive to the presence of tails (i.e. the small concentration of larger particles away from the main peak of the distribution). These tails can come from contamination, aggregation due to changes in chemistry, CMP delivery systems, or from applied shear forces. The relationship between the large particle count (LPC) >0.5 – 1 µm and defect, or scratch count, has been well established, and the ideal characterization system should provide an accurate LPC value.

PARTICLE SIZE/COUNTING TECHNIQUES

There are many particle characterization techniques being used to measure the size and concentration of particles in CMP slurries. Light scattering techniques including dynamic light scattering (DLS) and laser diffraction can measure the size and breadth of the distribution, but do not provide any useful concentration information. Single particle optical sizing (SPOS) measures the particles one-at-a-time as they pass through a narrow measurement chamber, providing both an accurate size and concentration (particles/mL) result. SPOS is an inherently high resolution technique capable of detecting the tail of a distribution removed from the main population. It is the ideal technique for detecting the LPCs, that causes the most trouble with CMP slurries.

Some instruments are best used in the laboratory while others, such as SPOS, can be used both in the lab and online at point-of-use.

THE ACCUSIZER MINI

The AccuSizer has been used for years by CMP slurry manufacturers and end-users to detect the presence of large particle tails. Depending on the slurry, the measurement can be made at full concentration, or with automatic dilution to optimize conditions for the analysis.

The AccuSizer Mini FX system, shown above is designed to work with smaller particle sizes and higher concentrations. The FX sensor uses a focused beam to reduce the total volume inspected, thus increasing the concentration limit of the sensor, and often allowing for measurement without dilution. The FX sensor measures particles from 0.65 – 20 µm at concentrations, 200 times greater than standard light extinction or scattering sensors. The results can be displayed in up to 512 size channels.

The AccuSizer Mini is designed for the requirements of the process line. A built-in touch screen computer controls the operation. The user connects a side stream of the CMP slurry, a stream of filtered DI water (for cleaning and dilution, if necessary), an air line at 50 MPa to control pneumatics, and a drain line. The system is fully automated.

SAMPLES USED

Two ceria samples were used in this study; Ceria A with a smaller tail of large particles, and Ceria B with a larger tail of large particles.

RESULTS

Ceria A was analyzed four times to establish the size distribution and concentration of particles in the base sample. The results of four analyses are shown in Figure 1 with concentration on a linear scale and Figure 2 with concentration on a log scale.

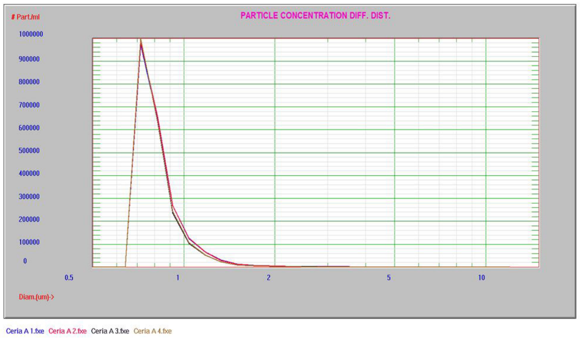

Figure 1. Ceria A, concentration in linear scale

Figure 2. Ceria A, concentration in log scale

Next Ceria A was spiked with ~10 e6 particles/mL of 1.36 polystyrene latex (PSL) standard particles to prove the ability to detect the large particles. The result is shown in Figures 3 and 4.

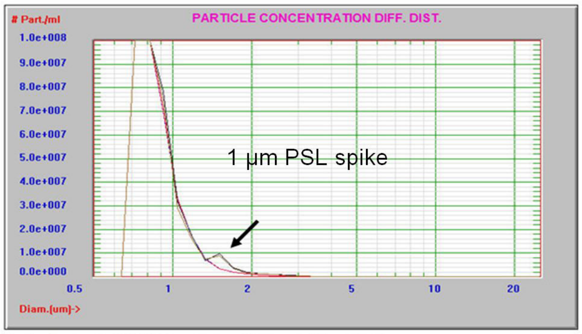

Figure 3. Ceria A (red) + 1 µm PSL spike (black)

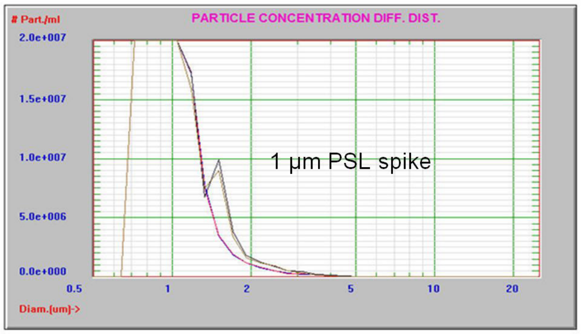

Figure 4. Same as Figure 3, but with 8 x expansion on the y-axis

Ceria A was then spiked with 1% (Figure 5) and 10% (Figure 6) of Ceria B that contains a longer tail of larger particles. The results in Figures 5 and 6 show both the sensitivity to tails and the excellent reproducibility of the AccuSizer due to the statistical confidence from measuring so many particles.

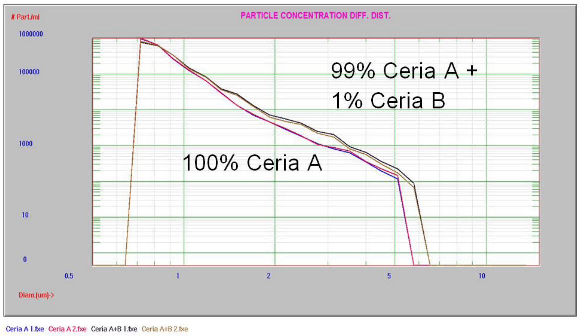

Figure 5. Ceria A spiked with 1% Ceria B

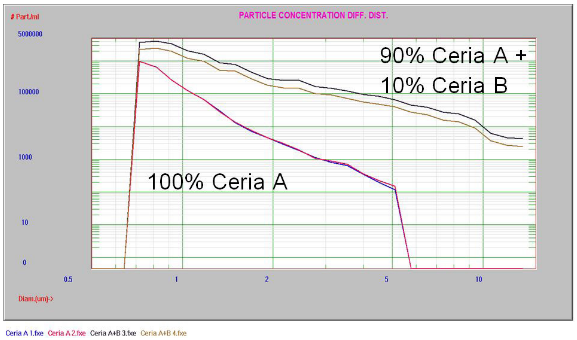

Figure 6. Ceria A spiked with 10% Ceria B

CONCLUSIONS

These results confirm that the AccuSizer Mini FX is an accurate, easy-to-use analytical tool to detect the presence of low concentration LPC particles. This system can be used in the lab or in the fab. The Mini FX analyzers can be located anywhere in the process, and are often placed after the final filters to monitor the slurry before it comes in contact with the wafers in the polishing tool as shown in Figure 7.

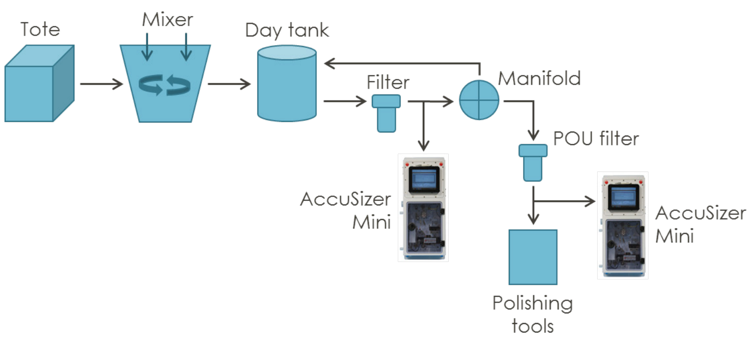

Figure 7. The AccuSizer Mini in the wafer processing process

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Entegris

Corporate Headquarters
129 Concord Road
Billerica, MA 01821
USA

Customer Service
Tel +1 952 556 4181
Fax +1 952 556 8022
Toll Free 800 394 4083