Post CMP Clean Effluent Endpointing and Monitoring with the LNS System

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Chemical Mechanical Planarization (CMP)
- Widely used and accepted planarization method
- Consumes large quantity of slurry
- Introduces defects and contaminations that must be removed

Post CMP Cleaning
- Megasonic cleaning
- **Brush scrubbing** Most widely used
- Fluid jet
- Spin rinse dry
Post CMP Clean – Brush Scrubbing

Abrasive Particles

– Removal efficiency not linear with cleaning time
– Removal rate is size dependent

(Kim, H.J., Defects and Post CMP Cleaning, ICPT 2018)
Post CMP Clean – Endpointing

- Combined removal of chemical and physical cleaning
- Mixed effect of particle removal and cross contamination
- Size dependent removal characteristics
- Complex behavior that needs a better monitoring method

(Kim, H.J., Defects and Post CMP Cleaning, ICPT 2018)
Particle Characterization – Size and Concentration

Dynamic light scattering
  – Requires high concentrations
  – Dependent on sample temperature and viscosity
  – No concentration information
  – Inconsistent multimodal performance

Nanoparticle Tracking Analysis
  – Functional down to 20 nm
  – Dependent on sample temperature and viscosity

Liquid Nanoparticle Sizing System (LNS)
  – Application to measurements at previously unattainable size thresholds
Quantifying Particle Size Distribution in Liquid

- In situ optical techniques do not provide concentration information
- Microscopy methods are costly and time consuming
- Volume concentration standards provide method to calibrate the true aerosolization rate, $R_{Aerosol}$

$$R_{Aerosol} = \frac{C_{Vol,Aerosol} Q_{Aerosol}}{C_{Vol,Hydrosol}}$$

![Diagram showing aerosolization and particle size distribution measurement processes.](image)
Liquid Nanoparticle Sizer (LNS) Advantages

- High sizing resolution comparing to other in-situ particle size distribution measurement techniques
- Reports absolute particle concentration information instead of relative signal intensity

LNS System with Patented Nebulizer Design

UPW in

Gas in

Patent granted
Post CMP Clean Effluent Monitoring with LNS

Experimental Setup

- Silicon wafer loaded with CMP slurry
- UPW flows toward the wafer surface to mimic a simplified post CMP clean process
- **Real-time** monitoring of the effluent by the LNS system using direct injection mode
Post CMP Clean Effluent Monitoring with LNS

- Particle Size Distribution Mode

**Number Weighted Slurry Particle Size Distribution**

- **Begin Rinse**
  - 1:20 PM
  - 1:22 PM
  - 1:24 PM
  - 1:26 PM

**UPW Background**

**Alumina**
Post CMP Clean Effluent Monitoring with LNS

- Cumulative Particle Number Concentration
LNS Results with Different Slurries

- Cleaning rate varies with particle size

**Ceria**

**Number Weighted Colloid Particle Size Distribution**

- 1:40 PM
- 1:44 PM
- 1:47 PM

**Zirconia**

**Number Weighted Colloid Particle Size Distribution**

- 3:03 PM
- 3:08 PM
- 3:13 PM
- 3:18 PM
LNS Results with Different Slurries

- Cleaning rate varies with slurry type

**Cleaning Rate for Different Slurries**

- Ceria
- Zirconia

For Ceria:
\[ y = -1 \times 10^{13} \ln(x) + 3 \times 10^{13} \]

For Zirconia:
\[ y = -5 \times 10^{12} \ln(x) + 1 \times 10^{13} \]
LNS Single Channel Monitoring Mode

- Particle count data reported at 1 Hz rate for the selected size channel

80nm Single Channel Monitoring

Cleaning target spec

Alumina
The LNS system is a perfect fit for characterizing size distribution of particles in post CMP cleaning effluent with its high sizing resolution, absolute concentration measurement, fast-response, and online, real-time monitoring capability.

The LNS system can be operated in:

1) Size distribution mode
2) Single channel mode

Cleaning rate of slurry particles varies with particle size and slurry type.

Complex CMP particle cleaning behavior can be understood and monitored using the LNS System.
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THANK YOU

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