AccuSizer $FX$

Online Monitoring of Particle Size in CMP Slurries by SPOS, Requiring Little or No Dilution

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♦ **Features of AccuSizer\textsubscript{FX}**

- High Concentration
  - Little or NO Dilution
- High Resolution: Single-particle Optical Sensing
- High Accuracy
- High Reproducibility
- Sensitivity to outliers several standard deviations above the mean diameter
- Adjustable lower size threshold limit
- Fast, easy to use

♦ **Applications**

- CMP Slurries
- Emulsions (oil/water)
- Dispersions
- Paints
- Inks / Pigments
- Ceramics
- Filtration media
- Homogenized products
- Abrasives
- Protein aggregates
- Macromolecules
Light-Extinction (LE) -- Momentary decrease in light intensity transmitted across a flow channel, caused by the passage of a particle through a very small optical sensing zone (OSZ). Mechanisms: refraction and scattering
High Resolution … using SPOS
High Concentration … AccuSizer $F_X$

Light Extinction (LE) -- Stylized representation of signal pulse produced by a single particle passing through the OSZ.

Useful size range of AccuSizer $F_X : \approx 0.6$ to $25 \mu m$
High Resolution (SPOS) and High Concentration (AccuSizer $FX$)

TRI-MODAL #1: 0.5-uL 1-μm + 1-uL 1.36-μm + 2-uL 1.59-μm uniform latex particles (1% w/w), added to 40-ml water. Measured volume: 16-ml
High Resolution (SPOS) and High Concentration (AccuSizer $FX$)

TRI-MODAL #2: same as TRIMODAL #1, but only 1/2 the amount of 1-µm latex particles (0.25-µL added to 40-ml water).
High Resolution (SPOS) and High Concentration (AccuSizer $F_X$)

TRI-MODAL #3: same as TRI-MODAL #1, but only 1/4 the amount of 1-μm latex particles (0.125-μL added to 40-ml water)
# High Resolution and Accuracy

## Summary of Latex Tri-modal Standard Results

# Particles/ml/1000 -- Measured PSDs vs Expected Values

<table>
<thead>
<tr>
<th>Tri-Modal</th>
<th>1-µm Peak</th>
<th>1.36-µm Peak</th>
<th>1.59-µm Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PSD</td>
<td>Expected</td>
<td>PSD</td>
</tr>
<tr>
<td>#1</td>
<td>318</td>
<td>325</td>
<td>165</td>
</tr>
<tr>
<td>#2</td>
<td>168</td>
<td>163</td>
<td>190</td>
</tr>
<tr>
<td>#3</td>
<td>67</td>
<td>81</td>
<td>187</td>
</tr>
</tbody>
</table>
Online Particle Size Monitoring of Concentrated CMP Slurries
High Sensitivity to Outliers ...
... the Key to Determining CMP Slurry Health

Silica CMP Slurry (SS25) -- full working concentration
High Sensitivity to Outliers ...  
... the Key to Determining CMP Slurry Health

Silica CMP Slurry (SS25) -- *full working concentration*  
Y-Axis expanded 20× to emphasize large-particle outliers
High Sensitivity to Outliers …  
… the Key to Determining CMP Slurry Health

Silica CMP Slurry (SS25) -- full working concentration
"Spike" of 1-μm latex particles added to raw slurry ($\approx 1.3 \times 10^5$ /ml)
High Sensitivity to Outliers ... … the Key to Determining CMP Slurry Health

Silica CMP Slurry (SS25) -- *full working concentration*
“Spike” of 1-μm latex particles (≈ 0.5 ppm) added to raw slurry
Y-Axis expanded 20× to emphasize the added latex spike
High Sensitivity to Outliers …
… the Key to Determining CMP Slurry Health

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
≈ $7 \times 10^8$ particles/ml larger than 1.15-μm in starting slurry
High Sensitivity to Outliers …
… the key to Determining CMP Slurry Health

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
“Spike” of 2.013-μm latex particles added to slurry (≈ 9 \times 10^6 /ml)
High Sensitivity to Outliers … … the Key to Determining CMP Slurry Health

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
Result of subtracting plain-slurry PSD from spiked-slurry PSD
High Sensitivity to Outliers …
… the Key to Determining CMP Slurry Health

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
Result of subtracting plain-slurry PSD from spiked-slurry PSD
Y-Axis expanded 100×  Spike conc. ≈ 7 × 10^6 /ml
High Reproducibility ... 
... the Key to Reliable AccuSizer $F_X$ Measurements

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
Overlay of four consecutive measurements (120-sec each)
High Reproducibility ...  
... the Key to Reliability of AccuSizer $F_X$ Results

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
Overlay of four consecutive measurements (120-sec each)
Y-Axis expanded 100×
High Reproducibility ...
... the Key to Reliability of AccuSizer $F_X$ Results

Cerium Oxide CMP Slurry (Hi8005) -- 160:1 dilution
Overlay of four consecutive measurements (120-sec each)
Y-Axis expanded an additional 10× (total: 1000×)
AccuSizer $FX$

*High Sensitivity at High Concentration ... ... a powerful (and unique) combination!*

* The AccuSizer$_{FX}$: The KEY to QUALITY

  - When particles several standard deviations away from the mean diameter of the distribution spell disaster (low yield) ... COUNT on the AccuSizer$_{FX}$ to detect and quantify them. The first step in solving a problem is identifying its root cause.

  - AccuSizer$^\text{TM}$ - Trademark of Particle Sizing Systems
  - $FX$ Technology - Patents Pending