Defects Panel Discussion

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Issues in Defects

• Nanoparticle standards for inspection system calibration
• Characterization of nanoparticle contaminations
• AMC and Haze
NIST PSL Particle Standard: 60 and 100 nm

Measurement of 100 nm and 60 nm Particle Standards by Differential Mobility Analysis

The peak particle size and expanded uncertainties (95% confidence interval) for two new particle calibration standards are measured to 101.6 nm ± 1.1 nm and 60.59 nm ± 0.61 nm. The particle samples are polystyrene spheres suspended in filtered, deionized water at a mass fraction of about 0.5%. The DMA distribution measurements of aerosolized particles were made using a differential mobility analyzer (DMA) system calibrated using SRM (1845 (100 nm polystyrene sphere)). An aerodynamic aerosol generator was used for generating the 60 nm aerosol to almost eliminate the generation of multiply-charged dimers and trimers, and to minimize the effect of non-volatile contamination increasing the particle size. The tuning for the ionization of the DMA and for the presence of remaining using dynamic light scattering is described. The use of the transfer function integrals in the calibration of the DMA is shown to reduce the uncertainty in the measurement of the peak particle size compared to the approach based on the peak in the concentration vs. voltage distribution. A modified aerosol/salt solution, recirculating salt bath, high purity salt bath, and a stainless steel bath were used to reduce the uncertainty in the measurement of the peak particle size. The specific correlation between the slip correction of the calibration particle and the measured particle. Including the correlation reduced the expanded uncertainties from approximately 1.5% of the particle size to about 0.5%. The effect of non-volatile contaminations in the DMA system on the peak particle size and the uncertainty in the size is determined. The DMA size distributions for both the 60 nm and 100 nm spheres are analyzed and selected mass sizes including the number mean diameter and the dynamic light scattering mean diameter are compared. The use of these particles for calibrating optical and the monitoring deposition standards to be used with surface scanning inspection systems is discussed.

Key words: differential mobility analysis, dynamic light scattering, electrical mobility, aerodynamic aerosol generator, particle size calibration standards, transfer function.

Accepted: June 20, 2000

Available online: http://www.nist.gov/pst
Nanometer Differential Mobility Analyzer
(Nano-DMA)
Modal (Peak) Diameter and Expanded Uncertainty
(95 % Confidence Interval) for Two New NIST SRMs®

- Nominal 100 nm Polystyrene Spheres
  101.76 nm ± 1.1 nm

- Nominal 60 nm Polystyrene Spheres
  60.41 nm ± 0.61 nm

100 nm spheres along with 205 nm spheres – Duke Scientific Co.

60 nm spheres with 200 nm length scale in bottom left of image – JSR Co.
Issues with PSL Particle Standard

- Different light scattering than particles from processes
- Decomposition from exposure to deep ultra-violet (DUV) lights
- Deformation due to adhesion forces

Demand for Particle Standardization

- Calibration of surface inspection tools with particles of different materials
- Development of accurate size standards
- Providing samples for cleaning studies
SiO$_2$ Particles in Original Suspension
Generation of Monodisperse Aerosols

Nanometer Differential Mobility Analyzer (Nano-DMA)
40 nm Classification from Polysciences SiO$_2$

Original Distribution

SEM Image of 40 nm SiO$_2$

1$^{st}$ DMA

2$^{nd}$ DMA
Electrostatic Deposition

Deposition chamber: a modified Standard Mechanical Interface (SMIF) pod

$N_{in} = Q_{in} C_a t$
Deposition Results on a Quartz Blank

**Deposition plan**  
**target 2000 per spot**

- 60nm PSL # ~ 2010  
- 50nm PSL # ~ 2060  
- 40nm PSL # ~ 2000  
- 80nm PSL # ~ 1930  
- 80nm SiO2 # ~ 1950  
- 60nm SiO2 # ~ 1820  
- 50nm SiO2 # ~ 2060  
- 40nm SiO2 # ~ 2010  
- 30nm SiO2 # ~ 1980

**Inspection results using Lasertec M1350 at Intel, Santa Clara, CA.**

- 60PSL  
- 80PSL  
- 80SiO2  
- 60SiO2

- The size of the four deposition spots is about 25 mm, very close to the target size of 25.4 mm.
- The deposition numbers computed from $N_{in} = Q_{in} C_a t$ are within the range of the target number ± 5%.
Scanner Counting Efficiencies

The diagrams show the capture efficiency (%) as a function of particle diameter ($d_p$) for different materials and coatings. The key materials include PSL on quartz, PSL on chrome, SiO2 on quartz, and SiO2 on chrome. The graphs illustrate how the capture efficiency varies with particle size for each material, highlighting the differences in efficiency under various conditions.
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Effect of Secondary Packaging

**Controlled Vibration**
- ISTA Procedure 1G at 1.15 $G_{\text{rms}}$
- Vertical position
- Particle detection on 4” wafers

- This work was done in cooperation with Entegris.

- Secondary packaging is helpful in reducing particle generation
Particle Source Identification

**ATOFMS**

- Complex organic compound or mixture
- Possibly polymer


**Mask Scan**

- Contact points between the mask surface and pins

- Particles come mostly from contact points between mask surface and pins
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Haze Observed under Atmospheric and Vacuum Conditions

50nm SiO$_2$. Target deposition area: 1 inch spot size at the center. Testing time: 2 min. (Atmospheric Pressure)

100 nm PSL particle. (Main Chamber $p = 50$ mTorr). Testing time: 1.5 hours
## Airborne Molecular Contaminants (AMCs)

### Classification of AMCs

<table>
<thead>
<tr>
<th>Acids</th>
<th>Bases</th>
<th>Condensable</th>
<th>Dopants</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>AMINE</td>
<td>DOP, DBP, DEP</td>
<td>B$_2$H$_6$, BF$_3$, AsH$_3$, TCEP, TEP, TPP</td>
</tr>
<tr>
<td>HCl</td>
<td>NH$_3$, NMP, HMDS</td>
<td>Siloxanes, BHT</td>
<td></td>
</tr>
<tr>
<td>H$_3$PO$_4$</td>
<td>H$_2$O$_2$, O$_3$, IPA, Acetone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

- **No Classes**

SEMI Standard F21-95, 1996
High speed injection, 100 nm, 10 K/cm (Vacuum)

Main Chamber $p = 50$ mTorr
Flow rate = 0.075 lpm
Particle C = 11000 p/cc
Testing time: 50 min
Particle speed: 11.3 m/s
Critical speed: 10.722 m/s

100 nm particles mainly correspond to 20 pixel particles. About 500 20-pixel particles are added.