Agenda

- Hard Disk (HD) Filtration Roadmap
- HD Manufacturing Processes: Need for Finer Level of Filtration
- Use of advanced filter design to achieve fine filtration with high flows
  - Unique Filter Pleating methods
  - Asymmetric membrane
- Asymmetric membrane performance validation
- Field performance data
### Road Map for Hard Disk (HD) Filtration

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>2004</th>
<th>2005</th>
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<th>2007</th>
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<td>Areal Density (Gb/in²)</td>
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<td>Head Flying Height (nm)</td>
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<tr>
<td>Particle, pits count sizes (nm)</td>
<td>&gt; 100nm @ 10</td>
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<tr>
<td>Scratch width (nm)</td>
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<td>Scratch depth (nm)</td>
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</table>

### HDD Filtration Filters

- **200nm Inorganic Fiber**
- **200 nm Polypropylene**
- **30nm PolyArylSulfone**
- **30nm PolyEtherSulfone**
- **40nm, 20nm Asymmetric Polyamide**
- **10nm Asymmetric Polyamide**
- **100nm PolyArylSulfone**
- **200nm Inorganic Fiber**
- **100 nm Polypropylene**
Typical Hard Disk Process

- Blank → ID/OD Cutting → Cleaning → Grinding
- → Plating → Cleaning → Polishing → Cleaning
- → Inspection → Cleaning → Texturing → Cleaning
- → Sputtering → Cleaning → Lubing → UV Baking
- → Tape Burnish → Testing → To HDD assembly

**Cleaning is critical in Hard Disk processing to**

- Reduce product defects
- Increase product yields

**Use of specially-designed filtration products allow us to meet those targets!!**
Design of Filtration System

Inputs

- **Contamination**
  (particle size distribution, quantity, properties, etc.)

- **System design**
  (bath, pump, piping, housing, acoustics, etc.)

- **Cleaning medium**
  (DIW, Hot DIW, detergent, chemicals, solvents, etc.)

- **Process condition**
  (temp, pressure, flow rate, time, etc.)

Filter Requirements

- flow rate
- differential pressure
- cleanliness
- compatibility
- life
Filtration Specification Directions

**DIRECTIONS**

- **removal rating**
  - < 50nm

- **material**
  - suitability
  - compatibility

- **flow vs dP**
  - > 1.00 gpm/psid/10”

- **cleanliness**
  - lowest extractable
    - metal, organic, particles
• **BUT Flowrate typically reduces as pore size becomes smaller**

• **Sub50nm filter need design change to minimize flow losses!!**
Filter Design to Increase Flowrates

Increase filter media area

Increase filter diameter

Material Engineering

Ultipleat is a registered trademark of Pall Corporation
Membrane design

Symmetric

Asymmetric

* Cross section profile of Pall membranes; SEM 500X
Asymmetric design benefits

- Benefits include
  - Reduced membrane differential pressure
  - Increased flow rate

Flowrate \( Q \) a function of membrane structure \( k \), pressure drop across filter \( \Delta P \)
\[ Q \propto (k, \Delta P) \]
Variety of asymmetric membranes developed for sub 50nm needs

**Sub 50nm Asymmetric Filters Flow rate**

<table>
<thead>
<tr>
<th>Material</th>
<th>Flowrate (gpm/psid/10&quot;, DIW)</th>
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</thead>
<tbody>
<tr>
<td>Polyamide 40nm</td>
<td>0.0 - 1.0</td>
</tr>
<tr>
<td>Polyethersulfone 30nm</td>
<td>TBA</td>
</tr>
<tr>
<td>Polyarylsulfone 30nm</td>
<td>0.0 - 1.0</td>
</tr>
<tr>
<td>Polysulfone 30nm</td>
<td>0.0 - 1.0</td>
</tr>
</tbody>
</table>

**Chemical structures**

- Polyamide: \((\text{NH}-(\text{CH}_2)_6-\text{NH}-\text{CO}-(\text{CH}_2)_4-\text{CO})_n\)
- Polysulfone: \((\text{O}_2-\text{S}-\text{O})_n\)
- Polyethersulfone: \((\text{O}_2-\text{S}-\text{O})_n\)
- Polyarylsulfone: \((\text{O}_2-\text{S}-\text{C}_6\text{H}_4\text{S}-\text{O})_n\)
Filter Retention Measurement Methods

- How then is particle retention performance validated ??

Eg. Dynamic Light Scattering ICP-MS *

Eg. Laser Particle counters Limit to 30nm
Faster bath cleanup achieved through:

- Higher flowrates
- Higher filter retention efficiency
Validation of Flowrate Effects

Increased flowrates results in faster bath cleanup!

Filter with good flow is required!!
Asymmetric Filter Particle Retention Validation

\[ \beta_x \times \text{Removal Efficiency} = \frac{\beta_x - 1}{\beta_x} \times 100 \]

- Filter efficiency testing using
  - Single pass mode
  - Single size 30 nm PSL spheres
  - 30nm particle counter

Test Filter | Efficiency (%)^* \\
------------|------------------- \\
1           | 99.98            \\
2           | 99.98            \\
3           | 99.82

*SLS Lab Proj No. MEGAS4106; PolyArylSulfone 30nm filter testing*
Asymmetric Filter Cleanliness Validation

- Rapid rinseup >18 MOhms.cm
- Low organic extractables
- Fast particle rinseup
- ppb metal extractables; acid extraction

Filter cleanliness controlled to meet desired cleanliness levels!!
Field Testing Data – HD Media Cleaning Process

- 3 asymmetric Polysulfone filter samples, 100nm, 50nm, 30nm, were tested in media cleaning process

- Significant Defect Count reduction with 30nm filter !!

Average Disk Defect Count Comparison with Various Filter Rating

- Asymmetric PolySulfone 100nm: 73%
- Asymmetric PolySulfone 50nm: 27%
- Asymmetric PolySulfone 30nm: 0%
Field Testing Data – HD Media Cleaning Process

- PALL Polysulfone 30nm single stage filter tested against 2 stage filters
  - Lower bath particles achieved with 1 stage finer filter!!
Conclusion

• Future HD roadmap requires:
  • finer filtration
  • minimal flow losses
  • clean and compatible materials

• Solution
  • Sub-50nm asymmetric filters with
    • good flows
    • good retention efficiencies
    • low extractables
    • quick rinse-up performance
    • different material choices
THANK YOU