**Nanoimprint Lithography Molds**

1. **Nickel Mold for Thermal Nanoimprint**

   Improvement of fabrication process for Optical Disk Mold
   - Advanced Lithography: Fine features, Large area, ...
   - Optimization of electroforming process

   **Mold Fabrication Process**

   (i) Fine Type A:
   - EB Resist Master
   - Si-wafar → EB lithography → Seed layer formation → Ni Electroplating → Peel off

   (ii) Fine Type B:
   - Etched-Si Master
   - Dry etching & Resist remove → Seed layer formation → Ni Electroplating → Peel off

   (iii) Large Type
   - Quartz Substrate → Photo lithography → Seed layer formation → Ni Electroplating → Peel off

   **Example of developed structures**

   - **Fine Type A**
     - (height: ~300nm)

   - **Fine Type B**
     - (hexagonal dot, width & height: 1 μm)

   - **Large Type**
     - (height: ~1 μm)

   - 30 μm width short Line (400x280mm area)
   - Line & Space (2 μm / 1 μm)
2 Quartz Mold for UV Nanoimprint

Using equipment and materials for Photomask fabrication
- Max. mold size: 6 inch square
- Easy to obtain fine features with good uniformity

Mold Fabrication Process

Quartz Substrate → Sputtering of Mask layer → Resist coating & EB lithography → Mask layer etching → Substrate etching → Mask remove

Example of Quartz structures

<table>
<thead>
<tr>
<th>Simple Structures, Small Features</th>
<th>Multi Layer type for Dual Damascene</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1 Line &amp; Space (50 nm depth)</td>
<td>M2 width: 600nm</td>
</tr>
<tr>
<td>Dot (50 nm height)</td>
<td>M2 width: 200nm</td>
</tr>
<tr>
<td>Hole (50 nm depth)</td>
<td></td>
</tr>
</tbody>
</table>

3 Silicon Mold for Thermal Nanoimprint

Applying fabrication process of EB Stencil Masks
- Max. mold size: 200 mm diameter
- Suitable for high aspect ratio structures

Mold Fabrication Process

Silicon Substrate → Resist coating & EB lithography → Substrate etching → Mask remove

Example of Silicon structures

<table>
<thead>
<tr>
<th>50nm 1:1 trench</th>
<th>High A / R structures</th>
<th>Tapered structures</th>
<th>Whole Wafer Mold</th>
</tr>
</thead>
<tbody>
<tr>
<td>100nm 1:1 trench</td>
<td>120nm hole</td>
<td></td>
<td>Opening Size:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5µm</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>2µm</td>
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<td></td>
<td>1µm</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Depth: 3µm</td>
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</tbody>
</table>