AR2 and AR3 DUV Anti-Reflectants are organic, thermally cross-linking bottom anti-reflectants designed to provide outstanding reflection control under DUV photoresists for excellent CD control over topography. Relative to other organic anti-reflectants, AR2 and AR3 provide excellent conformality over topography.

AR2 and AR3 have been formulated to work as a system with Shipley advanced DUV photoresists to meet sub-180 nm design rules. They also act as a chemical barrier between the photoresist and substrate, presenting a common substrate for all layers.

AR2 and AR3 are available in two dilutions. AR2-600 and AR3-600 are formulated for coatings in the range of 550–750Å over reflective substrates. AR2-900 and AR3-900 are formulated for coatings in the range of 800–1,200Å over thick dielectrics.

**Features:**
- First minimum thickness at 600Å on Si
- High optical density at 248 nm
  - AR2 ≈ 9.0/µm
  - AR3 ≈ 9.6/µm
- E₀ swing curve ≤3%
- Excellent CD control over topography
- Wider process windows than planar silicon
- Steep sidewalls and excellent profiles with Shipley DUV photoresists
- Good conformality for excellent step coverage
- Compatibility with common spin-coating and EBR solvents
- Fast etching

**Equipment Preparation**

When converting plumbing from BARL™ or CD-11™ to AR2 or AR3, first flush lines with cyclohexanone or gamma-butyrolactone solvent to thoroughly remove previous BARC residues. Next, flush lines again with propylene glycol methyl ether, AR2 or AR3 to provide a compatible solvent medium.
Substrate

AR2 and AR3 are compatible with a wide range of substrates, including silicon, SiO₂, polysilicon, Si₃N₄, TiN, and aluminum. Do not use adhesion promoters, such as hexamethyldisilazane (HMDS).

Coat

AR2 and AR3 are spin bowl compatible with common spin-coating and EBR solvents (see Table 1). Dedicated spin bowl and drain lines are not required.

<table>
<thead>
<tr>
<th>Table 1. Compatible Solvents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethyl lactate</td>
</tr>
<tr>
<td>Propylene Glycol Methyl Ether</td>
</tr>
<tr>
<td>Propylene Glycol Methyl Ether Acetate</td>
</tr>
<tr>
<td>60% PGME/40% PGMEA</td>
</tr>
<tr>
<td>50% PGMEA/50% Methyl Ethyl Ketone</td>
</tr>
</tbody>
</table>

Figure 3 shows the relation between spin speed and film thickness for 6-inch substrates. Nominal film thickness may vary slightly due to process, equipment, and ambient conditions.

<table>
<thead>
<tr>
<th>Table 2. Kinematic Viscosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR2-600, AR3-600</td>
</tr>
<tr>
<td>AR2-900, AR3-900</td>
</tr>
</tbody>
</table>

Do not use adhesion promoters, such as HMDS, between anti-reflectants and resist layers.

<table>
<thead>
<tr>
<th>Table 3. Recommended Process Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Film Thickness*: 600Å or 900Å</td>
</tr>
<tr>
<td>Cure*: 195-220°C/60 sec. Proximity Hotplate</td>
</tr>
</tbody>
</table>

*Optimum AR2/AR3 film thickness will depend on substrate reflectivity and topography, film transparency and thickness, and desired etch performance.

Cure

For Shipley resists, linewidth profile at the substrate interface can be controlled by AR2 or AR3 cure temperature. For positive resists, increasing cure temperature minimizes linewidth pinching; decreasing cure temperature minimizes footing. Cure effects on resist profiles are identical for AR2 and AR3. APEX-E and UVN2 profiles are minimally affected by ARC cure temperature.

Shipley has observed optimum performance with DUV Series Photoresists at AR2 and AR3 cure temperatures between 195°C and 220°C. Please contact your TSR for specific recommendations with your equipment and process. Actual results may vary with process, equipment, and ambient conditions such as hotplate proximity gap, resist type, relative humidity, etc.

Film Thickness Measurement

Optical constants, n and k, at 248 nm appear in Table 4.
Table 4. Optical Constants at 248 nm

<table>
<thead>
<tr>
<th></th>
<th>AR2</th>
<th>AR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>1.47</td>
<td>1.46</td>
</tr>
<tr>
<td>k</td>
<td>0.42</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Figure 4 shows the refractive index of AR2 and AR3 as a function of wavelength.

**Figure 4. Dispersion Curves, 205°C Cure**

Cauchy coefficients for AR2 and AR3 are listed in Table 5.

Table 5. Cauchy Coefficients  

205°C Cure Temperature

<table>
<thead>
<tr>
<th></th>
<th>AR2</th>
<th>AR3</th>
</tr>
</thead>
<tbody>
<tr>
<td>n₁</td>
<td>1.548</td>
<td>1.556</td>
</tr>
<tr>
<td>n₂</td>
<td>-3.7e4</td>
<td>3.6e5</td>
</tr>
<tr>
<td>n₃</td>
<td>1.9e13</td>
<td>1.4e13</td>
</tr>
</tbody>
</table>

**Reflection Control**

AR2 and AR3 absorbance spectra appear in Figure 5. AR2 and AR3 films are transparent in the visible region.

A plot of substrate reflectivity is shown in Figure 6. The plot was generated from Prolith/2™ for silicon, polysilicon, aluminum, and TiN.

**Figure 6. AR2 and AR3 Reflectivity over Reflective Substrates**

Contour plots of reflectivity over varying thicknesses of SiO₂ and Si₃N₄ (both over silicon) appear in Figures 7 through 10.
Figures 7 and 10 display reflectivity for AR2 and AR3 films over SiO\textsubscript{2} and Si\textsubscript{3}N\textsubscript{4} on silicon, respectively.

Figures 11 and 12 display swing curves for UV6 over silicon, AR2-600, AR3-600, and BARL.
E\textsubscript{0} swing curves for UVIIHS on silicon and on varying AR2 film thicknesses are shown in Figure 13.

**Figure 13. Swing Curves for UVIIHS on Silicon and Four Film Thicknesses of AR2-600**

![Figure 13](image)

**Etch**

AR2 and AR3 exhibit excellent etch rates relative to BARL or CD-11. Relative etch rates for four RIE processes appear in Figure 14. Corresponding etch recipes appear in Table 6. Etch rates for AR3 typically will be 5–10% slower than AR2.

**Figure 14. Etch Rates of AR2 and AR3 Relative to CD-11**

![Figure 14](image)

![Table 6. Etch Recipes](image)

<table>
<thead>
<tr>
<th>Process</th>
<th>Chamber</th>
<th>Pressure (mT)</th>
<th>Top Power (Watts)</th>
<th>Bottom Power (Watts)</th>
<th>BCl\textsubscript{3} (Sccm)</th>
<th>Cl\textsubscript{2} (Sccm)</th>
<th>He (Sccm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARC Etch</td>
<td>Applied 5000™ (Mark II™Oxide Etch Chamber)</td>
<td>25</td>
<td>600</td>
<td></td>
<td>33</td>
<td>7</td>
<td>80</td>
</tr>
<tr>
<td>Metal Etch</td>
<td>LAM TCP 9600™</td>
<td>10</td>
<td>500</td>
<td></td>
<td></td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Oxide Etch</td>
<td>LAM/Drytek ASIQ™</td>
<td>100</td>
<td>1300</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Poly Etch</td>
<td>Applied 5000 (MXP™ Poly Etch Chamber)</td>
<td>150</td>
<td>500</td>
<td></td>
<td>106</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AR2 and AR3 can be removed with standard photoresist ashing processes and standard H\textsubscript{2}SO\textsubscript{4}/H\textsubscript{2}O\textsubscript{2} type processes.

A plasma ash recipe for AR2 and AR3 appears in Table 7.

**Table 7. GaSonics Aura 2000LL™ Downstream Plasma Strip Recipe**

<table>
<thead>
<tr>
<th>Process</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Pressure (T)</td>
<td>2.0</td>
</tr>
<tr>
<td>O\textsubscript{2} Flow Rate (L/min.)</td>
<td>3.75</td>
</tr>
<tr>
<td>N\textsubscript{2} Flow Rate (L/min.)</td>
<td>0.35</td>
</tr>
<tr>
<td>Step Time (sec.)</td>
<td>30</td>
</tr>
<tr>
<td>Low Lamp on Time (sec.)</td>
<td>30</td>
</tr>
<tr>
<td>High Lamp on Time (sec.)</td>
<td>18</td>
</tr>
</tbody>
</table>

*200 nm wafer size
Handling Precautions

WARNING! AR2 and AR3 are flammable liquids containing propylene glycol methyl ether. Keep liquid and vapor away from heat, sparks, and open flame. Irritation to eyes, nose and respiratory tract can occur. Do not get in eyes or on skin. Avoid breathing vapors. Use with adequate ventilation and avoid breathing vapors and mists. Wash thoroughly after handling and always wear chemical goggles, gloves, and suitable protective clothing. In case of eye or skin contact, flush affected areas with plenty of water for at least 15 minutes.

Consult Product Material Safety Data Sheet before using.

Waste Treatment

AR2 and AR3 contain propylene glycol monomethyl ether. They may be included with other wastes containing similar organic solvents to be discarded for destruction or reclaim in accordance with local, state, and federal regulations.

Storage

Store AR2 and AR3 in an upright, sealed original container in a dry area at 30–50°F away from heat and sunlight. Keep away from alkaline materials, acids, and oxidizers.

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