Honeywell UVAS™ Polymer
A Silicon-Rich Middle Layer for ArF and KrF Tri-Layer Patterning Applications

INTRODUCTION TO UVAS POLYMER PRODUCTS

The UVAS technology is a SiO-rich siloxane polymer designed for use as the middle layer (etch transfer layer) in both ArF and KrF tri-layer patterning in state-of-the-art IC devices. UVAS polymer also functions as a superb hard mask material for double patterning and EUV lithography. UVAS polymer is synthesized using monomers tailored to meet the lithographic and etch requirements for these demanding applications.

UVAS films include anti-reflective properties for ArF and KrF patterning and a high Si content for optimum etch selectivity to the photoresist and organic underlayer. UVAS products meet all the material shelf life properties required for the IC manufacturing environment.

FEATURES & BENEFITS

- Wide DOF (depth of focus) and collapse margin with multiple photoresist and underlayer systems (Figure 1)
- Optically matched with multiple photoresist and underlayer systems
- High silicon content for selective etch transfer exhibiting very high etch selectivities relative to the photoresist and organic underlayers. (Figure 2)
- UVAS polymer acts as a Si-BARC with no queue-time effects.
- Compatible with photoresist track and drain systems
- Excellent shelf life properties—spun UVAS films have excellent room temperature stability and may be stored for greater than nine months in a photoresist refrigerator. (Figure 3)

<table>
<thead>
<tr>
<th>Blanket Film Etch Selectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVAS to ArF resist (fluorocarbon based etch chemistry)</td>
</tr>
<tr>
<td>HM8006 underlayer to UVAS (oxygen based etch chemistry)</td>
</tr>
</tbody>
</table>

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**Figure 1**

50nm L/S Features Patterned-Wide DOF and Collapse Margin

**Figure 2**

UVAS-A425 Thickness vs. Rsub

**Figure 3**

Substrate Reflectivity – Long Term +5°C and RT Aging Study
UVAS FILM APPLICATIONS

- UVAS™ layers may be used as:
  - BARC
  - Masking Layers
  - Etch Selectivity Layers

- Conventional Lithography (ArF, KrF & EUV)—
  UVAS layers have been successfully used in patterning 248nm and 193nm optical resists. The adhesion control as well as reflectivity control allow the integrator to select the best combination of thinness for reflectivity control vs. thickness required for etch masking. (Figures 4, 5 and 6)

- Double Patterning Applicability —
  A spun UVAS film is an outstanding choice as a BARC for a variety of double patterning applications. The stability of the cured polymer offers excellent resistance to chemical freeze systems.
  - UVAS Si-BARCs and hard masks exhibit inconsequential degradation during optical freeze processing of resist, such as high intensity 172nm freeze.
  - UVAS layers do not suffer significant loss of antireflective capability during the resist freezing, which allows optimum process of the second photoresist during double patterning. (Figure 9, back page)

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EL & DOF Comparison — BARC vs. Tri-layer
80nm space / 160nm pitch

![Graph showing DOF comparison between BARC and tri-layer](image)

Exposure Latitude

<table>
<thead>
<tr>
<th>RESULTS</th>
<th>BARC</th>
<th>A414 / HM8006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope</td>
<td>3.36</td>
<td>3.41</td>
</tr>
<tr>
<td>y-intercept</td>
<td>-43.55</td>
<td>-44.43</td>
</tr>
<tr>
<td>ecd</td>
<td>36.81</td>
<td>36.47</td>
</tr>
<tr>
<td>10%</td>
<td>39.19</td>
<td>38.81</td>
</tr>
<tr>
<td>-10%</td>
<td>34.42</td>
<td>34.12</td>
</tr>
<tr>
<td>EL</td>
<td>-12.95</td>
<td>-12.86</td>
</tr>
</tbody>
</table>

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73nm L/S Pattern Etch

Selectivity | UVAS-A814:PR | 2.5:1 | HM8006: UVAS-A814 | 45:1

![Images showing resist patterning after UVAS-A814 etch and HM8006 etch](image)

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Substrate Reflectivity vs. NA & UVAS-Ax39 Thickness

1st Min

![Graph showing substrate reflectivity vs NA and UVAS-Ax39 thickness for 1st Min](image)

2nd Min

![Graph showing substrate reflectivity vs NA and UVAS-Ax39 thickness for 2nd Min](image)

Min Rs at 30~40nm UVAS FT for all NA

UVAS-Ax39 Thickness for Minimum Rs Identified

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- UVAS-Ax39 SiBARC (n=1.68, k=0.15 @193nm)
- JSR HM8006 Underlayer (n = 1.53, k = 0.28 @193nm 200nm FT)
  - Simulation parameter:
    - No immersion top-coat used in the simulation
    - Photoresist thickness is set as infinity

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WORKING WITH UVAS

- UVAS™ polymer is compatible with conventional lithography spin tracks. It may be plumbed to PR catch-cups and nozzles.
- Recommended Coat Parameters:
  - Predispense 0.5ml
  - Dynamic Dispense* 4ml / wafer
  - Edge Bead Removal—PGMEA or similar solvent
  - Backside Rinse—PGMEA or similar solvent
  - Single 60sec Bake
  - Bake range of 150°C to 300°C
  * See Spin Speed Curves (Figure 8)
- Photoresist Only Rework:
  - UVAS layers are resistant to PR solvents
  - No change in the litho process window after PR rework processing
  - PGMEA has been identified as the best PR rework solvents (Figure 7)
- Full Stack Rework:
  - UVAS layer and underlayer removal is possible using commercially available and Low-k compatible post-etch cleaning chemistries
  - Complete removal of UVAS-A films in piranha etch has been demonstrated

UVAS Polymer Coated on 300mm Bare Si Wafers, 250°C 90sec Hot Bake Plate—Film Thickness is Measured Using Spectroscopic Woollam Ellipsometer

For UVAS-A339:  Thickness = 8712.3 * (RPM)^{-0.4414}

For UVAS-A839:  Thickness = 21996.4 * (RPM)^{0.4534}

Figure 7

Figure 8

Effect of Rework on Depth of Focus (70nm L/S)

<table>
<thead>
<tr>
<th></th>
<th>ECD (mJ/cm²)</th>
<th>EL (%)</th>
<th>Mclps (%)</th>
<th>Line width at Mclps (nm)</th>
<th>DOF (µm)</th>
<th>LWR (nm) at 0.05µm focus</th>
<th>LWR (nm) at 0.15µm focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM2073J / UVAS-A339</td>
<td>24.02</td>
<td>13.03</td>
<td>20.70</td>
<td>50.10</td>
<td>&gt;0.85µm</td>
<td>8.90</td>
<td>7.20</td>
</tr>
<tr>
<td>(reworked) AM2073J / UVAS-A339</td>
<td>24.02</td>
<td>12.17</td>
<td>20.70</td>
<td>49.00</td>
<td>&gt;0.85µm</td>
<td>7.10</td>
<td>8.30</td>
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<tr>
<td>ARX2895JN / UVAS-A314</td>
<td>32.07</td>
<td>11.70</td>
<td>13.80</td>
<td>54.00</td>
<td>0.55µm</td>
<td>5.30</td>
<td>4.10</td>
</tr>
<tr>
<td>(reworked) ARX2895JN / UVAS-A314</td>
<td>33.30</td>
<td>12.42</td>
<td>18.60</td>
<td>48.40</td>
<td>0.55µm</td>
<td>5.40</td>
<td>7.60</td>
</tr>
<tr>
<td>ARX1221J / UVAS-A825</td>
<td>30.57</td>
<td>12.89</td>
<td>14.50</td>
<td>56.50</td>
<td>0.55µm</td>
<td>12.40</td>
<td>10.40</td>
</tr>
<tr>
<td>(reworked) ARX1221J / UVAS-A825</td>
<td>31.27</td>
<td>10.87</td>
<td>11.90</td>
<td>56.30</td>
<td>0.70µm</td>
<td>11.20</td>
<td>10.90</td>
</tr>
</tbody>
</table>
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UVAS/HM8006 Stack with UV Flood Exposure Treatment Yields Excellent Double Patterning Lithography Results

Test Process Flow Diagram

| 1st Layer Lithography | UV Flood Exposure (High Dose) | Post UV Treatment | 2nd Layer Lithography | CD Measurement |

X-grid structure
Layer 1 P120nm* (V) 1st Pattern
Layer 2 P120nm* (H) 2nd Pattern

Pitch-split structure
Layer 1 P320nm* (V) 1st Pattern
Layer 2 P320nm* (H) 2nd Pattern

60nm X-grid Test Result (x/y axis)

80nm Pitch-split Test Result (x/y axis)

Honeywell LEADERSHIP IN ELECTRONIC MATERIALS

Established SOG Supplier for the IC Industry
- Over 30 years proven history of supplying SOG to the IC industry.
- Long-standing supply relationships with key industry players.
- World-class experts in formulated electronic polymers for the IC industry.
- Financial stability and backing by a major multinational company.

Best in Technology
- Dedicated R&D engineers in US and Asia (>50) for new EP (electronic polymers) products and commercialized product support.
- EP Products qualified for 45 and 32nm nodes, R&D programs in 22nm and 18nm nodes.
- Regional technical support with fab experience to address application issues.
- Widest selection of spin-on electronic polymers for IC applications.
- Customized formulations to address specific customer needs.

Best in Customer Service
- Dedicated account managers to service customer needs closely.
- Fast customer response.
- Well-established logistic infrastructure to optimize supply channel, ensure quality and timeliness, and enable rush delivery in case of emergency.

Industry Leading Quality System
- ISO9000 & TS 16949 certified quality control system.
- In-house application and metrology capabilities.
- In-house analytical capabilities.
- Audited supplier quality systems.
- Change control system.

HEM PUBLICATIONS

a. A High-Si Content Middle Layer for ArF Tri-layer Patterning

b. Performance of an ArF Siloxane BARC Exposed to a 172-nm UV Cure for Double Patterning Applications

c. High-Si Content BARC for Dual-BARC Systems Such as Tri-layer Patterning

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