Technical Report

ZEP7000

ZEONrex Electronic Chemicals

High Resolution Positive Electron Beam Resist

ZEON CORPORATION

Specialty Materials Division

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Specialty Materials Division

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Process conditions and data are examples.
They will not guarantee the same data in customers’ process.
1. Characteristics

ZEP7000 series are high performance positive EB resists which show high resolution, high sensitivity and dry etch resistance.

They are suitable for mask making, including the 50kV process.

(1) Resolution
   It shows high resolution and rectangle pattern profiles.
(2) Resistance to dry etching
   It shows high dry etch resistance and are almost equivalent to that of positive photoresist generally used.
(3) Sensitivity
   It shows high sensitivity.

2. Properties

<table>
<thead>
<tr>
<th>Item</th>
<th>Mw</th>
<th>Viscosity (mPa’s)</th>
<th>Solvent</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZEP7000</td>
<td>340,000</td>
<td>22.5</td>
<td>Diethylene glycol dimethyl ether</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP7000-17</td>
<td>340,000</td>
<td>17</td>
<td>Diethylene glycol dimethyl ether</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP7000B-32</td>
<td>340,000</td>
<td>32</td>
<td>o-Dichlorobenzene</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP7000B-48</td>
<td>340,000</td>
<td>48</td>
<td>o-Dichlorobenzene</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP7000A</td>
<td>340,000</td>
<td>(19.5)</td>
<td>Anisol</td>
<td>1QT bottle</td>
</tr>
</tbody>
</table>
3. Developer

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZED-400</td>
<td>high sensitivity</td>
<td>1GL bottle</td>
</tr>
<tr>
<td>ZED-450</td>
<td>fine pattern for spray</td>
<td>1GL bottle</td>
</tr>
<tr>
<td>ZED-500</td>
<td>fine pattern for spray</td>
<td>1GL bottle</td>
</tr>
<tr>
<td>ZED-750</td>
<td>fine pattern for puddle</td>
<td>1GL bottle</td>
</tr>
</tbody>
</table>

4. Rinse

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZMD-D</td>
<td></td>
<td>1GL bottle</td>
</tr>
</tbody>
</table>

5. Thinner

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZEP-S</td>
<td>o-Dichlorobenzene</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP-D</td>
<td>Diethylene glycol dimethyl ether</td>
<td>1QT bottle</td>
</tr>
<tr>
<td>ZEP-A</td>
<td>Anisol</td>
<td>1QT bottle</td>
</tr>
</tbody>
</table>

6. Remover

<table>
<thead>
<tr>
<th>Item</th>
<th>Remarks</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZDMAC</td>
<td></td>
<td>1GL bottle</td>
</tr>
</tbody>
</table>
7. Spin curves

**Process conditions**
Substrate: 4inch Si Wafer
Spin: 300rpm×3sec.→1000~5000rpm×177sec.
Bake: 180°,180sec.(Hot plate)
8. Dilution rate and Film thickness

1) Dilution Rate
   \[ \frac{\text{Original Resist(g)} + \text{Solvent(g)}}{\text{Original Resist(g)}} \]

Solvent: ZEP7000/Diethyleneglycol dimethyl ether
   ZEP7000A/Anisol

Process conditions
   Substrate: 4inch Si Wafer
   Spin: ZEP7000 300rpm×3sec.→490rpm×177sec.
   ZEP7000A 300rpm×3sec.→550rpm×177sec.
   Bake: 180°, 180sec.(Hot plate)
9. Dependence on prebake temperature

**Dose to clear**

- **Bake temp. (°C)**
  - 150, 160, 170, 180, 190, 200, 210
- **Dose to clear (µ C/sqcm)**
  - 3, 4, 5, 6, 7, 8, 9

**Residual thickness**

- **Bake temp. (°C)**
  - 150, 160, 170, 180, 190, 200, 210
- **Residual thickness (%)**
  - 80, 85, 90, 95, 100

**Process conditions**
- Substrate: 4inch Si Wafer
- Bake: 180sec.(Hot plate)
- Film thickness: 5000Å
- DEV.: ZED500, 23°, 180sec.
10. Dependence on film thickness

Process Conditions
Substrate: 4inch Si Wafer
Bake: 180°C, 180sec.(Hot plate)
DEV.: ZED500, 23°, 180sec.
11. Dependence on develop temperature/time

**Process Conditions**
- Substrate: 4inch Si Wafer
- Bake: 180°C, 180sec.(Hot plate)
- Film thickness: 5000Å
- EXP.: ELS3300, 20kV
- DEV.: ZED500, 180sec.
12. Dependence on developer

Process Conditions
Substrate: 4inch Si Wafer
Film thickness 5000Å
Bake: 180°C, 180sec.(Hot plate)
EXP.: ELS3300, 20kV
DEV.: ZED400, 23 °C, 90sec.
    ZED450, 23 °C, 90sec.
    ZED500, 23 °C, 180sec.
    ZED750, 23 °C, 180sec.
<table>
<thead>
<tr>
<th>C / sqcm</th>
<th>1.5 μm L/S</th>
<th>1.0 μm L/S</th>
<th>0.7 μm L/S</th>
<th>0.5 μm L/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.9 μC / sqcm</td>
<td><img src="image1.png" alt="Image" /></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 μC / sqcm</td>
<td></td>
<td><img src="image2.png" alt="Image" /></td>
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<td></td>
</tr>
<tr>
<td>3.5 μC / sqcm</td>
<td></td>
<td></td>
<td><img src="image3.png" alt="Image" /></td>
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</tr>
<tr>
<td>3.9 μC / sqcm</td>
<td></td>
<td></td>
<td></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>4.2 μC / sqcm</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4.4 μC / sqcm</td>
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</tr>
<tr>
<td>4.8 μC / sqcm</td>
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</tr>
</tbody>
</table>

SUBSTRATE: 4 inch Cr Wafer  
RESIST: ZEP7000  
Prebake: 180°C, 180sec., Hot plate  
F.T.: 5000Å  
EXP.: ELS3300, 20keV  
DEV.: ZED400, 23 °C, 90sec., Dipping  
RINSE: ZMD-D, 23 °C, 10sec., Dipping
ZED450

ZED-450, 0.6 μm isolated holes at accelerating voltage of 50kV

ZED-450, hole patterns at accelerating voltage of 50kV
<table>
<thead>
<tr>
<th>SUBSTRATE: 4 inch CrOx Wafer</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESIST: ZEP7000</td>
</tr>
<tr>
<td>Prebake: 180°C, 180sec., Hot plate</td>
</tr>
<tr>
<td>F.T.: 5000Å</td>
</tr>
<tr>
<td>EXP.: ELS3300, 20keV</td>
</tr>
<tr>
<td>DEV.: ZED500, 23 °C, 180sec., Dipping</td>
</tr>
<tr>
<td>RINSE: ZMD-D, 23 °C, 10sec., Dipping</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>10 μ C/cm²</th>
<th>11 μ C/cm²</th>
<th>12 μ C/cm²</th>
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</thead>
<tbody>
<tr>
<td>1.00 μm L/S</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>0.90 μm L/S</td>
<td><img src="image4.png" alt="Image" /></td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>0.80 μm L/S</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
<td><img src="image9.png" alt="Image" /></td>
</tr>
<tr>
<td>0.70 μm L/S</td>
<td><img src="image10.png" alt="Image" /></td>
<td><img src="image11.png" alt="Image" /></td>
<td><img src="image12.png" alt="Image" /></td>
</tr>
<tr>
<td>0.60 μm L/S</td>
<td><img src="image13.png" alt="Image" /></td>
<td><img src="image14.png" alt="Image" /></td>
<td><img src="image15.png" alt="Image" /></td>
</tr>
<tr>
<td>0.50 μm L/S</td>
<td><img src="image16.png" alt="Image" /></td>
<td><img src="image17.png" alt="Image" /></td>
<td><img src="image18.png" alt="Image" /></td>
</tr>
<tr>
<td>0.45 μm L/S</td>
<td><img src="image19.png" alt="Image" /></td>
<td><img src="image20.png" alt="Image" /></td>
<td><img src="image21.png" alt="Image" /></td>
</tr>
<tr>
<td>0.40 μm L/S</td>
<td><img src="image22.png" alt="Image" /></td>
<td><img src="image23.png" alt="Image" /></td>
<td><img src="image24.png" alt="Image" /></td>
</tr>
<tr>
<td>0.35 μm L/S</td>
<td><img src="image25.png" alt="Image" /></td>
<td><img src="image26.png" alt="Image" /></td>
<td><img src="image27.png" alt="Image" /></td>
</tr>
<tr>
<td>0.30 μm L/S</td>
<td><img src="image28.png" alt="Image" /></td>
<td><img src="image29.png" alt="Image" /></td>
<td><img src="image30.png" alt="Image" /></td>
</tr>
<tr>
<td>0.25 μm L/S</td>
<td><img src="image31.png" alt="Image" /></td>
<td><img src="image32.png" alt="Image" /></td>
<td><img src="image33.png" alt="Image" /></td>
</tr>
<tr>
<td>0.20 μm L/S</td>
<td><img src="image34.png" alt="Image" /></td>
<td><img src="image35.png" alt="Image" /></td>
<td><img src="image36.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>18 μ C/cm²</td>
<td>19 μ C/cm²</td>
<td>20 μ C/cm²</td>
</tr>
<tr>
<td>-------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>1.00 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.90 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.80 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.70 μ m L/S</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>0.60 μ m L/S</td>
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</tr>
<tr>
<td>0.50 μ m L/S</td>
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<td></td>
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</tr>
<tr>
<td>0.45 μ m L/S</td>
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<tr>
<td>0.40 μ m L/S</td>
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<tr>
<td>0.35 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.30 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.25 μ m L/S</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>0.20 μ m L/S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SUBSTRATE: 4 inch CrOx Wafer
RESIST: ZEP7000
Prebake: 180°C, 180sec., Hot plate
F.T.: 5000Å
EXP.: ELS3300, 20keV
DEV.: ZED750, 23 °C, 180sec., Dipping
RINSE: ZMD-D, 23 °C, 10sec., Dipping
13. Dry etch resistance

(1) CF₄ Dry Etching Rate

**CF₄ Dry Etching Condition**
0.15torr, 70sqcm. 200W

(2) Cl₂ + O₂ Dry Etching Rate

**Cl₂ + O₂ Dry Etching Condition**
Cl₂/O₂ = 4/1, 5 min.
14. Resist removing

(1) Resist removing conditions

① deep-UV + organic solvent (ZDMAC)
② deep-UV + H₂SO₄-H₂O₂ (90~100°C)
③ H₂SO₄-H₂O₂ (90~100°C)

(2) Mw Change by Deep-UV Irradiation

Process conditions
- Film Thickness: 5000Å
- Bake: 180°C, 180sec.(Hot plate)
- Equipment: HMW-457 (ORC MANUFACTURING CO., LTD.)
- Lamp: Low Pressure Mercury Vapor Lamp
  (185nm+254nm)
- Illumination: 10mW/cm²
15. CD-Linearity

CD linearity for isolated hole at accelerating voltage of 20kV or 50kV (with PEC)
*PEC; Proximity effect correction

CD linearity for isolated spaces and holes at accelerating voltage of 50kV (with PEC)
16. Mask fabrication process

1. Resist coating
   (1) Blanks cleaning
   (2) Coating
   (3) Prebake
   (4) Coolong

2. Lithography
   (1) EB exposure
   (2) Development
   (3) Rinse

3. Post bake

4. De-scum

5. Etching

6. Resist removing
17. Handling precautions

(1) Flammable Liquid.
(2) Harmful by inhalation.
(3) Avoid contact with skin and eyes.

CAUTION: Open carefully. Use in well ventilated area. In case of contact with skin and eyes, rinse immediately with plenty of water for 15 minutes and get medical attention.

In case of fire use Alcohol form CO₂ or dry chemical, never use water.

STORAGE: Keep capped and away from oxidants, spark and open flame. Store at cool [32°F(0°C) ~77°F (25°C)] and dark place. Use in clean room.
18. Appendix

(1) Refractive index of ZEP7000 film

Cauchy coefficient
\[ n = n_0 + \frac{n_1}{\lambda^2} + \frac{n_2}{\lambda^4} \]
\[ n_0 = 1.541093 \]
\[ n_1 = 4.113002 \times 10^5 \]
\[ n_2 = 4.070357 \times 10^{12} \]

absorption coefficient = 0

unit of \( \lambda \): Å

measured by UV-1250/SE (KLA Tencor)

(2) Glass transition temperature of ZEP7000 polymer

Tg : 148°C measured by DSC

__< U.S.A > __

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