HANTOP: An Effort on Photoresist Localization

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OUTLINE

- Lithography Evolution
- Photoresist Evolution and Challenges
- HANTOP Photoresist Introduction
- SUMMARY
Lithography Evolution with Logic Device Development

- Lithography defines the transistor speed (L: CD) and density (R: Pitch)...
Photoresist Evolution with Exposure Wavelength

- **Power**: Low laser power introduce CAR type to ensure WPH.

- **Transparent**: Polymer type evolution due to absorption increase with light wavelength decrease.

- **Resolution**: Shorten acid diffusion length (ADL) with Polymer/PAG/Base modulation to achieve high resolution.

### Mercury Lamp
- G-line 436nm
- I-line 365nm

### Excimer Laser
- KrF 248nm
- ArF 193nm
- ArFi Immersion 193nm

### EUV 13.5nm

#### Resins
- Novolac
- PAC
- Additive
- Solvent

#### Additives
- PHS
- PAG
- Base
- Additive
- Solvent

#### Non-CAR type
- Acrylates
- PAG
- Base
- Additive
- Solvent

#### CAR type
- Acrylates
- PAG (bulky)
- Base (PDB)
- Topcoat (self)
- Solvent

#### NTD resist

#### Inorganic resist
Photoresist Challenges

- Complex system including Organic Chemistry, Polymerization, Photochemistry, Lithography Engineering.

Monomers
- PHS, Acrylates
- Acid-liable/Polar/ETCH Resistance monomers
- high level purification

Polymers
- Most Tri-Tet copolymers
- Monomer type and composition
- Mw/PDI (Statistic-controlled)

Resist Formulation
- Film formation
- PAG or PAC Modulation
- Multi-material Mix process
- Purification

Lithography
* Patterning: Pitch, CD, OPC, Profile, PW, CDU, Defect etc..
* Capable for the following process, like ETCH, WET, IMP etc..
HANTOP: Local Photoresist Company

- China photoresist is not ZERO in the past, BUT almost lost for more than 20 years.
- HANTOP setup in 2014, with technique background from HuaFei at 2004.
HANTOP Photoresist: “IDM” Mode

- Self-Developed Technique
- Self-Controlled Supply Chain
- Lab to Factory

Photoresist
10+ projects cooperation with customers, including ArF, KrF, Iline, Ebeam, Bumping resist

Polymers
PMMA, PHS, Acrylates polymers with electrical level, including lab and factory scale

Solvent & Additives
Factory purification system

PAGs
Iline, KrF, ArF PAGs

Monomers
Mature self-making factory products

配套材料电子级加工生产

光刻胶

树脂聚合物

几十种248，193NM系列电子级高纯单体

十多种电子级高纯PAG

Lab to Factory

Self-Developed Technique

Self-Controlled Supply Chain
HANTOP Photoresist Introduction

- **Customerization** with self-developed technology instead of BENCHMARK.
- **Focusing on CAR type and Negative Resist;**
- **Advance Ebeam resist solution to bridge the gaps.**

<table>
<thead>
<tr>
<th>GHI Line</th>
<th>I Line</th>
<th>KrF</th>
<th>ArF(i)</th>
<th>Ebeam</th>
</tr>
</thead>
<tbody>
<tr>
<td>436-365nm</td>
<td>365nm</td>
<td>248nm</td>
<td>193nm</td>
<td>&lt; 1nm</td>
</tr>
</tbody>
</table>

- **GHI Line**
  - 436-365nm
  - Slip & Sinking
    - HTF4110
    - 60~120um
  - Slip & Sinking
    - HTF4025
    - 18~40um
  - Slip & Sinking
    - HTH688
    - 8~60um

- **I Line**
  - 365nm
  - Lift off & Risso
    - HTI560系列
    - 1-8um
  - Lift off & Risso
    - HTIN160系列
    - 0.8~7um
  - Lift off & Risso
    - HTI251
    - 0.7~1um

- **KrF**
  - 248nm
  - HTK800系列
    - 8~15um
  - HTK510系列
    - 2~5um
  - Lift off & Risso
    - HTKN601
    - 0.6~1.2um
  - HTK109-0.9
    - 7500A~1.2um
  - HTK109-0.4
    - 4000A~6000A

- **ArF(i)**
  - 193nm
  - KrF BACKUP
    - HTA205
    - 1.7~2.5um
  - KrF BACKUP
    - HTA150
    - 4500A~7500A
  - N90 Mx
    - HTP120nm
    - 2500A~4000A
  - N55 Mx
    - HTP95mm
    - 1700A~2800A
  - N55 Vx
    - HTP95mm
    - 2000~3500A
  - HNQ
    - RE500

- **Ebeam**
  - < 1nm
  - Chemical R2209系列
  - PMMA
    - RE300系列
  - High-resolution RE650
  - HSQ RE500
HANTOP I-line Fast CAR series: HTI560*

- **What we may suffer with I-line Novolac resist?**
  - High dose especially for thick resist slow down scanner WPH and increase lens heating;
  - Taper Profile due to less transparent;
  - Resolution limitation due to less contrast.
  - High Outgassing;

- **What we can gain with I-line CAR resist?**
  - Low dose (Fast);
  - Total CoO Reduction;
  - Straight Resist Profile;
  - High Resolution;
  - Less Outgassing
HANTOP I-line CAR series: HTI560*

- Fast I-line CAR resist with Eop 100-200mj;
- High Resolution (AR>4) with good PW;
- Straight Profile; Good D-I bias; High thermal resistance;

Thickness coverage: 8um-2.5um

2um LS
THK 8um AR=4

1um ISO space
THK 7um AR=7

1um LS/ ISO space
THK 5um AR=5

0.8m LS/ ISO space
THK 4um AR=5

0.6um LS/ ISO space
THK 2.5um AR=4

HB130C 300S
HANTOP I-line CAR series:

- HTI560-5: 0.8um Patterning @ THK=5UM (AR=6)

Process condition:
Si+5umPR, PAB130C90s, PEB110C90s, NA 0.63, Nikon I12, Binary mask, Dev 60s, Single puddle
HANTOP KrF Thick Resist series (3D NAND Application)

- Challenge increase with resist thickness.
  - Film formation: Crack, Viscosity, Thickness, Uniformity (THU), Pin Hole
  - Patterning: Adhesion (Peeling or Foot Crack), Sensitivity, Residue, Profile (Taper)
  - Integration: ET resistance
HANTOP KrF Thick Resist series: **HTK81x_15um**

- **Thickness:** 5 to 15um
- **Reasonable Sensitivity:** 40-60mj
- **Controlled Profile:** SWA 80-85 varied w/ focus
- **Good film Addhesion, Optical and Mechanical property;**

<table>
<thead>
<tr>
<th>Energy</th>
<th>45mj</th>
<th>48mj</th>
<th>51mj</th>
<th>54mj</th>
<th>57mj</th>
<th>60mj</th>
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</thead>
<tbody>
<tr>
<td>Anchor 5umLine L:S=1:1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5umLine L:S=1:1</td>
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</tbody>
</table>

**Process condition:**
Substrate+PR, PAB140C150s, PEB125C90s, NA 0.55/C 0.6, Nikon S204, TMAH 2.38%, Double Puddle 60S
HANTOP ArF Resist

- More complex and variable approaches to achieve smaller patterning size.
- Higher quality requirement for polymer composition/Mw/PDI, particle, metal ion and sensitivity control.
HANTOP ArF Resist

Co-optimization of Photoresist and Lithography Process

**N90nm**

- HP140nm LS @3000A
  - EL: 12%
  - E=24mj
  - DOF: >0.24um
  - (ADI=140nm)

**N65nm**

- HP90nm LS @2100A
  - EL: 13.5%
  - E=33mj
  - DOF: >0.2um
  - (ADI=90nm)

**N55nm Contact**

- HP90nm Hole @3000A
  - EL: 16%
  - E=36mj
  - DOF: >0.16um
  - (ADI=110nm)
HANTOP ArF Resist: **HTK12x HP90nm hole @3000A**

- Resolution to HP90nm hole patterning with good PW and circularity
- Acceptable MEF ~3.5

<table>
<thead>
<tr>
<th>Resolutions</th>
<th>Images</th>
<th>MEF</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td><img src="image1" alt="Image" /></td>
<td>103.96</td>
</tr>
<tr>
<td>30</td>
<td><img src="image2" alt="Image" /></td>
<td>105.79</td>
</tr>
<tr>
<td>32</td>
<td><img src="image3" alt="Image" /></td>
<td>110.04</td>
</tr>
<tr>
<td>34</td>
<td><img src="image4" alt="Image" /></td>
<td>111.32</td>
</tr>
<tr>
<td>36</td>
<td><img src="image5" alt="Image" /></td>
<td>115.7</td>
</tr>
<tr>
<td>38</td>
<td><img src="image6" alt="Image" /></td>
<td>119.27</td>
</tr>
<tr>
<td>40</td>
<td><img src="image7" alt="Image" /></td>
<td>105.76</td>
</tr>
</tbody>
</table>

**EL 25% DOF >160nm**
HANTOP Ebeam Resist

- Diff. types capable for diff. applications: PMMA series, PHS CAR, P(MCA/MST), HSQ etc..
- Production starting from Y2015, supporting more than 15+ customers for their high-tech researchs.

<table>
<thead>
<tr>
<th>Ebeam Resist</th>
<th>Polymer</th>
<th>Type</th>
<th>DEV</th>
<th>Charatistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE209</td>
<td>PHS CAR</td>
<td>Posi.</td>
<td>2.38% TMAH</td>
<td>CAR, high resistance</td>
</tr>
<tr>
<td>RE300.XX.X</td>
<td>PMMA(70K~950K)</td>
<td>Posi.</td>
<td>MIBK:IPA=1:3</td>
<td>high resolution, bi-layers</td>
</tr>
<tr>
<td>RE610</td>
<td>P(MCA/MST)</td>
<td>Posi.</td>
<td>amyl acetate</td>
<td>high resolution, resistance</td>
</tr>
<tr>
<td>RE500</td>
<td>HSQ</td>
<td>Nega.</td>
<td>2.38% TMAH</td>
<td>high resolution, resistance</td>
</tr>
<tr>
<td>NRE800</td>
<td>PHS CAR</td>
<td>Nega.</td>
<td>2.38% TMAH</td>
<td>CAR, high resistance</td>
</tr>
</tbody>
</table>
SUMMARY

- Photoresist is one of the most complex materials in semiconductor manufacture, supporting and developing with IC technology;

- HANTOP, as a local photoresist supplier, provides variable customerized products with its advantage of self-controlled supply chain and self-developed techniques;
Thank You！
谢谢！