Main Knobs to turn in (CAR) Resist

**Exposure**
- EUV absorption.
- Secondary electron generation.
- Acid formation

**Post Exposure Bake (PEB)**
- Acid diffusion.
- Acid catalyzed deprotection → solubility switch

**Development**
- Dissolution of exposed regions by developer, pattern formation

**Resolution**

- Absorption
  - Absorptivity (Dill B)
  - Resist Thickness
  - Out of band (OOB) sensitivity (photoacid generator (PAG) type, TC)

- (Secondary) electron yield
- Electron blur
  - Material type
- QE (acid yield)
  - PAG type (polarity), PAG load

- Acid diffusion (blur) \( (Q \text{ diff as well}) \)
  - Bulky/Polar/ Bound (PAG,), Tg,
  - Quencher (Photodecomposable)
  - PEB Temperature
- Reaction Efficiency
  - \( E_a \) of Protecting Group

- Pattern Collapse
  - Rinse material
  - Resist type, adhesion
- Development
  - Developer type/size, strength
  - Wetting...

- Rinse material
- Resist type, adhesion

**LWR Sensitivity**

- EUV absorption.
- Secondary electron generation.
- Acid formation

- Acid catalyzed deprotection → solubility switch

- Dissolution of exposed regions by developer, pattern formation
Inorganic Non-CAR EUV resists

- Can print resolutions down to 8 nm lines and spaces
- Consists of nano clusters of ~1nm in size
- Metal Core → ~4x higher absorptivity than CAR resist (capture more photons/volume)
- There are no acids, so no acid diffusion → only electron blur

<table>
<thead>
<tr>
<th></th>
<th>CAR</th>
<th>Non-CAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Photon absorption</td>
<td>Low (C,H,O) ~5 μm⁻¹</td>
<td>High (Sn, Hf) ~20 μm⁻¹</td>
</tr>
<tr>
<td>Chemical noise</td>
<td>High: low PAG concentration</td>
<td>Potentially lower: no acids required</td>
</tr>
<tr>
<td>Etch resistance</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>

Metal oxo-clusters

L⁺ = radiation sensitive ligand

Patterned film

M⁻ + H₂O, L⁺
Current EUV resists face several challenges

Challenging to improve R, L and S simultaneously

- Photon Shot Noise: enough photons needed to have low roughness (dose ↑ PSN ↓)
- Smaller blur needed at smaller pitches
- Absorptivity should increase (Film thickness going down)
- Pattern Collapse: (due to High Aspect Ratio at small pitch)
- Etch resistance should increase (FT going down)
R, L and S are coupled

*challenging to improve simultaneously*

The relation is for a given contrast:

- Improve the Contrast → scanner side
- Improve the relation between R, L and S → resist companies, academia
Non-CAR 13nm dense lines performance

<table>
<thead>
<tr>
<th>13nm H Dense Lines</th>
<th>New Non-CAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEM image @BE/BF</td>
<td>![SEM Image]</td>
</tr>
<tr>
<td>Dose</td>
<td>34 mJ/cm²</td>
</tr>
<tr>
<td>EL</td>
<td>21 %</td>
</tr>
<tr>
<td>DoF</td>
<td>160nm</td>
</tr>
<tr>
<td>LWR</td>
<td>3.8 nm</td>
</tr>
</tbody>
</table>

*Exposures done on NXE:3400 system with standard leafshape dipoleY illumination*
EUV Resist Discussion Points for TWG

1. Models point towards benefit of high absorption → how to efficiently make use of the high absorption?

2. What is the spatial distribution of electrons (secondary electron blur), how to prove experimentally?

3. Does the energy (distribution) of secondary electrons relate to the energy needed for the chemical reaction?

4. Attention to theory and modelling part of development process can be beneficial → how the LWR/LCDU are affected from development?

5. Experimental work on how building block size of resist affect resolution/roughness/dose can be helpful.