Introduction to Plasmas & Chemistries for Etching Novel Materials

Daniel L. Flamm

Microtechnology Law & Analysis

Walnut Creek, CA 94596
email: dlf@microtechnologylaw.com

 создаёт, защищает и приносит доходы IP
5 Classes of Mechanism

- **Sputter Etching**
- **Chemical Etching**
- **Accelerated Ion-Assisted Etching**
- **Sidewall-Protected Ion-assisted Etching**
- **Reactive Ion Etching**
Plasma Etching Options

- Physical/Universal

  - **Sputtering by Ion Bombardment**
    - Energetic Ion Beam (a plasma)
    - Sheath biased plasma

  - **Plasma induced vaporization**
    - Thermal plasma
    - Laser Plasma
Plasma Etching Options

- Physical / Chemical
  - Capacitive in reactive ambient
  - Inductive in reactive ambient
Factors & Process Requirements

- Amount/Thickness/Rate

- Uniformity

- Selectivity

\[ \text{Tradeoff possible} \]

\[ \begin{align*}
\text{Chemical Selectivity} & \quad \text{Threshold/Yield} \\
\text{Physical & Ion-Assisted Chemical} & \quad \text{Plasma Applicator Uniformity}
\end{align*} \]
## Chemistry Options to Form Volatile Products

- **Surface Chemical Gasification (purely)**
  - Stable Gases
  - Radicals
  - Ion Assisted

<table>
<thead>
<tr>
<th>Species</th>
<th>Typ. Feed</th>
<th>Si</th>
<th>SiO₂</th>
<th>Si₃N₄</th>
<th>CₓHᵧOᵢ</th>
<th>GaAs</th>
<th>Al</th>
<th>Cu</th>
<th>W</th>
<th>WSiₓ</th>
<th>Cr</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O₂, N₂O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>NF₃, SF₆, CF₄+O₂</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td></td>
<td></td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td>☺</td>
</tr>
<tr>
<td>Cl</td>
<td>Cl₂, CFₓClᵧ, HCl+O₂</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td></td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
</tr>
<tr>
<td>Br</td>
<td>Br₂, HBr, CF₃Br</td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>HI, I₂</td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>H₂</td>
<td>☺</td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFₓ layer</td>
<td>CHF₃+O₂, C₄F₈, C₃F₆, CF₄+C₂F₆</td>
<td>☺</td>
<td>☺</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Major Control Variables

- Surface Temperature
- Energy Flux
  - Ion Energy
  - Ion Flux
  - Laser fluence/pulse rate
- Plasma Gas Composition

![Graph showing relationship between temperature and evaporation rate.](image)

An involatile product can limit etching rate.