To produce circuit features, the resist patterns (made by lithography) must be transferred into the underlying layers comprising the device.

The pattern transfer is accomplished by an etching process that selectively removes unmasked portions of a layer.

Etching categories:
- Dry etching
- Wet etching
Wet chemical etching is used extensively in semiconductor processing. Starting from semiconductor wafers sliced from an ingot, chemical etchants are used for lapping and polishing to give an optically flat damage free surface. Prior to thermal oxidation or epitaxial growth, semiconductor wafers are chemically cleaned to remove contamination that results from handling and storing. Wet chemical etching is especially suitable for blanket etches (i.e. Over the hole wafer surface) of polysilicon oxide, nitride metals, and III-V compounds.

The mechanisms for wet chemical etching involve three essential steps:
- The reactants are transported by diffusion to the reacting surface
- chemical reactions occur at the surface
- the products from the surface are removed by diffusion.

Both agitation and the temperature of the etchant solution influence the etch rate, which is the amount of film removed by etching per unit time.
For semiconductor materials wet chemical etching usually proceeds by oxidation, followed by the dissolution or the oxide by a chemical reaction.

For silicon the most commonly used etchants are mixtures or nitric acid (HNO₃) and hydrofluoric acid (HF) in water or acetic acid (CH₃COOH).

\[
Si + 4HNO₃ → SiO₂ + 2H₂O + 4NO₂
\]

HF is used to dissolve the SiO₂ layer:

\[
Si + 6HF → H₂SiF₆ + 2H₂O
\]
For <111> planes the etching rate is slower.

For <100> plane:

\[ W_b = W_o - 2l \cos 54.7^\circ = W_o + 2^{1/2}l \]

<100> 0.6 \text{ um/min}
<110> 0.1 \text{ um/min}
<111> 0.006 \text{ um/min}
<100>:<110>:<111> 100:16:1 80^\circ C

---

**TABLE 6.1 Etchants for Insulators and Conductors**

<table>
<thead>
<tr>
<th>Material</th>
<th>Etchant Composition</th>
<th>Etch Rate (um/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>28 ml HF 170 ml HF 113 g NH₄F</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>15 ml HF 10 ml HNO₃ Petch 300 ml H₂O</td>
<td>12</td>
</tr>
<tr>
<td>Si₃N₄</td>
<td>Buffered HF</td>
<td>0.5</td>
</tr>
<tr>
<td>Al</td>
<td>H₃PO₄ 4 ml HNO₃ 3.5 ml CH₃COOH 73 ml H₃PO₄ 19.5 ml H₂O</td>
<td>10</td>
</tr>
<tr>
<td>Au</td>
<td>4 g KI</td>
<td>1000</td>
</tr>
</tbody>
</table>
Dry Etching

Comparison of wet chemical etching and dry etching for pattern transfer.