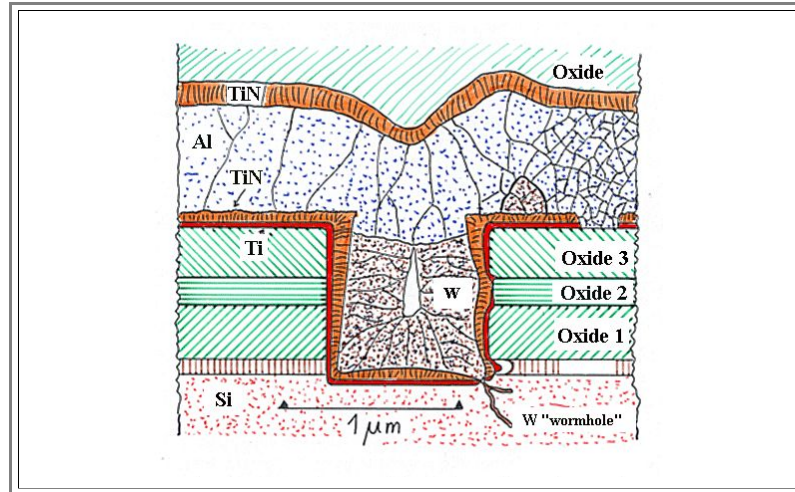


6.5 Etching Techniques

6.5.1 General Remarks

After we have produced all kinds of layer, we must now proceed to the [structure module](#) of our basic process cycle. First we discuss **etching techniques**.

- Lets see what it means to produce a structure by etching. Lets make, e.g., a contact hole in a somewhat advanced process (and do some of the follow-up processes for clarity).
- What the structure contains may look like this:



Obviously, before you deposit the **Ti/TiN diffusion barrier layer** (and then the **W**, and so on), you must etch a hole through **3** oxide layers and an **Si₃N₄** - and here we don't care why we have all those layers. (The right hand side of the picture shows a few things that can go wrong in the contact making process, but that shall not concern us at present).

There are some obvious requirements for the etching of this contact hole that also come up for most other etching processes.

1. You only want to etch **straight down** - not in the lateral direction. In other words, you want strongly **anisotropic etching** that only affects the bottom of the contact hole to be formed, but not the sidewalls (which are, after all, of the same material).
2. You want to **stop** as soon as you reach the **Si** substrate. Ideally, whatever you do for etching will not affect **Si** (or whatever material you want not to be affected). In other words, you want a large **selectivity** (= ratio of etch rates).
3. You also want reasonable **etching rates** (time is money), the ability to etch through several **different** layers in **one** process (as above), no **damage** of any kind (including rough surfaces) to the layer where you stop, and sometimes **extreme** geometries (e.g. when you etch a trench for a capacitor: **0,8 μm** in diameter and **8 μm** deep) - and you want perfect **homogeneity and reproducibility** all the time (e.g. all the about **200.000.000.000** trenches on **one 300 mm** wafer containing **256 Mbit DRAMs** must be identical to the ones on the other **500 - 1000** wafers you etch today, **and** to the **thousands** you etched before, or are going to etch in the future).

Lets face it: **This is tough!** There is no single technique that meets all the requirements for all situations.

- Structure etching thus is almost always a search for the best compromise, and new etching techniques are introduced all the time.
- Here we can only scratch at the surface and look at the two basic technologies in use: **Chemical or wet etching** and **plasma or dry etching**.

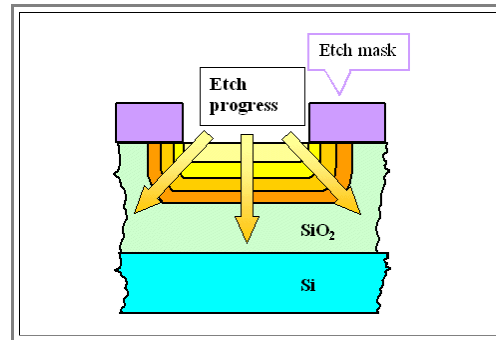
6.5.2 Chemical Etching

Chemical etching is simple: Find some (liquid) chemical that dissolves the layer to be etched, but that does not react with everything else.

- Sometimes this works, sometimes it doesn't. Hydrofluoric acid (**HF**), for example will dissolve **SiO₂**, but not **Si** - so there is an etching solution for etching **SiO₂** with extreme selectivity to **Si**.
- The other way around does not work: Whatever dissolves **Si**, will always dissolve **SiO₂**, too. At best you may come up with an etchant that shows somewhat different etching rates, i.e. some (poor) selectivity.

Anyway, the thing to remember is: Chemical etchants, if existing, can provide extremely good selectivity and thus meet our **second** request from above.

- How about the **first** request, anisotropy? Well, as you guessed: It is rotten, practically non-existent. A chemical etchant always dissolves the material it is in contact with, the forming of a contact hole would look like this:



There is a simple and painful consequence: As soon as your feature size is about **2 μm** or smaller, **forget chemical structure etching**.

- Really? How about making the opening in the mask smaller, accounting for the increase in lateral dimensions?
 - You could do that - it would work. But it would be foolish: If you **can** make the opening smaller, you also want your features smaller. In real life, you put up a tremendous effort to make the contact hole opening as small as you can, and you sure like hell don't want to increase it by the structure etching!
- Does that mean that there is no chemical etching in **Si** microelectronics? Far from it. There just is no chemical **structure** etching any more. But there are plenty of opportunities to use chemical etches (cf. the [statistics to the 16 Mbit DRAM process](#)). Lets list a few:
- Etching off whole layers.** Be it some sacrificial layer after it fulfilled its purpose, the photo resist, or simply all the **CVD** layers or thermal oxides which are automatically deposited on the wafer backside, too - they all must come off eventually and this is best done by wet chemistry.
 - Etching **coarse structures**, e.g. the opening in some protective layers to the large **Al** pads which are necessary for attaching a wire to the outside world.
 - Etching off unwanted **native oxide** on all **Si** or poly-**Si** layers that were exposed to air for more than about **10 min**.
 - All **cleaning steps** may be considered to be an extreme form of chemical etching. Etching off about **1,8 nm** of native oxide might be considered cleaning, and a cleaning step where nothing is changed at the surface, simply has no effect.
- While these are not the exciting process modules, experienced process engineers know that this is where trouble lurks. Many factories have suffered large losses because the yield was down - due to [some problem with wet chemistry](#).
- A totally new field, just making it into production for some special applications, is **electrochemical etching**. A few amazing (and not yet well understood) things can be done that way; the link provides some [samples](#).