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XeF2 Etcher

An Xetch-X3 xenon difluoride (XeF2) etching system has recently been installed in the Nanofabrication Lab of UCSB.

The applications of this tool are mainly in MEMS-device fabrication areas (releasing a MEMS structure by etching a sacrificial layer below), in which Si or Ge or even some metals, such as Mo, can be isotropically dry etched using gaseous XeF2 (no plasma enhancement or heating is needed) with the use of photoresist or SiO2 or Al as an etch mask at room temperature.

At no circumstance, this tool will be used to etch through or very deep into a Si wafer because the cost of XeF2 source material is too expensive. For users who want to etch through or very deep into a Si wafer, they should use the Si Deep RIE tool in the lab.

The XeF2 etch process is a purely chemical one and usually results in a rough etched surface.

The tool is operated in a pulsed mode in which the etch chamber is repeatedly filled with XeF2 gas and, then, pumped out (to 0.3 Torr). The etch time for each cycle is recommended to be short (5s is the minimum) for a fully exposed wafer, up to 6" one (if the wafer is mostly masked, then, one should increase the etch time to 30s), and 60s for a smaller sample.

You can also add N2 gas, together with XeF2 gas, into the etch chamber for some applications.

There is a microscope attached to this tool, with which you can monitor the etch process of your sample. You can change the number of etch cycles during a run, which will be effective in that run. Also, to stop the run, you can press the STOP button once, which will stop the run after finishing the current cycle; or you can press the STOP button twice, which will hard stop the run immediately.

Some Si Etching results using this XeF2 etcher are shown below.

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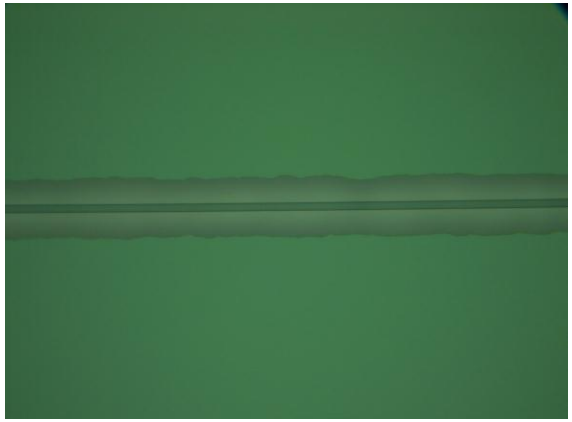
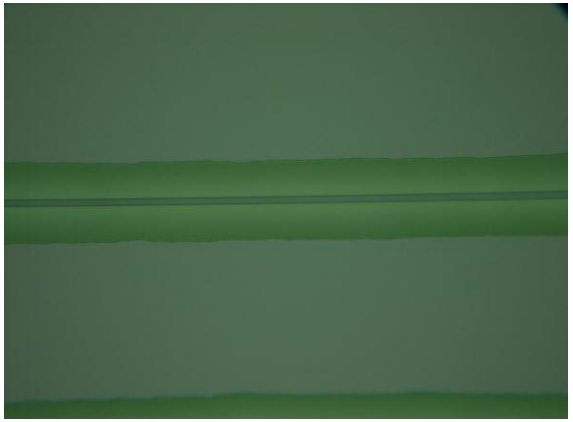
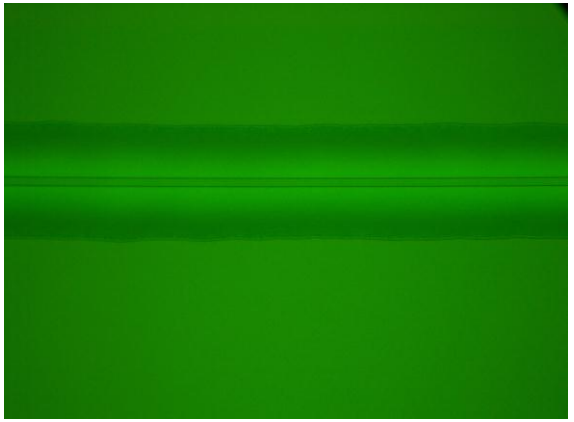
Figure 1. Microscopic pictures of etching Si samples (sample size: ~0.5x0.5 inch) with a PR (SPR955-0.9) mask. The number of cycles and etch time for each cycle were fixed at 10 and 60s, respectively, (a) XeF2 pressure*=2Torr, (b) 3Torr, (c) 4Torr, and (d) 5Torr.



(a)



(b)



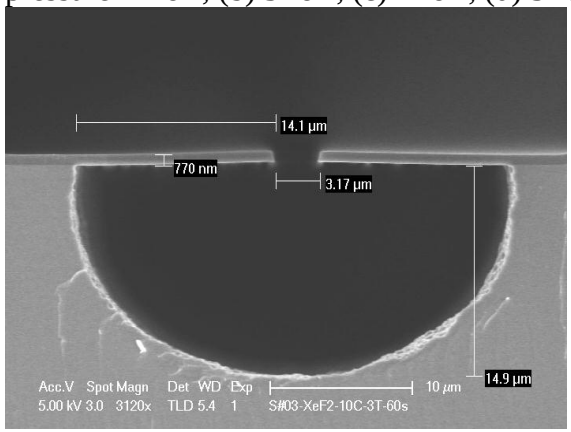
(c)

(d)

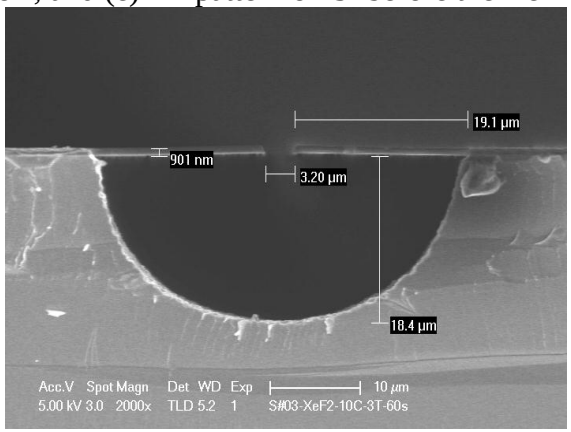
***: XeF2 pressure in the recipe is the one in the expansion chamber before opening to the etch chamber. The actual etch pressure is about a half of this recipe pressure after the expansion chamber opening to the etch chamber.**

From the above pictures, one can see that the Si undercut increases with the XeF2 pressure until 4Torr, beyond which the undercut is almost saturated.

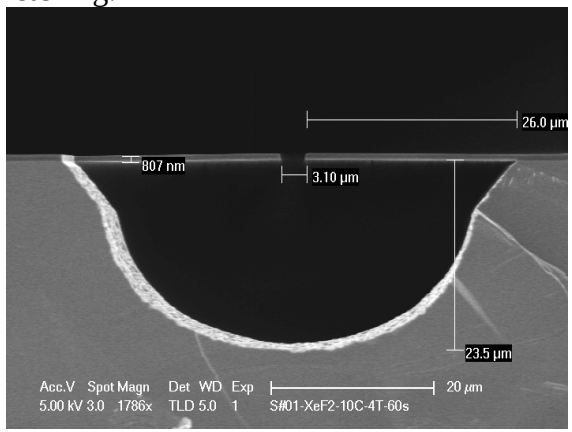
Figure 2. SEM pictures of etching Si samples (the same Si samples as above; the width of the opening window line is 3μm) with a PR (SPR955-0.9) mask. The number of cycles and etch time for each cycle were fixed at 10 and 60s, respectively, (a) XeF2 pressure=2Torr, (b) 3Torr, (c) 4Torr, (d) 5Torr, and (e) PR pattern on Si before the XeF2 etching.



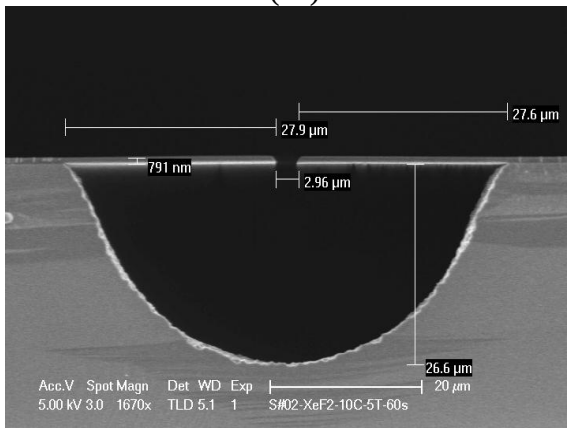
(a*)



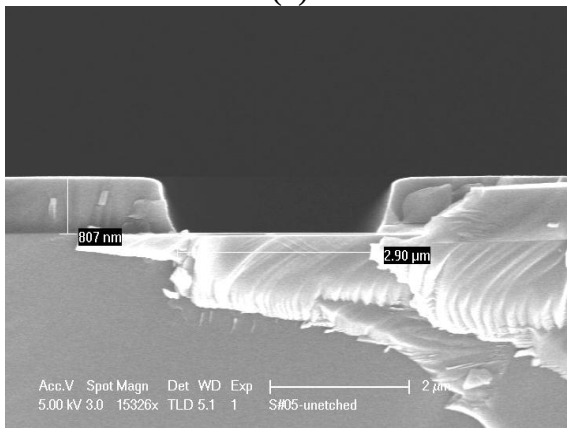
(b)



(c)



(d)



*: The label in Figure 2(a) is wrong: it should be S#04-XeF2-10C-2T-60s.

It is noted that, from Figure 2, the XeF2 etching is purely isotropic and, also, the XeF2 gas does not attack the photoresist mask.

Figure 3. Si etch undercut as a function of XeF2 pressure (# of etch cycles and etch time for each cycle were fixed at 10 and 60s, respectively).

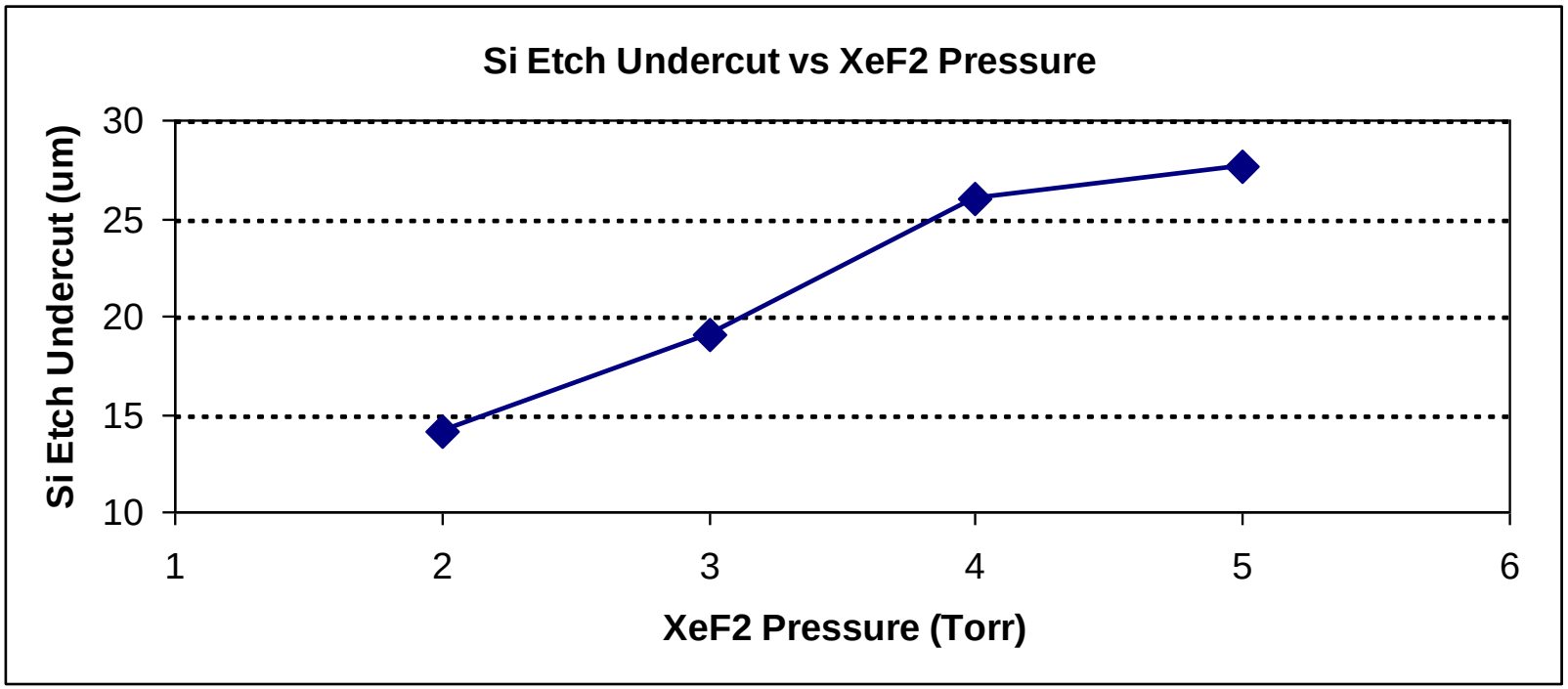


Figure 3 clearly shows that the Si-etch-undercut increases with the XeF2 pressure between 2 and 4 Torr and is almost saturated between 4 and 5 Torr.