Baseline Etch Processes: Evaluating Etching and Stripping Tools

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Primary CNF Tools Used: Oxford 81, Oxford 82, PT740, FilMetrics F50, P-7 Profilometer

Abstract:

Reactive Ion Etching is a technique that can achieve highly anisotropic etches, as well as high selectivity. Etching is performed by high energy ions as well as reactive species that interact with the surface, with an etch rate dependent on the recipe and the material being etched. Certain tools in the cleanroom, such as the PT740, Oxford 81, Oxford 82, and Glen 1000 all have stated etch rates for certain recipes. However, over time, these rates have changed from when the measurements were originally taken, meaning the manuals may no longer be accurate. The goal of this project is to measure the current etch rates of these machines across many recipes and materials to update the manuals, ensuring that future users will be able to more precisely etch their samples.

Summary of Research:

When measuring etch rates on the PT740, Oxford 81, and Oxford 82 tools, recipes stated in their respective manuals were used. Measurements of the samples before and after etching were performed by the FilMetrics F50 optical metrology tool, allowing for the characterization of etch rates across the sample. Silicon oxide wafers were deposited using 4 different PECVD methods; high rate, low rate, HDP, and TEOS deposition. Silicon Nitride wafers (figure 1) were produced with PECVD, LPCVD, HDP-CVD, as well as with the NIT N=2 recipe on the PT Takachi HDP-CVD. Carbide wafers were made by LPCVD. All aforementioned wafers were produced by Aaron Windsor. The Glen 1000 oxygen plasma tool was also characterized alongside the RIE machines. Three different resists were measured: Shipley 1813, nLof Az 2020, and SPR220-3.0. These were characterized using the RIE configuration of the Glen 1000 (figure 4), with etch rates measured using the P-7 profilometer. The final characterization that was performed was BARC (Bottom Anti-Reflective Coating) strip times. With a thin layer of BARC, incremental 1-minute runs on different machines were performed, until the coating was no longer measurable on the wafer. Two machines were able to remove the layer in under a minute; the Glen 1000 rack B (either 400 or 500 W), as well as the YES Ecoclean Asher using the recipe "0resist_strip_1min" (figure 2).

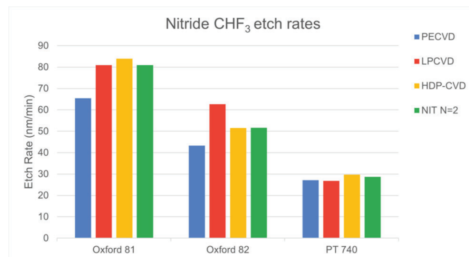

Figure 1

Figure 1: Etch rates over 3 tools and 4 deposition methods of silicon nitride, showing trend that the Oxford 81 is the fastest, followed by the Oxford 82, then the PT740.

ARC removal tool:	Wattage	Minutes:
Glen rack A	500W	5
Glen rack B	500W	1
Glen rack C	500W	4
Glen rack A	400W	5
Glen rack B	400W	1
Glen rack C	400W	6
Anatech	300W	3
Yes asher	100W	14
Yes ecoclean asher	3000W	1

Figure 2

Figure 2: Time to remove ARC layer over different tools.

Etch/strip rates:

When comparing the measured etch rates with the etch rates stated in the manuals, two machines have changed considerably since the last time they were characterized.

The Oxford 82 recipe "CHF_3 / O_2 oxide etch" was stated to have an etch rate of 43 nm/min, however, the measured etch rate is only around 25 nm/min. The "CF_4 / O_2 oxide etch" also has decreased over time, as the stated etch rate is 42 nm/min, while the measured etch rate is

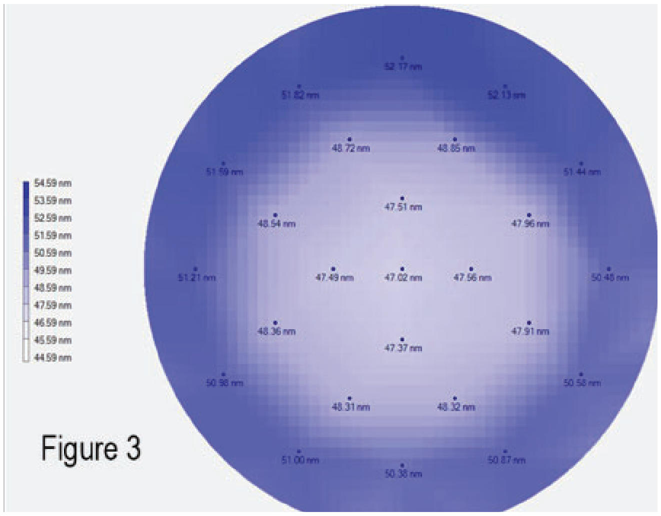

Figure 3: Difference map of before and after an etch with the PT740, showing a higher etch rate along the edge of the wafer.

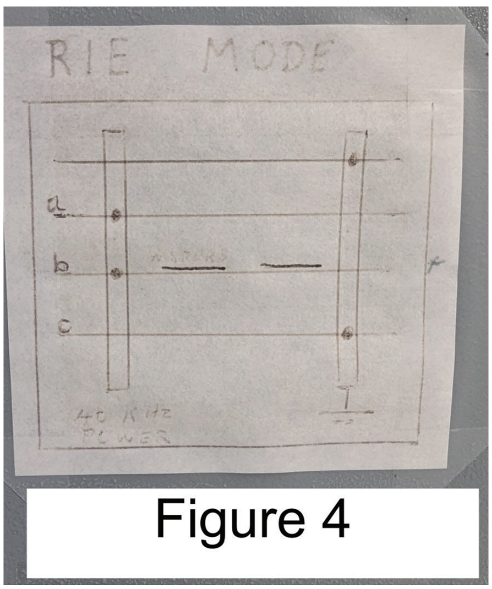

Figure 4: Design showing the configuration of the Glen 1000 during testing, with 1st and 4th rack being grounded, and the 2nd and 3rd rack attached to power.

closer to 21 nm/min. The Glen 1000, has significantly changed since the last characterization, which was taken around 2003. The old stated values for racks A, B, and C are respectively; 300nm/10min, 730nm/10 min, and 280nm/10 min. The current measured values are 92 nm/10 min, 410 nm/10 min, and 41 nm/10 min. The PT740 manual had one stated recipe that did not match the measured rate, that being the 'CHF_3 / O_2 nitride etch LSN", with the stated value being 19 nm/min, and the measured value 27 nm/min. However, this etch rate was characterized recently, and it is suspected that the etch rates of the PT740 vary due to other uncontrolled factors, so further testing would be required to definitively state whether this recipe needs to be updated.

Uniformity:

Tests were run on the RIE machines using 100mm wafers. The two Oxford 80 tools have similarly uniform etches, with a uniformity of around ± 2.5-3%. The Oxford 81 appears to etch slightly faster in the center than the outside, with the Oxford 82 being the opposite. With the PT740, however, it is clearly visible that the outside of the wafer etches with the highest rate, with the outside of the wafer (10mm from the edge) etching around 10% faster than the middle (figure 3). This machine has a uniformity across the wafer of around ± 5%.

Conclusions and Future Steps:

When etching Silicon compounds, the tool with the highest etch rate is the Oxford 81, followed by the Oxford 82 then the PT740. The fact that the two Oxford tools have differing etch rates is surprising, given that they are two identical instruments. The reason for this discrepancy is unclear, and determining and correcting the cause of this difference is a possible area for future work. Using this new data the recipes for the Oxford 82 stated in this report should be updated, as well as all the numbers on the Glen 1000. BARC stripping can now be suggested for some users with material restrictions to be done in the Glen 1000 rack B or the YES Ecoclean Asher could be used.

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References:

[1] Coburn, J.W., and Harold F. Winters. "Plasma etching—A discussion of mechanisms." Journal of Vacuum Science and Technology, vol. 16, no. 2, 1979. Accessed 4 8 2025.

[2] Link to data spreadsheet containing all measured etch rates: https://1drv.ms/x/c/402b9da0fc160dae/Efrv37R3g3JJlw8Ylu3WqJoBCddXBHjEDM6YexCmTonH5w?e=1vMcMx