Oxford 100 Etch Processes and Repeatability in the Utah nanofab

Is it reasonable to expect that using the same etch recipe on the Oxford 100 will always deliver the same results? **NO!**

The Oxford 100 is a multi-purpose etcher currently supporting many different processes and etching needs. Please see the chart below that represents use for 2015.

One or more of the previous processes, combined with chamber condition are uncontrolled inputs to the process specified by the recipe. The previous process can leave trace amounts of process gasses, reaction gasses and residue on the chamber surfaces. The residue can be in various forms and along with temperature, approximately determines the chamber condition. Chamber condition determines in large part the outcome of the etch process

So what should a user do to minimize the risk to their wafer, based on what prior users have run?

1. Use only approved materials and substrates in each nanofab tool.
2. Provide complete data entries for process, recipe, all gasses, substrate material/exposed film, time and result. If running multiple wafers, record total time. If running multiple processes record data for etch process (disable and enable - CORAL). You need this info from others to make decisions for your process and they need it from you.
3. Users should access prior run data to assess potential impact, see <https://coral.nanofab.utah.edu/lab/rundata_reports> available on the website.
4. If the previous process was not the same as yours, consider running “conditioning run(s)”. In manufacturing, chamber conditioning prior to running product is a standard practice.
5. Prepare representative process validation sample(s) to verify process result, prior to running more valuable “product”. In manufacturing, running some type of process validation or “qual” wafer prior to product is also a standard practice. And they don’t have the problem of multiple incompatible processes.
6. Talk to nanofab staff about chamber conditioning and simple ways to make validation samples
7. Conditioning wafers and validation samples also provide a means of verifying the wafer handling of the Oxford 100 prior to committing product. This minimizes risk of breaking the wafer you have spent weeks developing.

In some cases a mechanical or chemical chamber clean by staff may be required to return a process chamber to a state where conditioning can be effective. Compared to MEB use the frequency of chamber cleans has increased 5-10 x, so nanofab staff are actively attempting to mitigate the results of use as a multi-process etch system. A challenge in assessing chamber condition is that we can’t see anything without venting and physically opening the chamber.

Chamber condition guidelines:

* Polymer building processes – The C4F8 based DRIE processes build a polymer layer to protect the etch structure sidewalls and also deposit a relatively dense polymer on the chamber. Other etch gas combinations that tend to provide sidewall etch protection may produce chamber deposits but typically not as dense and of different compositions according to the gasses and reactions.
* The C4F8 based DRIE processes comprise about 30% of use so the presence of a polymer layer on the chamber is likely.
* Polymer “destroying” processes – Physical etches such as Ar and others with aggressive ion bombardment tend to heat up the chamber surfaces and can cause any chamber deposits (films) to char and flake in the more extreme uses and long duration etches.
* The O2 and O2 containing etches along with SF6 etches tend to leave a white dusty material on the surface, which appears to be a combination of breaking down the C4F8 based polymer films and in some cases some deposition of a low density deposit. The material does not have enough cohesive strength to support a subsequent C4F8 based polymer film of any significant accumulation.
* Temperature – The chuck temperature can be monitored and set to achieve desired process temperature for the wafer. The chamber is not monitored but for consistent results should be at a stable temperature. For the polymer “destroying” physical etches, it may require running conditioning wafer(s) for the chamber to heat and reach an equilibrium temperature.
* Mechanical chamber clean – Frequently required to get adequate adhesion for a new C4F8 based film or if flakes or particles are observed on wafers after etch. A mechanical chamber clean is a dirty process for a cleanroom environment and therefore, minimized to the need. The clean does not replace conditioning but rather puts the chamber is a state where conditioning can be effective.

Cost and efficiency are primary drivers for industry, they don't waste manpower or equipment time. From an overall nanofab project or product view, we should expect that running conditioning wafers and validation samples or “qual” wafers will offer better results and efficiency for nanofab users too.

A couple of reminders on use related to wafer breakage:

* Deep or through-wafer etches can result in cracked or broken wafers, so an aluminum carrier wafer (with high vacuum grease) is typically required for these etches to give the wafers mechanical support.
* Any user experiencing a wafer breakage (or parts of the wafer remaining inside the chamber) must contact nanofab staff immediately for chamber cleaning. A shutdown in coral is appropriate to provide the notification and prevent subsequent use until the condition has been corrected.