Process 2.6

Pocket Wafer Fabrication for Chip Pockets in 6" Wafers

1.0 Process Summary

1.1 Pocket wafers are 6" wafers with a 300 micron deep recessed area that is fabricated to fit a range of chip sizes. Standard pocket wafers are made to fit 10 mm and 18 mm chips. Chips can be mounted on pocket wafers and processed in various 6" tools including deposition tools. Check with process staff prior to using the pocket wafer, as you must have permission before using a pocket wafer in a tool.

1.2 This process manual describes pocket wafer processing for chips, see staff for information about processing 4" pocket wafers.

1.3 This manual provides information about how to batch process pocket wafers. If you just need one pocket wafer for your process, see the appendix for more information about fabricating single wafers or for vendor recommendations.

2.0 Material Controls & Compatibility

2.1 Pocket wafers are considered MOS clean.

2.2 Pocket wafers are not compatible with all 6" tools. Some tools have a designated pocket wafer that is the only pocket wafer you may use. Designated pocket wafers must never leave the tool they are assigned to. Pocket wafers are not suited for any tools with vacuum chucks or backside cooling. Read the equipment manual and check with process staff before using a pocket wafer on any tool.

3.0 Applicable Documents

3.1 Etch Rates for Micromachining Processing—Part II: http://lwlin.me.berkeley.edu/me119/MEMSetching.pdf

4.0 Definitions & Process Terminology

4.1 PR: photoresist

4.2 TEBR: Top-side Edge Bead Removal

4.3 PEB: post-exposure bake

4.4 DI: de-ionized

4.5 HF: Hydrofluoric acid

4.6 TMAH: Tetramethylammonium hydroxide

4.7 DRIE: Deep reactive ion etching

5.0 Safety

5.1 Follow general safety guidelines for the lab; the safety rules outlined in Chapter 1.01 - Marvell NanoLab Chemical Hygiene Plan. Note the location of the closest safety shower before before beginning work at the wet chemical sinks. In the event of chemical exposure, follow all guidelines found in section 5.3 of the CHP, namely to rinse the affected area for 15 minutes either with a safety shower, eye wash, or deck hose. Take care to scrub around fingernails and cuticles. If you are exposed to HF, apply calcium gluconate gel after 15 minutes of rinsing.

5.2 Concentrated TMAH poses significant chemical hazards. TMAH (Tetramethylammonium hydroxide) is widely used as a photoresist developer (2-3%) and for the anisotropic etching of silicon (10-15%). TMAH is corrosive, a strong base, and hazardous by ingestion, inhalation, skin (dermal) exposure and eye contact. In addition to alkalinity-related chemical burn, dermal exposure to concentrated (>15%) TMAH may also result in respiratory failure and/or cardiac arrest as it is a ganglion inhibitor. Fatalities have been reported after exposure to 25% TMAH (the concentration from the bottle) to only 7% body surface area for less than a minute.

6.0 Process Explanation

6.1 Oxide Growth: oxide growth is performed to produce a hard mask - the oxide is patterned then used as a hard mask during the TMAH etch. 1 um of oxide is sufficient to etch over 300 um of silicon.

6.2 Lithography: Gcaws6 is used to produce die-sized pockets because we can use cassette-to-cassette transfer instead of wafer wand or tweezer handling. By handling the wafers less, fewer pinholes and defects are created on the wafer surface. 4" Pocket wafers must be fabricated on a mask aligner, see staff for more information.

6.3 PR ashing: photoresist removal is done in centura-mxp to ensure all teflon deposition is removed from the silicon surface. Teflon deposition can interfere with the wet etch if not properly removed.

6.4 Etching: before TMAH etching, an HF dip is necessary to ensure all oxide is removed from the surface to be etched. TMAH is used instead of KOH because it keeps the wafer MOS clean and can be used to batch etch wafers.

6.5 Silicon trilogy etch: the final etch step is an isotropic etch made from HNO_3, NH_4F, and H_2O. The trilogy etch step is used to smooth the silicon surface. The solution slowly etches silicon oxide, so it is not used for the main etch.

6.6 Final oxide growth: The final oxide growth is not necessary, as these wafers should not be used in etch tools. It can be used to further smooth the pocket surface slightly.

7.0 Process Procedure

7.1 Select your wafers, both test and prime grade wafers can be used. In general pocket wafers are formed in four steps: oxide growth, lithography, etch, and final oxide growth.

7.2 Oxide growth

7.2.1 Furnace pre-clean in msink6.

7.2.1.1 Place wafers in the piranha bath for 10 minutes

7.2.1.2 Rinse in the QDR and place in the HF bath for 1 minute

7.2.1.3 Rinse in the QDR and dry in the SRD

7.2.2 Wet oxidation

7.2.2.1 Perform a wet oxidation on the wafers in tystar2 or tystar5

7.2.2.2 Perform oxidation at 1050C for 3 hours. These parameters are used to grow a 1 um oxide on your wafers.

7.2.2.3 When the oxidation is complete, wait for the wafers to cool, then transfer them back to your wafer box using the red vacuum wand.

7.2.3 Use nanospec to measure and record the oxide thickness

7.3 Lithography

7.3.1 Use picotrack1 or svgcoat6 to coat wafers with MiR 701 PR

7.3.1.1 Coat the wafers with 2.0 um of MiR 701 resist on picotrack or svgcoat6.

7.3.1.2 Be sure to download a recipe with no TEBR - you want the wafers to be completely coated in PR.

7.3.1.3 Do not use tweezers to handle the wafers, use vacuum wands. Tweezers form holes in PR that promote formation of pockmarks and pinholes during the TMAH etch.

7.3.2 Use gcaws6 to pattern the wafers

7.3.2.1 Use the clear reticle and POCKETEB2 job with pass 1 and pass 2.

7.3.2.2 Use 2.0 second exposures (200 mJ/cm2)

7.3.2.3 Use cassette to cassette transfer to handle the wafers, so as not to scratch the PR.

7.3.2.4 See staff if you would like to fabricate pocket wafers with differently sized pockets.

7.3.3 Use picotrack2 or svgdev6 to develop wafers

7.3.3.1 Use the standard MiR 701 development recipe. This recipe includes a post exposure bake at 110 C for 90 seconds and a development step in MF-26A for 60 seconds.

7.3.3.2 Check each wafer for backside contamination. If there is any PR or develop residue, wipe with IPA.

7.3.4 Hard bake

7.3.4.1 Place in VWR bake oven at 120 C for 1 hour.

7.4 Etch

7.4.1 Use centura-mxp to perform an oxide etch

7.4.1.1 Run an oxygen clean on the chamber prior to performing the etch

7.4.1.2 Run one unpatterned oxide wafer through the oxide etch to season the chamber

7.4.1.3 Perform pocket etch “MXP-POCKET-ETCH”

7.4.1.4 Stop the etch when it endpoints, ~3 minutes.

7.4.1.5 Every 5 or so wafers, run the clean and season steps again to maintain good conditions in the chamber

7.4.2 Use centura-mxp to ash the PR

7.4.2.1 Run the oxygen clean recipe on the wafers after oxide etching

7.4.2.2 Place in piranha bath at msink8 to remove remaining PR residue

7.4.3 Perform TMAH etch at msink4

7.4.3.1 For 4000 mL of 15 wt% etchant, mix 2400 mL of 25% TMAH with 1600 mL DI water. You will need roughly 14-16 L of etchant to cover a 6” wafer cassette.

7.4.3.2 Set TMAH bath to 90C

7.4.3.3 Perform an HF dip at msink8 to remove the native oxide on the silicon surface. Check for hydrophobic silicon surface where the pockets will be.

7.4.3.4 Remove the wafers from the HF bath, rinse them with DI water and dry them

7.4.3.5 Space wafers in every other slot of the TMAH cassette; this helps produce a more uniform etch.

7.4.3.6 The etch rate is estimated to be around 55 microns per hour. Etch for roughly 5 hours to remove 275 microns.

7.4.3.7 Check the bath occasionally to ensure the liquid level has not depleted. Use the deck hose to refill the bath if necessary.

7.4.3.8 Remove the wafers from the TMAH bath, rinse with DI water and dry them.

7.4.4 Measure the etch profile with a profilometer or confocal microscope

7.4.5 Perform a silicon trilogy etch

7.4.5.1 Piranha clean and HF dip msink8

7.4.5.2 Perform etch at msink7

7.4.5.3 Immerse the wafers for 5 minutes.

7.4.5.4 This step will help smooth the edges of the pocket

7.5 Final Oxide Growth (optional)

7.5.1 Perform pre-furnace clean at msink8, msink6

7.5.1.1 Piranha clean and HF dip at msink8

7.5.1.2 Rinse and dry wafers, transfer to an msink6 cassette

7.5.1.3 Piranha clean and HF dip at msink6

7.5.1.4 Rinse and dry wafers

7.5.2 Perform final wet oxidation

7.5.2.1 Use tystar 2 to perform a wet oxidation at 1050 C for 1 hour

8.0 Troubleshooting Guidelines

8.1 Pinholes and scratches

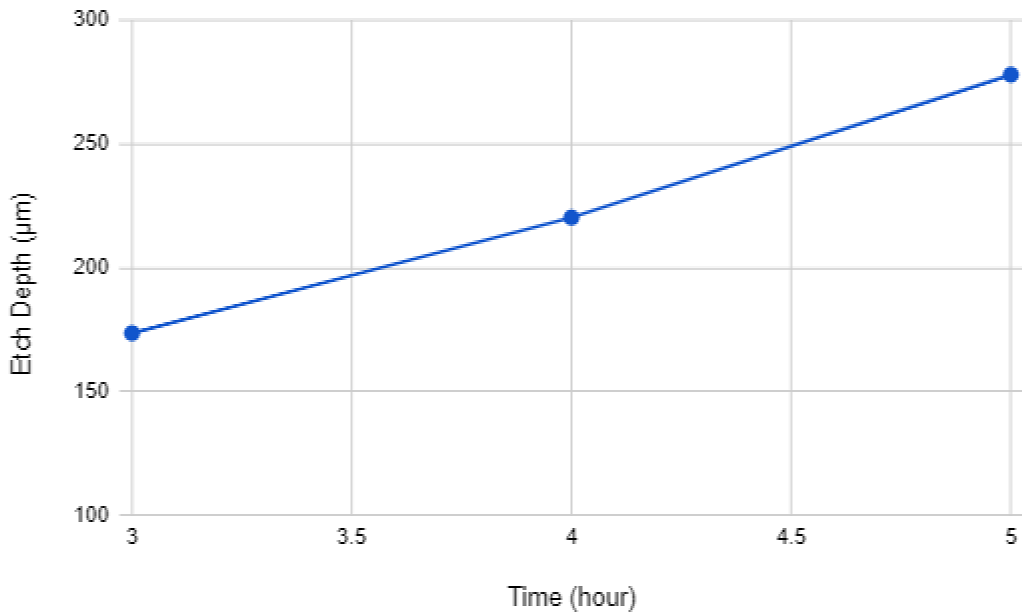
8.1.1 If you notice pinholes appear on the wafer outside the pocket after wet etching, you may need to improve your handling or lithography process. It is crucial that you handle the pocket wafers as little as possible. Use cassette-to-cassette transfer as much as possible and leave the wafer box lid on without latching it all the way. Before hardbaking, double check the wafer surface for complete photoresist coverage. If you notice any holes in the photoresist, you can use a pipette to drop a small amount of photoresist onto the wafer or use a photoresist pen.

8.2 Bottom of pocket is not smooth

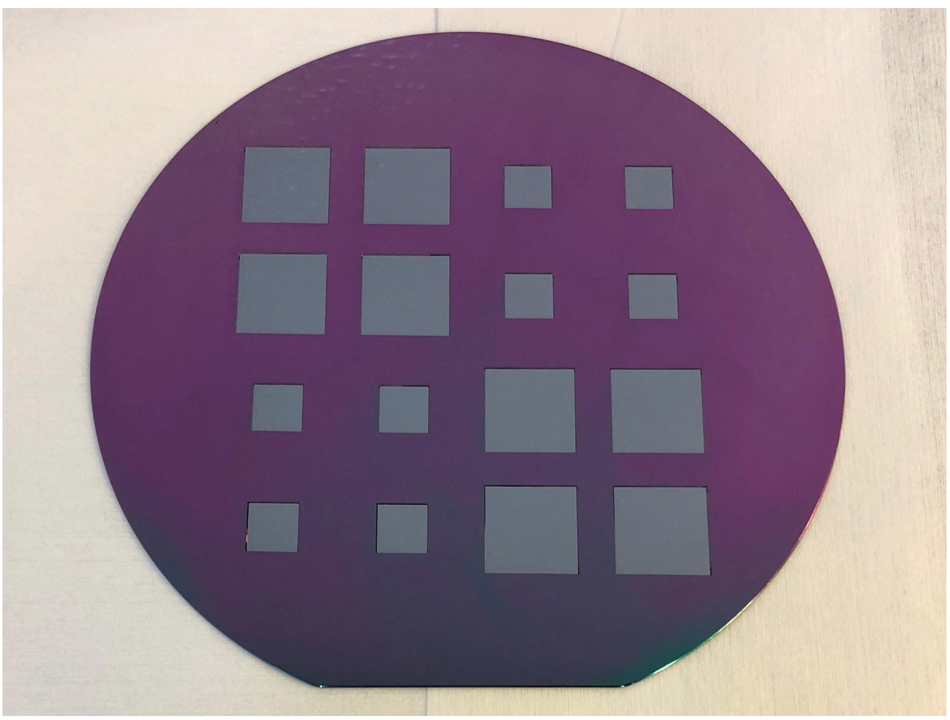
8.2.1 TMAH tends to selectively etch along certain crystallographic planes, which produces a non-uniform surface at the bottom of the pockets. This roughness may improve friction between your chip and the pocket wafer, but if you require a smoother surface you may follow these suggestions. Make sure the space the wafers with at least one extra slot between each one during the TMAH etch. Make sure to run the N_2 bubbler during the etch. Place the wafers in the trilogy etch for a longer time. Make sure you perform the final oxide growth step.

9.0 Process Data and Figures

9.1 Three wafers were etched for different times to determine an overall etch rate (figure 1). The etch rate was found to be 55 um/hour.



9.2 Example of the pocket wafer layout with 18 mm and 10 mm pockets:



10.0 Appendices

10.1 Outside vendor for pocket wafers:
http://www.semistarcorp.com/product/silicon-wafer-with-pockets/

10.2 Pocket wafers with more uniform backsides

10.2.1 Pocket wafers made with wet etching cannot be used in systems with vacuum chucks because the backsides of the wafers often have scratches and pinholes. See staff anytime you want to use a pocket wafer in a tool you have not previously used a pocket wafer in. If you do still want to make a pocket wafer with a uniform backside, you will need to use DRIE. Use photoresist AZ P4620 and sts2 to perform the etch, target 300 um depth. More information is provided in the AZ P4620 process manual. This process is also useful where only a single pocket wafer is required.