HEX02 EMBOSsing System

Location: Hot Embossing Area

Primary Trainer: Scott Munro (2-4826, smunro@ualberta.ca)

1. Overview

The hot embosser is available to users who require polymer mold fabrication. This majority of this procedure applies to 100mm diameter Si masters. 6” tooling is available for larger masters.

2. Safety Precautions

Polymer processing – This unit contains polymer O-rings and is used to process several different types of polymers at elevated temperatures. Above certain temperatures, these polymers may decompose and/or burn. Care should be taken not to exceed the maximum recommended temperatures, as outlined in this SOP and in MSDS sheets for specific embossing polymers, respectively. The o-rings installed are the low temperature type, temperatures should not exceed 200°C. A second set of high temperature o-rings that reach 320°C are available, contact NanoFab staff for installation.
During normal operation, users will have to handle materials in contact with hot surfaces. Do so with due care and attention. No parts should be handled above 40°C.

The HEX 02 contains a 200 kN press, which could cause serious injury to an operator. Never bypass the safeguards which are in place to prevent unsafe press operation. Such safeguards include, but are not limited to the following:

a) Sliding front access panel
b) Side / rear paneling

The Sliding front access panel may cause injury to personnel if, for example, a user’s fingers were near the upper pane before activating the “close door” command.

Users should be familiar with the HEX02 manual. Particular note should be taken with the description of hazards as outlined in the Safety Instructions (pages 2 – 3).

If you are bringing any new materials into the NanoFab for use in your process, it is necessary to fill out a chemical import form (available on our website, http://www.nanofab.ualberta.ca) and supply an MSDS data sheet to Stephanie Bozic.

3. PROCESS COMPONENTS OR FEATURES

Master fabrication is typically done using Si wafer, with features being etched using a DRIE system. For a basic procedural outline, please refer to Appendix A. Other fabrication methods may include standard machining for large scale feature, or masters fabricated with Ni. At this point, only Si master fabrication is performed in the Nanofab.

Both 4” and 6” tooling is available for masters. Changing between the 4” and 6” tooling requires a fairly significant hardware change. Please contact Nanofab staff if you require the tooling to be changed.

Please contact the appropriate trainers for further information on the above processes.

4. OPERATING INSTRUCTIONS

4.1 Mounting the Embossing Master

4.1.1 The mounting procedure assumes that the master has been fabricated and is ready for embossing. This initial procedure will describe the mounting of a full 100mm Si wafer. Smaller pieces may be mounted with a thin layer of silicone. The silicone can easily be removed by soaking in acetone.
4.1.2 Place a blank dummy plate on the tape dispenser platform. Place three 2 mm spacers around the plate.

4.1.3 Pull the tape over top of the dummy plate.
4.1.4 Use a roller to carefully press the tape on the surface. Ensure that no air bubbles remain.

4.1.5 Cut the tape away from the roll. Next, carefully cut around the dummy plate. Make certain that all of the tape is removed from the edges, especially on the lip of the plate.
4.1.6 Next, peel away the paper from the top side of the tape and carefully place the dummy ring around the dummy plate. The dummy ring should rest on the 2 mm spacers so that it forms a raised surface around the plate.

4.1.7 The raised surface of the ring will enable accurate placement of the Si embossing master over the dummy plate. Start from the edge closest to you, carefully dropping the Si master onto the tape.
4.1.8 At this point, some fine position adjustments can be made. The master must fit through the opening of the dummy ring, and the tolerances are very tight. Any misalignment will make loading and mounting the wafer difficult, and likely result in a cracked master.

4.2 Embosser Setup

4.2.1 Turn on the main power switch and the heating and vacuum switches by rotating clockwise 90°. The computer should turn on the heating and vacuum switches light up.
4.2.2 Enter the login information when prompted on Windows startup. When Windows has loaded, open the Hot Embossing program on the desktop.

4.2.3 When prompted, press the On button on the side of the tool. Press the initialize button to open the chamber.

4.2.4 Press the Open Safety Door button to access the upper and lower chucks. Remove the glass on the lower chuck if it's present. Note – to see the operation of any given button, hover the cursor over the button.

4.2.5 Before aligning the master to the holder, make sure there is no tape or foreign material on the lip of the carrier to the holder. Carefully slide the mounted master through the holder until the master is raised above the edge of the holder.
4.2.6 Mount the o-rings on the side and top of the holder. The top o-ring will be loose, but should stay in place. These o-rings are required for de-embossing; if de-embossing is not required (in the case of bonding process, for example), the o-rings are not needed and will make the installation and removal of the holder much easier.

4.2.7 There should be an arrow drawn on the upper chuck, indicating the location of the corresponding alignment pin. The alignment pin on the holder must be installed within the alignment hole on the chuck.

4.2.8 Users may find it easier to use a smaller sized allen key to align a screw hole in the holder with a corresponding hole in the chuck. Using an allen key, slide the key through the screw hole, and place the tip of the key in the corresponding hole in the upper chuck. Level the tool, and forcefully press the tool into the chuck. You should feel the o-rings slide into the chuck, but does require considerable force. The tool should stay mounted in the chuck if it's seated properly and o-rings are being used. If
o-rings are not used, the holder will be loose and you will have to hold the holder while the screws are inserted and tightened.

4.2.9 Use the supplied allen screws and tighten the holder into place. Use a star pattern to evenly tighten the holder. Once tight, there should be no movement of the master or holder. If the screws do not catch right away, the holder is likely misaligned. Remove the master and start the alignment and installation procedure again. Do not continue to tighten the screw if it's not catching.

4.2.10 Wipe the lower chuck with IPA and a clean room wipe. Wipe a glass plate with IPA and place onto the lower chuck.

4.2.11 Peel the protective layers off the polymer (if needed), clean with IPA (if needed), and place on the glass plate on lower chuck. If the clamp spacers or the clamps need to be changed, remove the screws, swap clamps/spaces, and replace the screws. Ensure that the clamps are lowered prior to running the macro or the clamping unit will be damaged.

4.2.12 Open the desired macro, located in the C:\Macro\Username. There are standard macros set up for PMMA and COC8007F. If other materials are to be embossed, a new embossing procedure will need to be developed. Refer to the HEX02 manual for further information.

4.2.13 With a macro loaded, browse each command line and ensure all parameters are at the proper setpoint. For a typical process, the macro is run from start to finish, but individual command lines can be selected to run either from the selected line to finish, or from the selected line in a step by step fashion. Refer to the Operations Manual, section 7.4, for a description of each command line.
A Micro Machining & Nanofabrication Facility

Standard PMMA Embossing macro

4.2.14 When a macro is started, users will be prompted to fill the input record and a filename for the logged data file. The data should be stored in the C:\Data\Username.

4.2.15 The macro will continue until the end of the macro is reached, at which time a message stating so will pop up. If the macro needs to be broken off at any point during the run, click the Stop button on the top right hand corner. Use caution in pressing stop as the system will have to be reset manually to begin again. This can be done easiest by running in line by line mode.

4.2.16 When processing is completed, the tool and holder must be removed from the upper chuck. Begin by removing the six screws holding the master in place. If no o-rings were used, the master should loosen as the last screw is removed. Be prepared to catch the master, do not let it drop.

4.2.17 If o-rings were used, the master and holder will remain fixed in the chuck even with the screws removed. The easiest way is to use the removal tool, which requires aligning and tightening using the two thumbscrews on the tool. Gripping the handle, pull down with considerable force until the o-rings begin to shift, then lessen the force and carefully pull down until the tool is removed. Use caution as losing your grip may cause you to punch the steel chuck, and be prepared to catch the tool and holder once it comes out.

4.2.18 With the tool now out and glass plate placed back on the lower chuck, close the Chamber by clicking the appropriate icon. Select Yes when prompted to close the Safety Door.
4.2.19 With the safety door and chamber closed, exit the embossing software. A cooling macro will automatically begin to run, wait until this is done before continuing. Once the software is closed, shut down the computer. Turn off the vacuum and cooling switches and finally the main power switch on the front panel of the system.

4.2.20 If the master was mounted on a steel chuck using double sided tape, it will need to be removed. The tape is nearly impossible to remove, the best way is to leave the chuck in a beaker of acetone and left to soak for a long period of time. The wafer should start to separate from the chuck starting from the outside, but may take several days to fully remove the entire wafer. Make sure there is no residue remaining before returning the chuck. Return the chuck to the container.

5. Troubleshooting
A common error occurs during initialization of the software where either the tool, substrate, or oil thermometers will fail to initialize. Performing a full shutdown and restart will typically resolve this problem.

If you encounter an unexpected error or require assistance please contact the primary or secondary trainer listed above. Should they not be available, please contact any staff member for assistance.

6. Approval

Qualified Trainer: Scott Munro
Training Coordinator: Stephanie Bozic
Appendix A – Master Fabrication

As of right now, the most straightforward method to fabricate a silicon master is to use the STS ICP-RIE system to pattern a silicon wafer. Large depths (>20um) will require use of a Bosch etch, which will roughen the sidewalls of the etched areas. It is possible to reduce this roughness by performing several iterations of thermal oxidation followed by a BOE etch. Shallow (<20um) features can be etched using and “unswitched” process, in which the etch step is continuous and no scalloping occurs, resulting in a much smoother sidewall.

Typical Process Flow
1. Hard mask deposition (if deeper etching required), typically SiO2 or Cr.
2. Lithography
3. Hard mask etching, wet etch for Cr, RIE etch for SiO2
4. DRIE of silicon
5. Resist strip (if required)
6. Hard mask removal (if required)
7. Anti-adhesion layer deposition – performed by evaporation of a fluorinated silane, or deposition of the C4F8 passivation layer from the Bosch etch.
8. Ready for mounting and embossing.

Large features can be machined into metal templates and mounted in the same manner as outlined in the procedure.