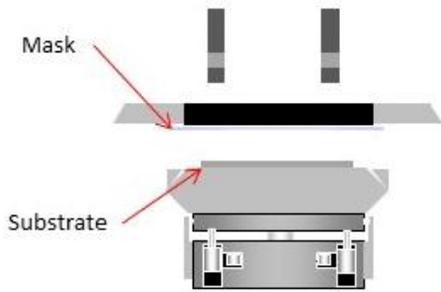


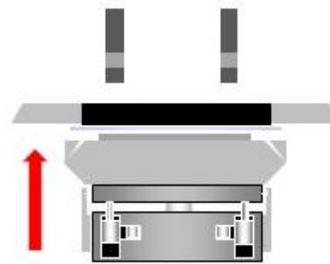


## EZImprinting PL600/400 Installation Manual

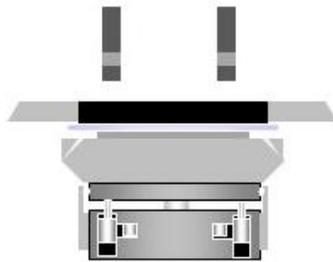
1. **Pressure connection:** Connect 6mm tubing (>50 PSI) to the “CDA” port on the rear panel of the control box. Connect 6mm nitrogen (pure N<sub>2</sub>, >99.5%) tubing to the “N<sub>2</sub>” port on the rear panel of control box. CDA is not acceptable for this N<sub>2</sub> port.
2. **Vacuum connection:** Assure that your vacuum pump can attain <1 Torr. Connect 6mm tubing from vacuum pump to the “Vacuum” port on the rear panel of the control box.
3. On the control box’s front panel, there are four 4mm quick-connection ports labeled with “Substrate”, “Seal”, “Top” and “Gap”. Insert the corresponding tubes (clear->substrate, red->seal, blue->top, black->gap) from the wafer chuck into the labeled ports. The wafer chuck can then be attached to the wafer chuck holder on the platform base.
4. Connect the touchscreen controller to the rear of the control box using the supplied power cord and Ethernet cable.
5. Connect the power cord to the rear of the control box, and plug into any 100-240V AC outlet.
6. Platform base: connect 6mm tubing from a separate vacuum pump to the port on the back of platform. Connect 6mm tubing (>80 PSI CDA) to the pressure port.



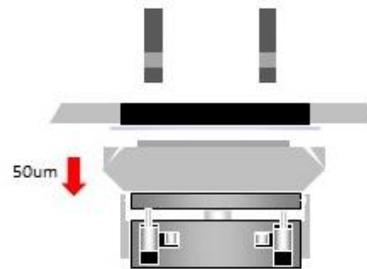
1. Loading substrate & mask.



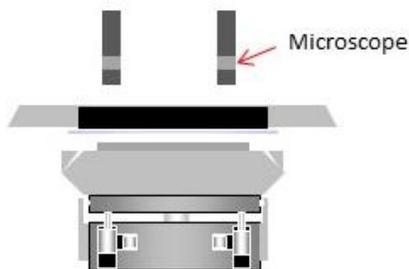
2. Push up stage by Z-axis micrometer till substrate & mask contact.



3. Push "Wedge Lock".



4. Making a "align gap" by Micrometer about 50um. (Is Your setting)



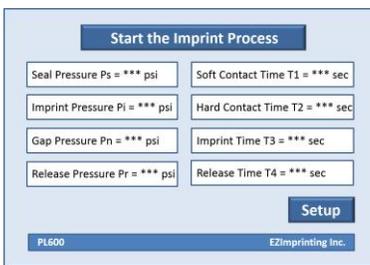
5. Make focus on microscope.  
After that make alignment by x,y,θ-axis micrometer.



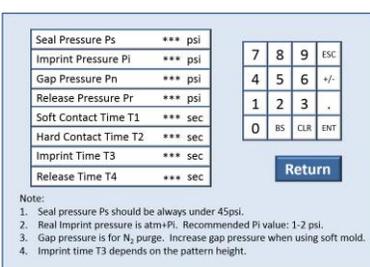
# EZImprinting Nanoimprint Controller Operation Manual



This manual covers the operation of the auto-release nanoimprint system. The integrated nanoimprint module consists of a nanoimprint chuck, and a nanoimprint control box. The system is controlled by a LCD touchscreen controller connected to the nanoimprint control box. The following procedure illustrates the basic operation of the system.

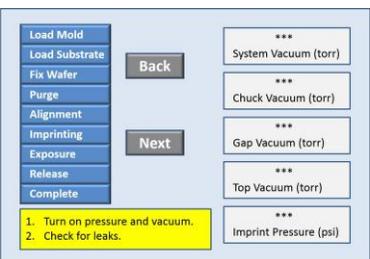


**1. Power on** – push the power button on the control box front panel to turn on the power of the whole system. When the system is powering on, a welcome screen will show on the LCD display. The system will execute an initialization process. After the initialization is done, the LCD display will change to a new screen, illustrated on the left. A group of setup parameters for the system are displayed on this screen. The user should check to make sure that they display recommended settings. Pushing the “Setup” button to set parameters if needed. Pushing the “Start the Imprint Process” button will set the controller to nanoimprint mode. The LCD display will change to the nanoimprint process control screen.



**2. Setup of the system** – Some parameters must be checked and set before the start of the nanoimprint process, both for the nanoimprint system and the aligner.

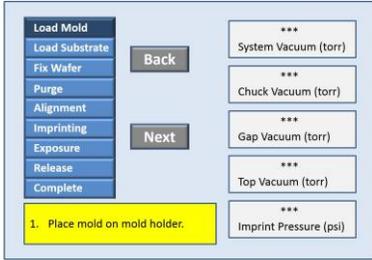
- Set the UV lamp intensity to 20 mW/cm<sup>2</sup> or Max (high).
- Planarize the substrate chuck (See PL600/400 stage manual).
- Attach the mold holder to the platform base.
- Roughly align the substrate chuck to the mold holder.



### For MD-400/600:

Press the “Setup” button on the LCD display to enter the Setup screen. Set parameters by touching the appropriate number, entering the value on the keypad, and pressing “Enter”. The new values will remain saved in the program’s memory even after the system is powered off. Pushing “Return” will return to the nanoimprint control screen. Recommended settings are listed below:

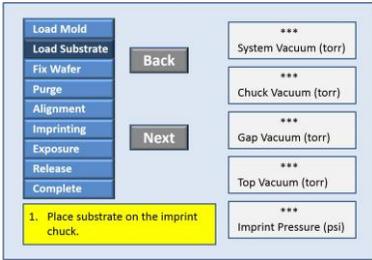
Parameter	Setting	Description
Ps	28-36	Inflatable seal pressure [psi]
Pi	0-3	Imprint pressure [psi]. <b>Use 0 for hard mold imprints.</b>
Pn	16	Gap pressure for purging the gap [psi]
Pr	1-3	Release pressure [psi]
T1	25-30	Wafer/mold soft contact time [s]
T2	10-30	Wafer/mold hard contact time [s]
T3	>=30	Minimum wait time for nanoimprint to settle before UV exposure [s]. Set T3 to 1s for the first trial. For details please refer to Troubleshooting 3.
T4	3-15	Gap purging time during release [s]. Increase T4 for small substrates.



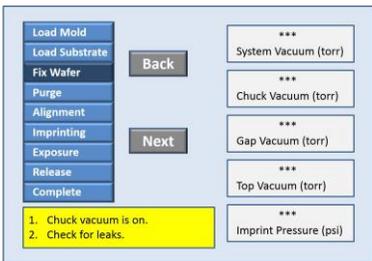
**3. Nanoimprint process** – Once the desired settings are programmed and the controller is set to nanoimprint mode, users can simply follow the on-screen instructions to execute the nanoimprint process. See Section 4 for detailed explanations of each step.

**4. Details of nanoimprint steps:**

**4.1 Load Mold:** displays a message prompting the user to load the imprint mold on the mask holder. Place the mold on the mold holder. Load the mold holder to the platform base.

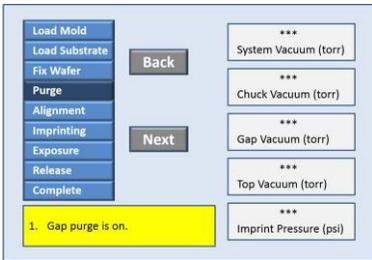


**4.2 Load Substrate:** displays a message prompting the user to load the imprint substrate on the substrate chuck. Place the substrate on the chuck. Align the center of the substrate to the chuck center.

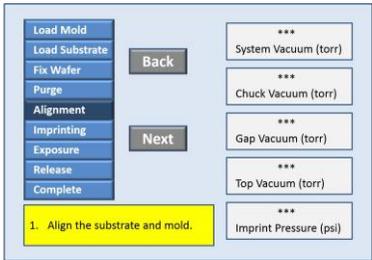


**4.3 Fix Wafer** nanoimprint controller will activate vacuum to hold the wafer. Check that the wafer is held securely without any leaks, then push “Next”. If there is a leak, go back to the previous step and re-load the substrate. Then press “Next” to fix the wafer again.

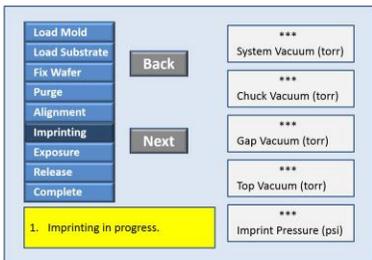
**4.4 Purge:** nanoimprint controller will activate gap nitrogen to purge the gap with nitrogen. For hard mold imprints, a 30 sec purge is recommended to remove the dust between the mold and substrate. For Fusion mold imprints, a 5 min purge is recommended to remove the oxygen in the chamber and ensure the I-UVF crosslink.

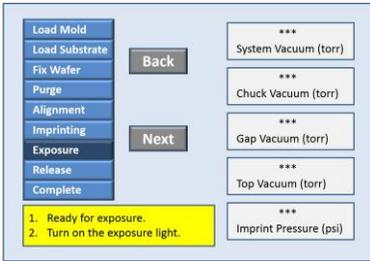


**4.5 Alignment:** displays a message prompting the user to perform the wafer/mold alignment process. Alignment is performed in the same manner as if the aligner were being used for traditional photolithography (See PL600 stage manual). Once this process is complete, push “Next” to start the imprint process.

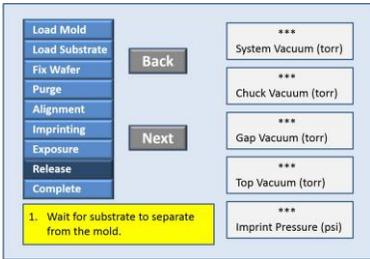


**4.6 Imprinting:** nanoimprint controller will start a sequence of actions to performance imprinting. This process has four steps: in the first step, the inflatable o-ring inflates and touches the spacer ring on the mold holder to form the seal. In the second step, the top vacuum and gap vacuum are both activated. At this step, the top vacuum should be slightly better than the gap vacuum. In the third step, the gap vacuum goes higher and pulls the mold down to the substrate. In the fourth step, the top chamber switches to pressure (atm + imprint pressure). If the vacuum value showed on the screen is not as desired, check the leaking. The valves on the back of the control box can be used to adjust the flow rate of each channel too. The imprint sequence is automatically controlled, and the total time is T1 + T2 + T3. At the end of the process, push “Next” to the “Exposure” step.

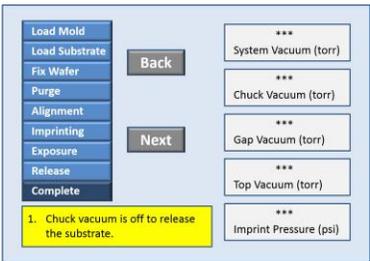




**4.7 Exposure:** once the “Imprinting” step is complete, the user is prompted to start UV exposure. The recommended UV exposure time is 2 mins (120 sec). If I-UVP is not crosslinked, check the nitrogen source purity and possible leaking in the system. An exclusive nitrogen tank is highly recommended for the imprint control box. When the UV light turns off, press “Next”.



**4.8 Release:** There are two steps in the release process. When the nanoimprint controller first enters the Release state, it will turn off the gap vacuum and start purging the gap with low pressure. Nitrogen will fill in the gap between the imprint film and the chuck first, then start to squeeze into the gap between the mold and substrate at the edge. Large mold/substrate (6”) may take 2-3 sec to have the nitrogen filled in. And small mold/substrate 1” may take 8 sec or even longer (see Recommended settings). Then the top chamber pressure changes to vacuum to pull the mold up. The wafer should be separated automatically from the mold. Remove the mold holder from the chuck. Press “Next” to go to the last step.



Note: Hard mold imprints need to have spacers on the mold to achieve auto-release.

**4.9 Complete:** The chuck vacuum is turned off. User can unload the substrate.

## Troubleshooting

### 1. The nanoimprint resist (I-UVP) is not fully crosslinked.

**Possible problem A:** when using Fusion mold the user did not use pure nitrogen for nitrogen supply.

**Notes:** I-UVP crosslinking is oxygen-sensitive and Fusion mold may carry some oxygen in its micropores. CDA or in-house nitrogen may contain too much oxygen that prevents resist crosslink.

**Solution:** use a nitrogen tank exclusively for the nitrogen supply on the back of the control box.

**Possible problem B:** the gap between the mold holder and the chuck is too big.

**Notes:** Before the red o-ring inflates, the gap between the red o-ring and the mold holder fix-ring should be 50 $\mu$ m or less. When the o-ring inflates, it will touch the fix-ring and make the seal.

**Solution:** bring the chuck up and make the gap 50 $\mu$ m or less.

**Possible problem C:** no UV light during exposure step, UV light is too dim or exposure time is not long enough.

**Notes:** I-UVP crosslink needs UV light.

**Solution:** Turn on the UV lamp, turning the adjustment knob to the highest level position, and set the exposure time to 120s or more.

### 2. The mold did not separate from the substrate at the “release” step.

**Possible problem A:** the mold holder is not fixed on the stage but raised up.

**Solution:** fix the mold holder on the stage so that it cannot raise up.

**Possible problem B:** did not adjust the vacuum valves for substrate correctly.

**Solution:** there are four vacuum lines to hold the substrate. The user should only open the vacuum channels that cover the substrate area.

**Possible problem C:** use a hard mold without auto-release spacers.

**Solution:** add auto-release spacers to the hard mold.

### 3. The T3 timer keeps starting over and cannot finish counting and move to the next step.

**Possible solution A:** check the leaking around imprint film and fix it.

**Possible solution B:** If the C3 reading is still not stable (it need to be kept at +/- 0.1 psi around the set point for the timer to keep counting), keep T3 at 1s but count the imprint settle-down time at the “exposure” step before turn on the UC lamp. Usually deeper and smaller gaps or holes need longer time for the resist to fill in, that is, a longer T3 setting or longer waiting time at the exposure step before turn on the UV lamp.

### 4. The “system alarm” is shown on the screen and the process stopped.

**Solution:** push “system alarm” to find out the error source and fix it.

# EZImprinting Auto Release™ Imprint Process Guide

These procedures cover all the steps necessary to perform a nanoimprint process using the **PL400/600** nanoimprint platform or **MD400/600** nanoimprint module. The process outlined here is designed to translate positive micro- and nano-patterns on a 3D quartz/glass mold to patterns on a wafer.

## EQUIPMENT AND MATERIALS

**PL400/600** nanoimprint platform or **MD400/600** nanoimprint module

RIE etcher

E-beam evaporator

Acid wet bench

Spin-coater

Hot plate

Tweezers

0.2 µm filters

Syringes

**I-UVP** UV curable nanoimprint resist

**I-ULP** under layer polymer

**I-UVM** UV polymer for Quick Mold

**M-AHS** Quick-mold adhesion promoter

**M-RLS** Mold release treatment agent

Acetone

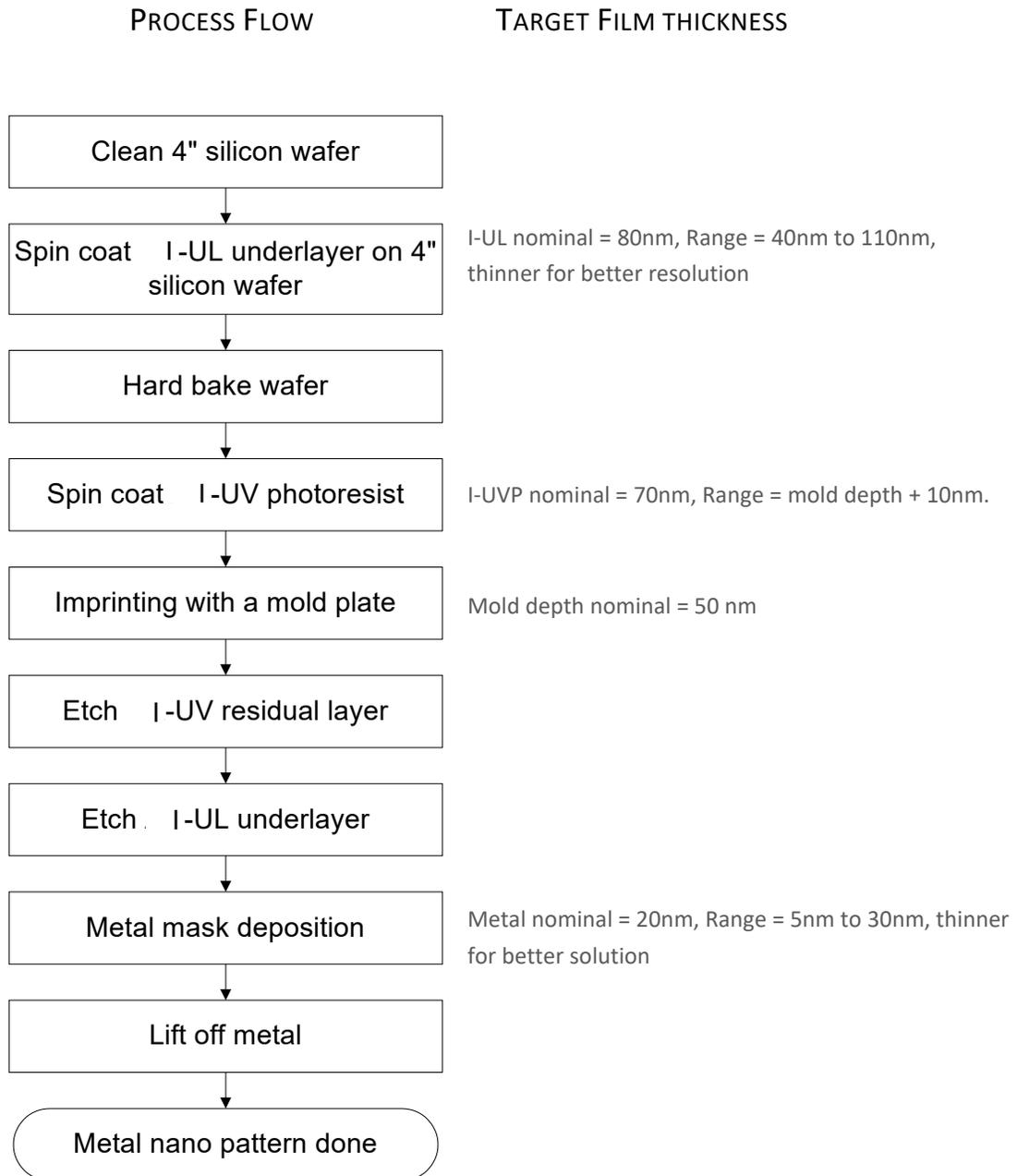
Methanol

Isopropanol

DI water

## PROCESS OVERVIEW

The following flow diagram illustrates the high-level process overview of transferring nanoimprint mold patterns to a silicon wafer (two-layer nanoimprint process).



## DETAIL PROCESS RECOMMENDATION

The following process is a recommendation for a typical micro-fabrication facility setting. Users may optimize the parameters according to their equipment.

### 1. Wafer Cleaning

Wafer Cleaning
Equip: wet bench Process: Soak in fresh piranha solution for 10 min Soak in DI water 1 min Spin Dry N2 Oven bake dry, 150 C, 5 min

### 2. Spin coat I-UL polymer

Spin Coat I-UL polymer
Equip: Spinner Process: Deposit 0.5ml I-UL polymer through 0.2um filter Spin wafer at 4000 RPM for 45 sec.

### 3. Hard bake I-UL polymer film

Hard Bake I-UL film
Equip: Hotplate Process: Preheat hotplate at 180C Place spinned wafer on the hotplate for 90 sec.

4. Spin coat I-UV polymer

Spin Coat I-UV polymer
Equip: Spinner Process: Deposit 0.3ml I-UV polymer through 0.2um filter Spin wafer at 5000 RPM for 7 sec.

5. Imprinting

Refer to Nanoimprint Controller Operation Manual.

Typical setting on imprint controller

T1: time for the mold to form soft contact with substrate 25-30 sec

T2: time for the mold to form hard contact with substrate 10-30 sec

T3: minimum time for imprint in second (depend on the depth and density of the nano-features on the mold).

6. I-UV polymer film etch

Etch I-UV residual layer
Equip: Oxford Plasmalab 80+ Gas flow: 2 sccm O2 + 10 sccm CHF3 RF forward power: 50W Process pressure: 4 mtorr Etch rate: ~8 A/s

7. I-UL polymer film etch

Etch I-UL underlayer
Equip: Oxford Plasmalab 80+ Gas flow: 25 sccm O2 RF forward power: 100W Process pressure: 10 mtorr Etch rate: ~30 A/s

8. Metal deposition

Metal Deposition
Equip: E-beam Depositor Deposition Cr: 30nm Deposition Rate: 20A/min

[Deposition rate will generally be 1 A/sec, or at least 0.5 A/sec. Also, deposited metal should not be thicker than 30 nm for the underlayer spin conditions indicated above. Underlayer is 95-100 nm for those conditions.]

9. Metal liftoff

Lift off metal
Equip: sonicator Acetone bath, sonicating for 5 min

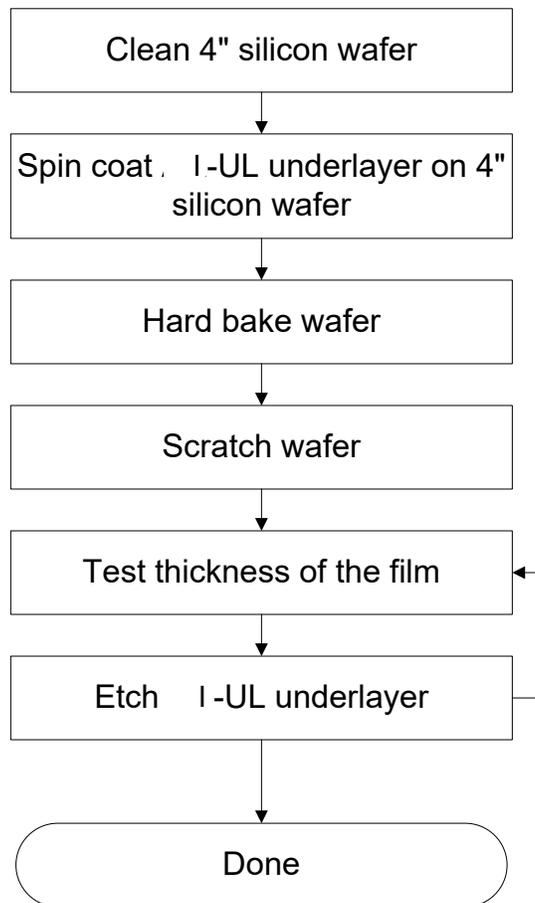
# PROCESS DEVELOPMENT GUIDE

This section is a set of guides for new users to optimize the processes on their own equipment.

One of the critical factors in yield nanoimprint results varies thinfilm processing. We recommend new users first test and optimize etching and deposition of the related thinfilms.

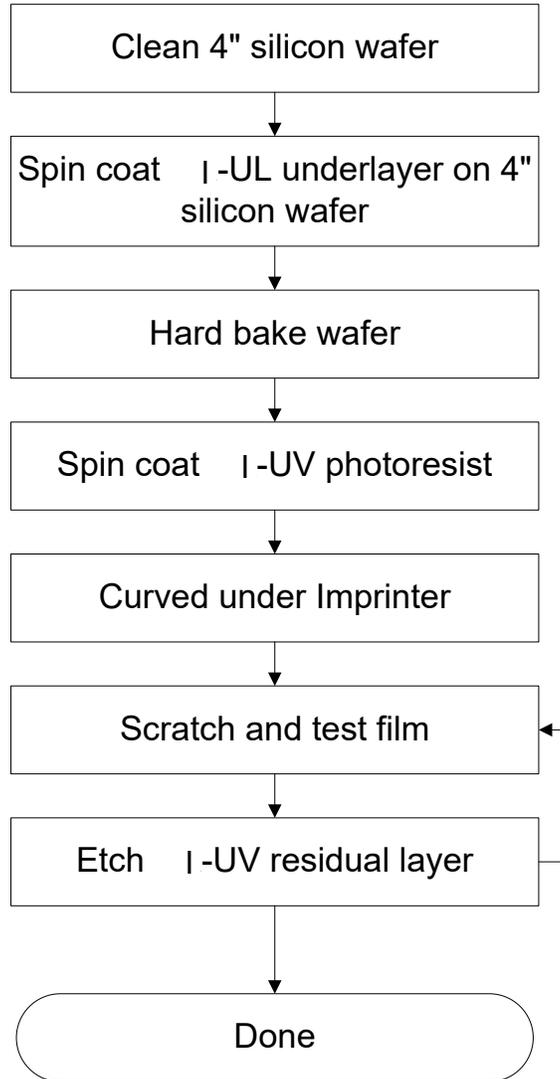
## 1. I-ULP film etch test

The following flow chart illustrates a process used to fine-tune the I-UL polymer film etch rate.



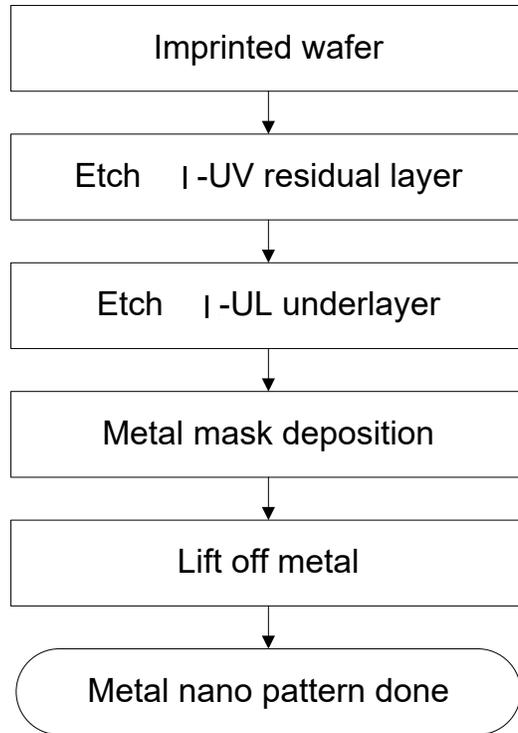
## 2. I-UV polymer film etch rate test

The following flow chart illustrates a process used to fine-tune the I-UV polymer film etch rate.



### 3. Pattern transfer test

In this test, the user would transfer the imprinted nanopatterns on an I-UV polymer film to metal nanopatterns on a silicon wafer.



## PROCEDURE FOR FABRICATING “QUICK” IMPRINT QUARTZ MOLD

This is a process for making a mold with quartz substrate without doing the transfer etch step (single layer nanoimprint process). Instead of etching into the substrate, the cured I-UVP layer is used as the functional imprinting layer. Therefore the polarity of the quick mold will be opposite from the master mold. The conventional underlayer for the transfer etch step is removed. The cured I-UVP is covalently bound with the substrate.

1. Start with a clean blank quartz/glass plate. Dehydrate the quartz plate on a hot plate at 150C for at least 5min.

Adhesion treatment in solution phase:

2. In a dry glove box, prepare 0.5% M-AHS (adhesion promoter) in anhydrous toluene. Immerse the quartz plate in the above solution for 5 min.
3. Immerse the quartz plate in pure toluene for 5 min.
4. Dry the quartz plate inside the glove box using a nitrogen gun.

Adhesion treatment in vapor phase:

2. Heat vacuum oven to 60C. Load the quartz plate into the oven.
3. Add one drop M-AHS on a clean glass slide in the oven.
4. Pump down the oven to -750Torr for 15min. Vent the oven and unload the quartz plate.
5. Spin-coat plate with I-UVM on the quartz plate at 3000 rpm for 7 sec.
6. Perform standard imprint procedure on the quartz plate using a master mold.
7. Oxidize the surface of the cured resist: treat plate with oxygen plasma O<sub>2</sub> 50 sccm, 50 mtorr, 50 W, 20 sec.
8. Perform the release layer treatment using CT Series.
9. Use the quick mold for imprints in the same way as a regular mold.