University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name: Ion Mill
Coral Name: ionmill -sims
Revision Number: 5
Model: Intlvac
Revisionist: Kevin Roberts
Location: Bay 2
Date: 08/17/2023

1 Description

The Intlvac Ion Mill is used for non-chemical etching of thin films. To accomplish this, the chamber is first pumped down to low pressure and then back filled with Argon gas. The Argon is then ionized and accelerated by an electric field toward the substrate. This kinetically energized Ar "sputters" or removes the film from the substrate (**see Figure 1**).

Figure 1 - The Intlvac Nanoquest Ion Mill Etching System:

2 Safety

a

3 Restrictions/Requirements

a Must be a qualified user on the Ion Mill.

4 Required Facilities

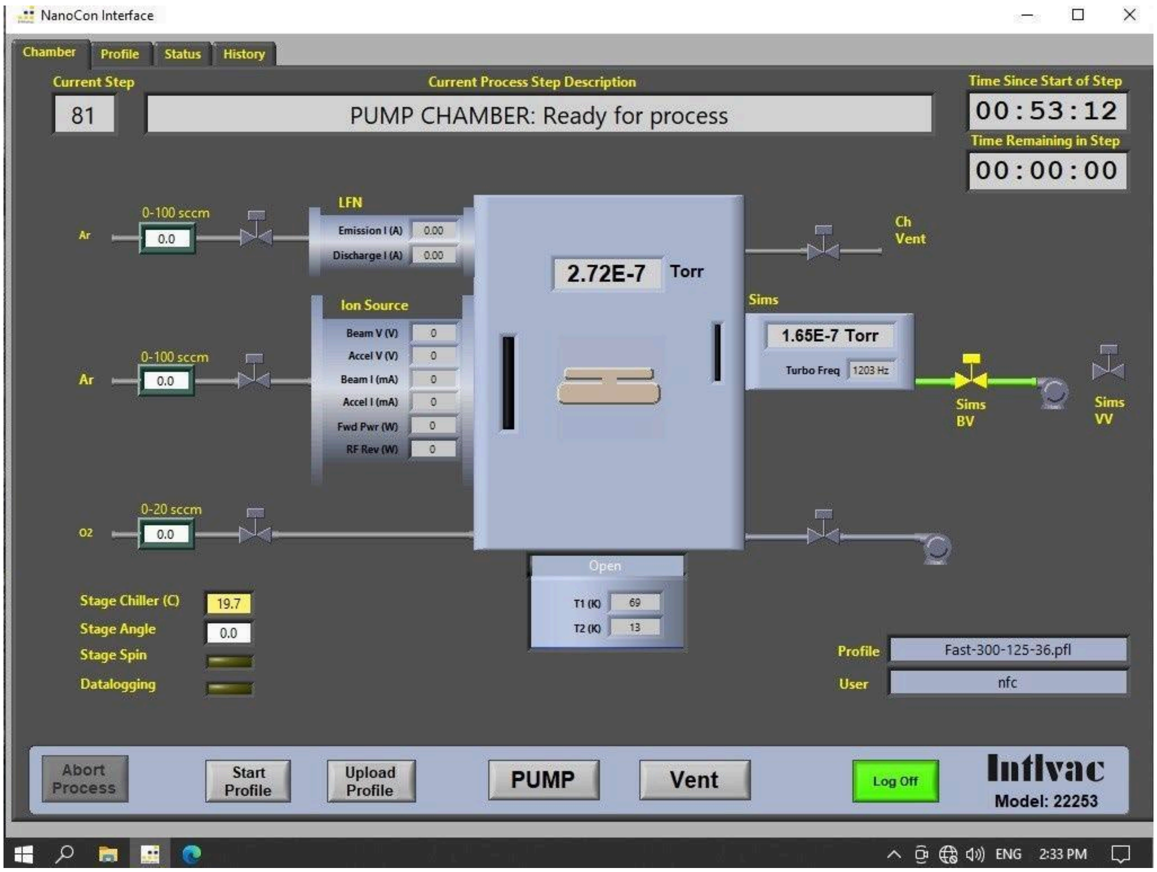
a Compressed air, 80 psi
b Argon, 16 psi
c Nitrogen, 32 psi
d Chilled water, 45 psi, 3.5 GPM

5 Definitions

a Ion Beam Current – The amount of ions being accelerated toward the substrate.

Chamber Vented:

Chamber Tab Screen Shot:



6 Operating Instructions

a ENABLING / LOGGING IN

1 Make sure latch on chamber door is in down position before proceeding, or you may experience errors in the software when you try to vent.

2 Enable 'ionmill' in Badger.

3 Go to **Chamber Tab** on screen.

4 Click on **Log On** icon.

5 Login with user name: nfc password: 1234

b CHAMBER VENTING

1 Press VENT on **Chamber Tab**. (hold icon down for several seconds to activate).

2 *Note: System will not fully vent until SIMS Turbo Frequency <10 Hz*

c SAMPLE LOADING OR CHANGING <u>FOR A FULL WAFER</u>
{for loading small chip samples, see next section}

1 Open door.

2 Remove metal retaining ring.

3 Remove old wafer.

4 Set new wafer on silver impregnated pad.

5 Press **Process Advance** green lit button (turns on dry vacuum pump in chase)

6 Hook up vacuum tube, and flip up toggle switch for stage vacuum. Allow to pump for several minutes.

7 Replace metal retaining ring (do not over tighten).

8 Flip stage vacuum toggle back down and disconnect tube from stage.

9 Press **Process Advance** green lit button.

10 Close door.

11 Throw latch on door so that handle is in horizontal position.

12 Press **Process Advance** green lit button. System will begin to pump down.

{see Pump Down Section ahead for pump down protocols}

c SAMPLE LOADING <u>OF A SMAL CHIP</u>

1 Open door.

2 Place a small amount of double-sided copper tape on carrier wafer inside machine.

3 Affix sample on double-sided copper tape.

4 Close door.

5 Throw latch on door so that handle is in horizontal position.

6 Press **Pump** icon on desktop. System will begin to pump down.
(hold icon down for several seconds to activate)

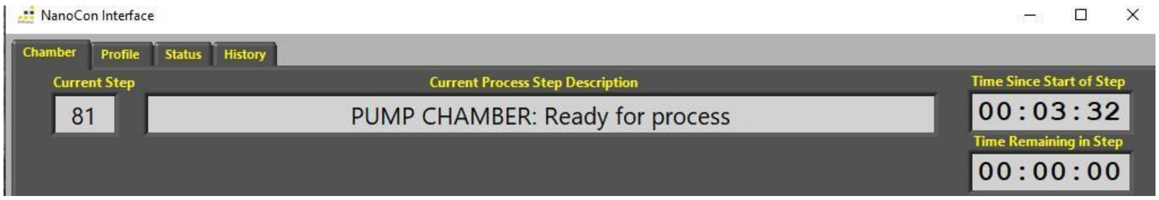
d PUMP DOWN

1 System will cross over to high vacuum (i.e open cryo) at 2.00E-1 Torr, or 200 mTorr.

2 SIMS Turbo will employ. It will reach 1200 MHz.

3 System is ready to run a Profile (i.e a recipe) at 5.00E-6 Torr.

4 Wait until Current Process Step Description says: Ready for process.



e ETCHING WITH A <u>TIMED</u> RUN

1 Go to **Profile Tab** on screen.

2 Click on **Open…** icon on screen.

3 Choose profile you wish to work with: slow or fast. Users can change process time or stage angle (75 degrees is default) if they want to, but should leave other parameters alone. Note: Users logged in as the 'nfc' user cannot save recipes.

4 Set **Segment Type** to ‘Timed’.

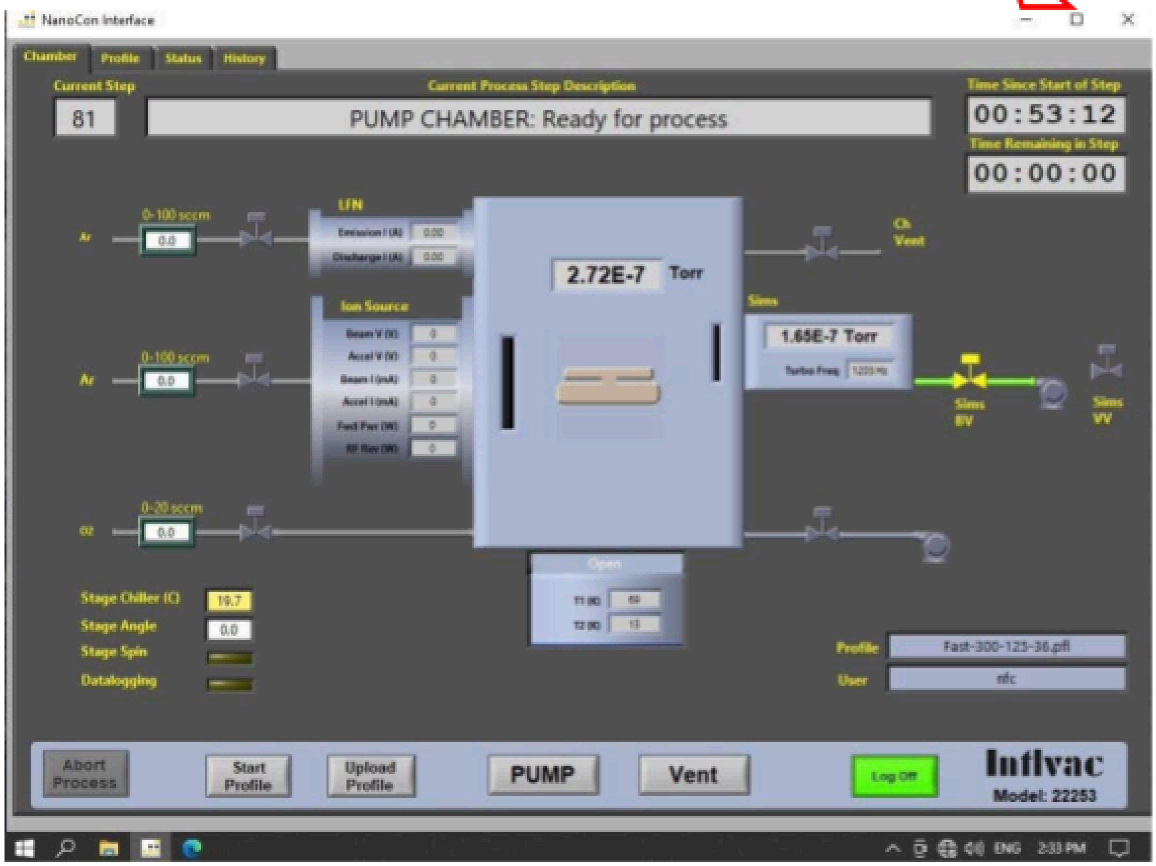
5 Click **Upload** icon to upload the profile to the programmable logic controller (PLC) of the system.

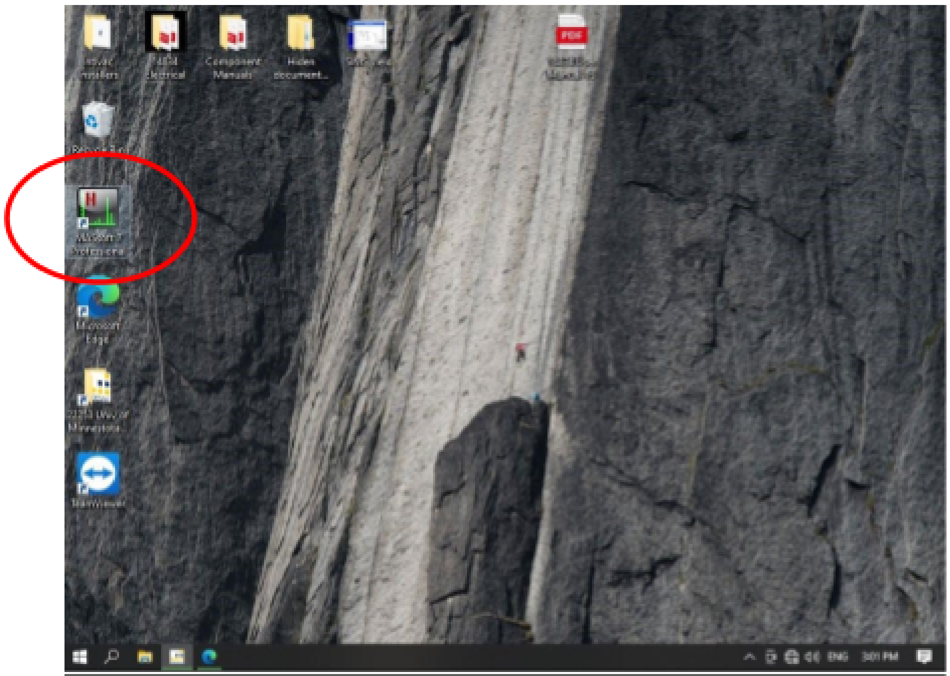
6 Go back to the **Chamber Tab**.

7 Click on **Start Profile.** Stage will cool from 20C to 6C which will take 10 minutes. Then, process will begin.

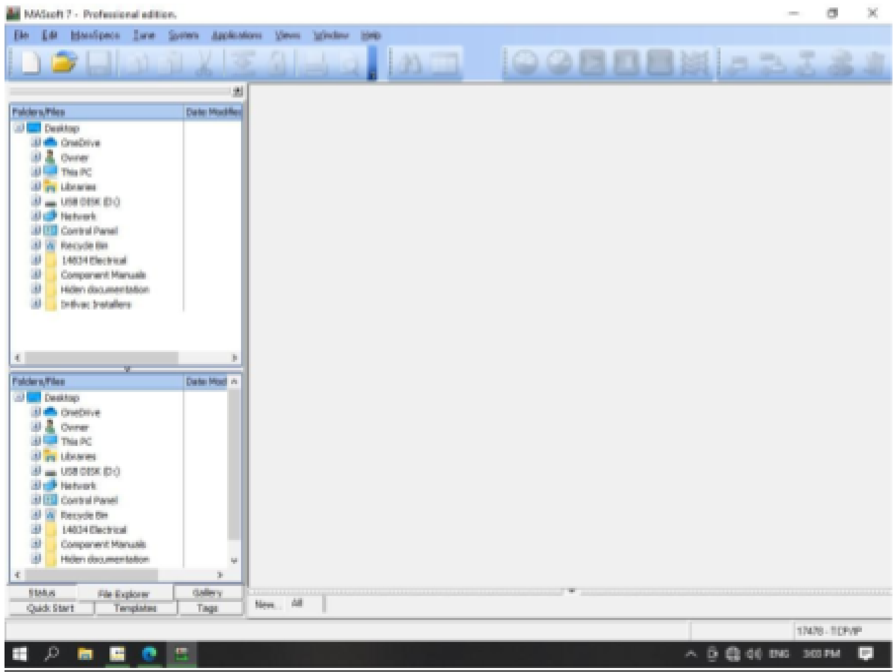
e ETCHING WITH SIMS ENDPOINT DETECTION

1 Minimize the NanoCon Interface, so one can see the desktop.

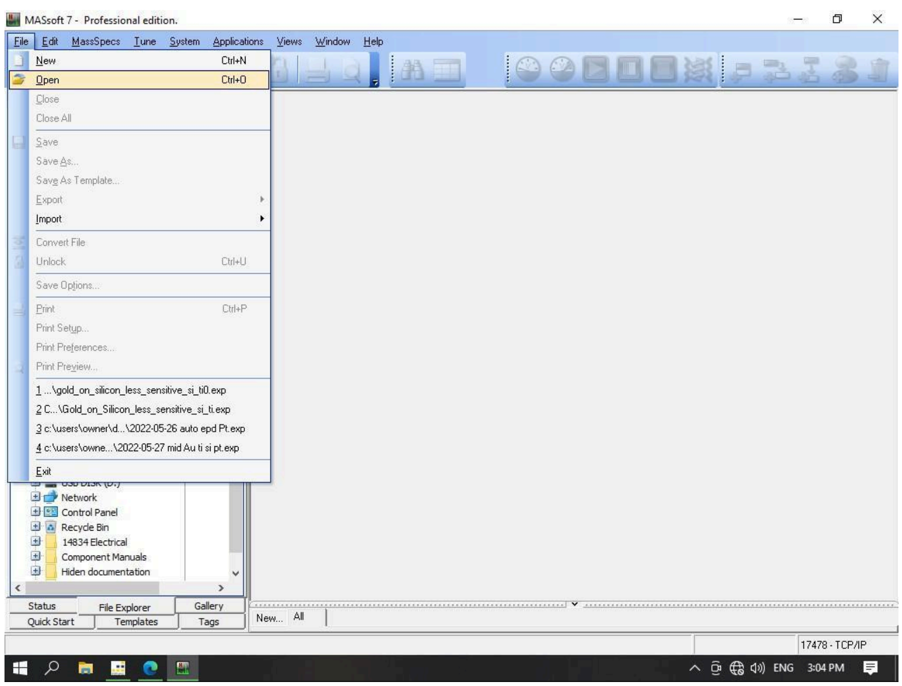




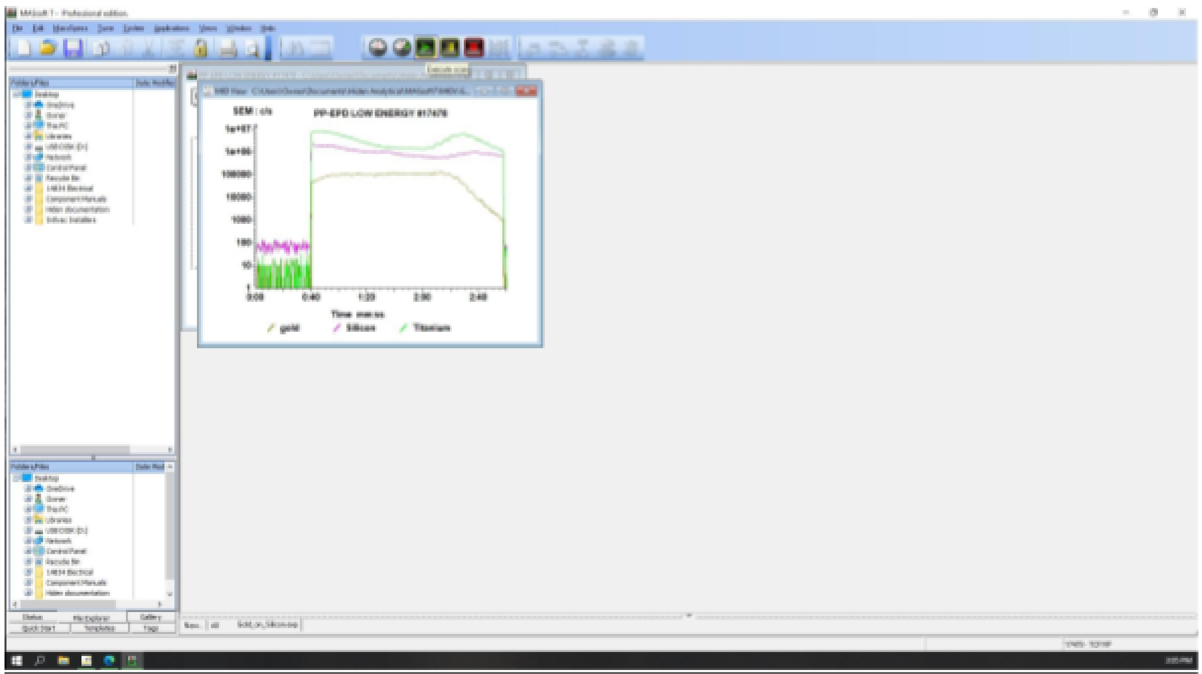
2 Open Hiden analytics software ‘MASsoft 7 Professional’



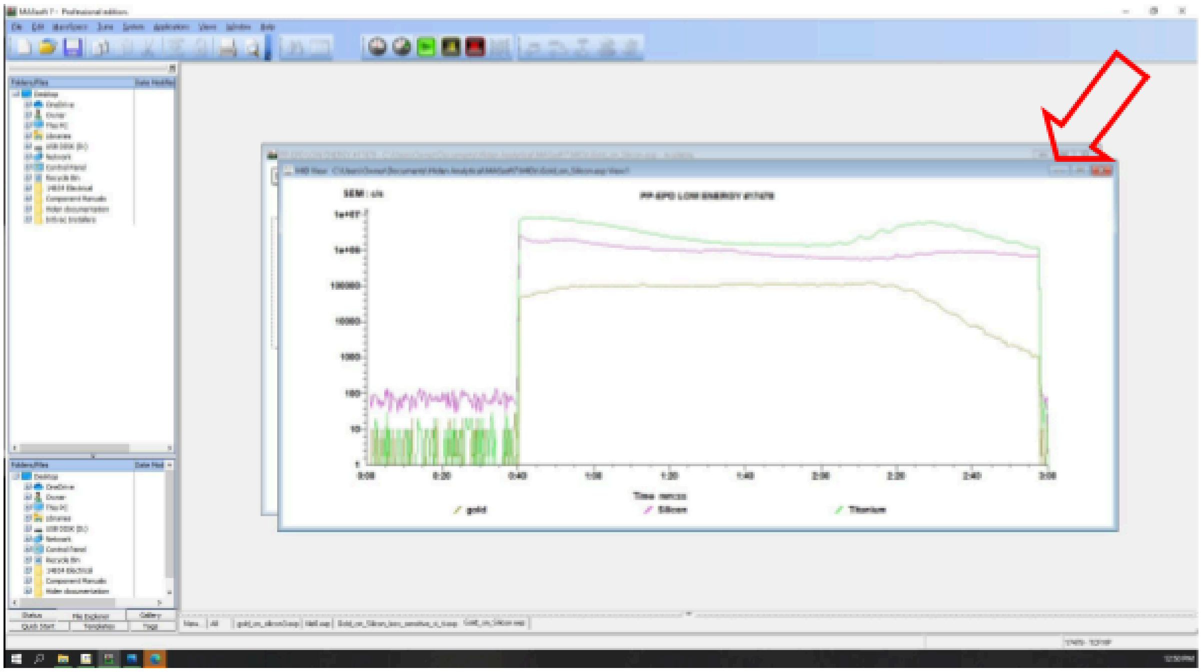
3 Once Hiden MASsoft 7 software is open, perform an 'Open File'



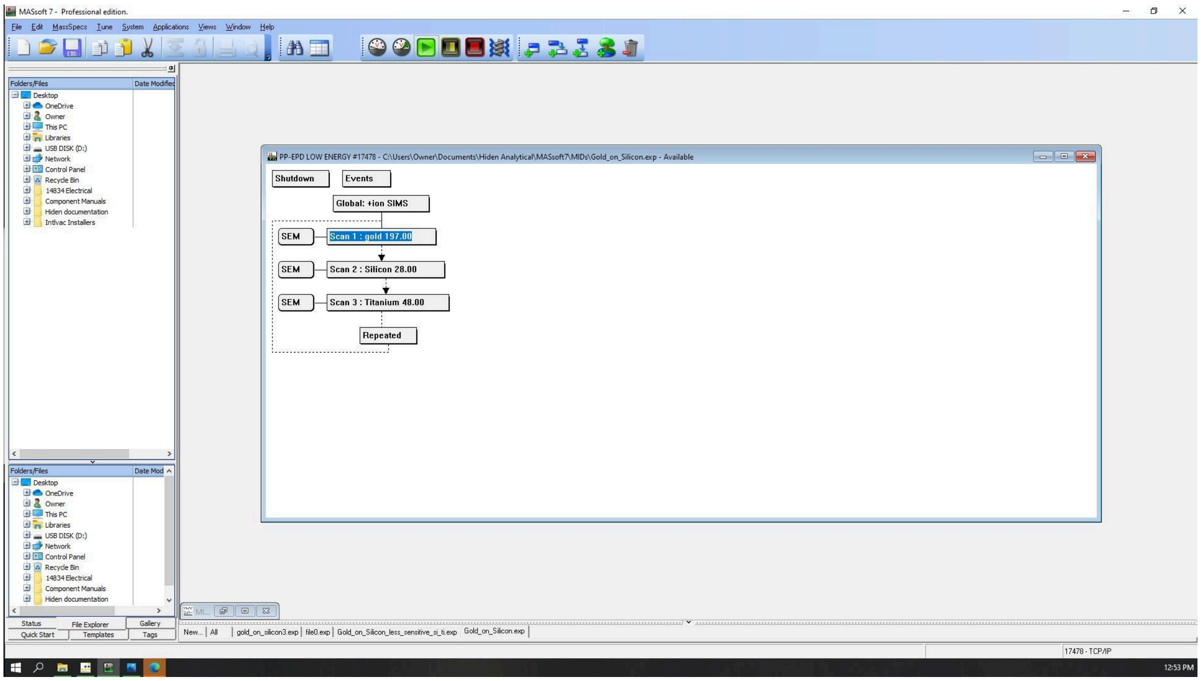
4 Open MIDs file of choice. Slide MASsoft 7 software window over to the large monitor on the right for easy viewing, and enlarge the Nanocon Interface window on the original monitor screen.



4 To change or modify MID file. Open file of choice, and then minimize MID View window, to reveal PP-EPD Low Energy window underneath.



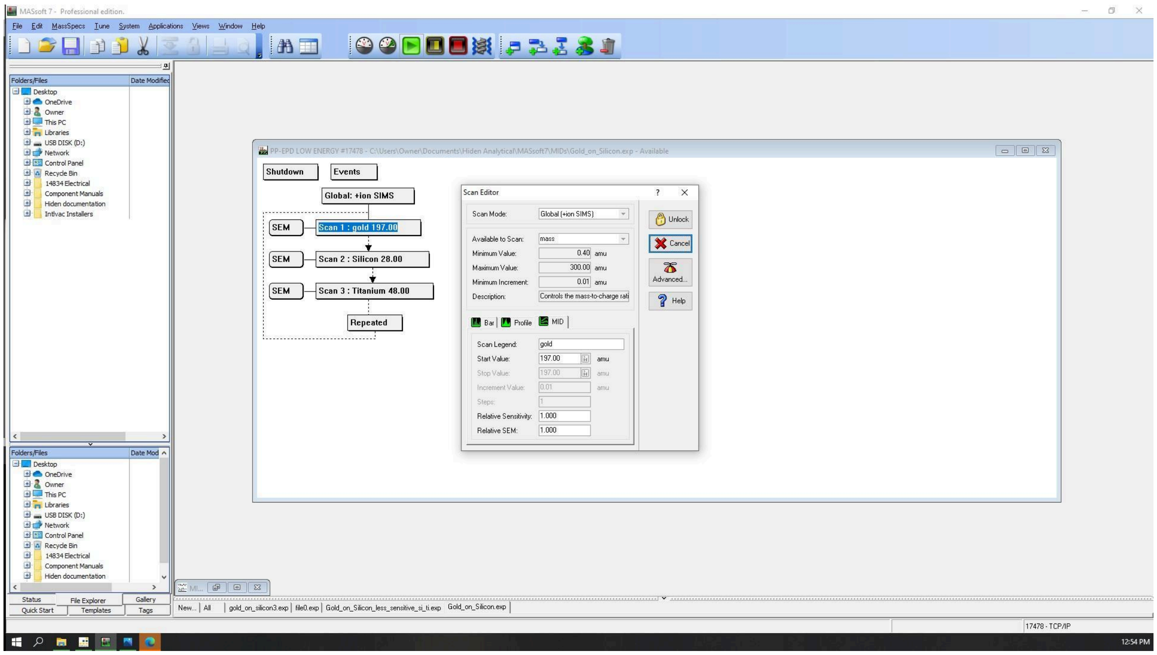
5 PP-EPD Low Energy window. Double left click on items to be changed.



6 Scan Editor dialogue box will open which allows you to modify materials.

7 After modifying, save new MID file with a new name.

8 Enlarge MID View window again when you are done making adjustments.



Shutdown
Events
Global: +ion SIMS
SEM
Scan 1 : gold 197.00
SEM
Scan 2 : Silicon 28.00
SEM
Scan 3 : Titanium 48.00
Repeated
Scan Editor

9 Go to **Profile Tab** on screen.

10 Click on **Open…** icon on screen.

11 Choose profile you wish to work with: slow or fast. Users can change <u>process time</u> or <u>stage angle</u> (75 degrees is default) if they want to, but should leave other parameters alone. Note: Users logged in as the 'nfc' user cannot save recipes.

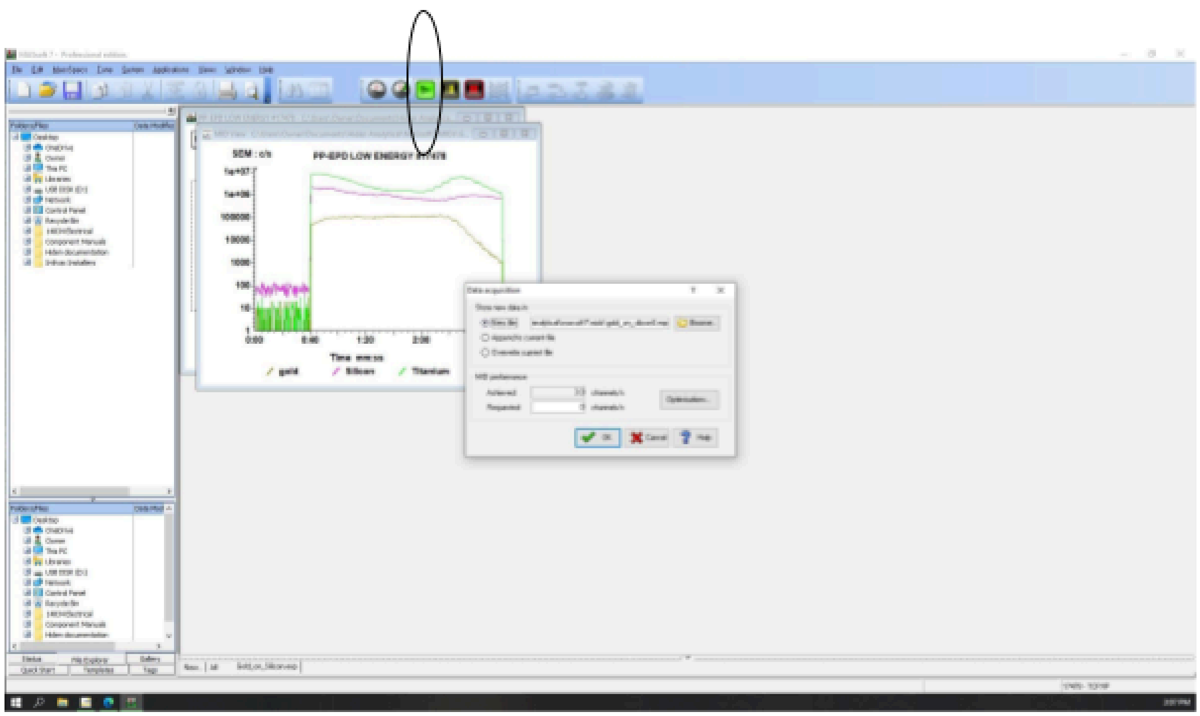
12 Set **Segment Type** to 'Manual'. <u>Because SIMS will determine the endpoint, make **Process Time** extra large (~ 1hr) or etch will abort at end of programmed time, prematurely overriding SIMS manual stop button (green lit button).</u>

13 Click **Upload** icon to upload the profile to the programmable logic controller (PLC) of the system.

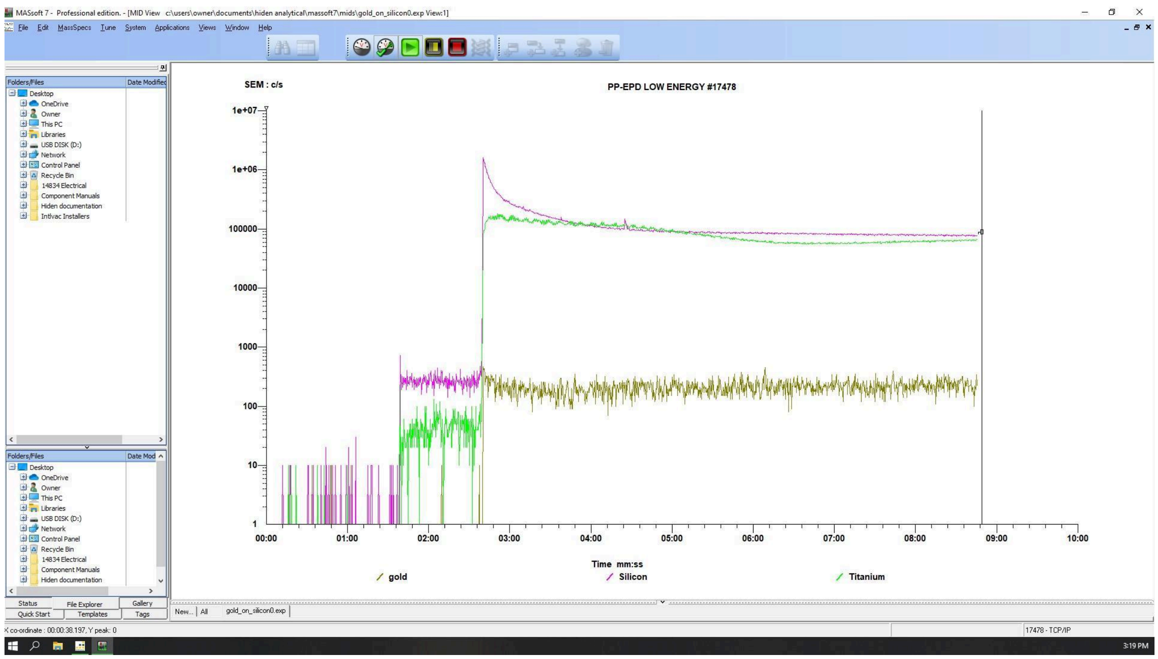
14 Go back to the **Chamber Tab**.

15 Click on **Start Profile.** Stage will cool from 20C to 6C which will take 10 minutes. Then, process will begin.

16 Once plasma is going inside chamber, feel free to start the SIMS detection and data acquisition by clicking on the green arrow on the screen.



17 Answer the data acquisition questions and decide on a file name (it increments automatically) as to where to store the acquired data.



18 Press green lit button on rack to end ion mill etching and SIMS monitoring when the signal of interest has either degraded to 1/10th of its original amount, or a new signal from an underlying film has increased to ten times its original amount.

f UNLOADING SAMPLE

1 Make sure latch on chamber door is in down position before proceeding, or you may experience errors in the software when you try to vent.

2 Click on **Vent** to vent chamber when process is over. (hold icon down for several seconds to activate) Stage will warm up from 6C to 20C which will take 10 minutes. Then, venting will begin.

If you forgot to move the latch down at the beginning and get a Vent Error, move latch down, and click Vent icon again to reinitiate vent cycle.

3 Open door.

4 Remove ring.

5 Remove wafer.

User can press Process Advance physical button for DriChuck nitrogen if they would like this option, but this is likely not needed. You can choose to ignore it too, and not hit Process Advance, and everything will sequence normally.

6 Replace dummy wafer. No need to vacuum the wafer down onto the chuck. The next user can do that.

7 Replace ring.

g SHUTDOWN

1 Close door.

2 Click on **Pump** icon.

3 Position latch on door in vertical upward position, but slightly biased so it will fall forward once pump down begins (i.e move latch so computer display shows "door open' going

away when correctly positioned). *Latch being positioned vertically initiates the pump down sequence.*

If latch does not fall down once pump down begins, move to down position for the sake of future process steps and avoiding venting errors.

4 Remain at system until cross over occurs at 2.00E-1 Torr or 200 mTorr.

5 Log off ion mill computer screen.

6 Disable in Badger.

<u>Note:</u> The slow and fast profile recipes can be run using a resist mask. The 3 types of 'Faster' recipes have to utilize a hard mask, because they will burn the resist on too much, and the resist won't be able to be removed.

<u>Slow Etch Profile</u>

Profile file 'Slow-200-70-24.pfl

Profile: Beam V = 200 V
Beam I = 70 mA
Accel V = 24 V

	Material	Center	1cm	2cm	3cm	4cm
Slow	Cu	7.67 - 8 nm/min	7.07 - 7.33 nm/mi	6.67 - 7.4 nm/min	6.67 - 7 nm/min	6.67 - 7.6 nm/min
	Au	6.8 - 7.1 nm/min	7.3 - 7.8 nm/min	7.4 - 7.5 nm/min	6.6 - 7 nm/min	7 - 8.4 nm/min
	Si	2.8 - 3.2 nm/min	2.3 - 3 nm/min	2.9 - 3.2 nm/min	2.9 - 3 nm/min	2.8 - 2.9 nm/min
	Al	3.6 - 3.8 nm/min	3.1 - 3.3 nm/min	3.1 - 3.2 nm/min	3 - 3.6 nm/min	2.7 - 3.2 nm/min
	SiO2	2.95 - 3 nm/min	2.75 - 3.4 nm/mir	2.75 - 3.25 nm/mi	2.9 - 2.95 nm/min	2.8 - 2.9 nm/min
	Ti	2.6 - 2.8 nm/min	2.2 - 2.3 nm/min	2.1 - 2.5 nm/min	2 - 2.6 nm/min	2.2 - 2.4 nm/min
	TiW	2.6 - 3 nm/min	2.9 - 3.1 nm/min	2.8 - 3.2 nm/min	3 - 3.2 nm/min	2.6 - 3 nm/min
	Si3N4	1.9 - 2.4 nm/min	2.2 - 2.3 nm/min	2 - 2.5 nm/min	2.4 - 2.6 nm/min	2.3 - 2.7 nm/min
	PMMA C4	5 - 5.8 nm/min	5 - 5.4 nm/min	5.2 - 7.3 nm/min	5.2 - 5.7 nm/min	5.4 - 5.3 nm/min
	ZEP	2.9 - 3 nm/min	2.5 - 2.6 nm/min	2.2 - 2.7 nm/min	3 - 3.3 nm/min	2.6 - 3.3 nm/min
	MgO	1.7 - 1.8 nm/min	1.6 - 1.9 nm/min	1.6 - 1.8 nm/min	1.5 - 1.7 nm/min	1.7 - 1.7 nm/min
	Co	2.9 - 3.7 nm/min	3.6 - 4 nm/min	3.7 - 4.1 nm/min	3.2 - 3.5 nm/min	3.4 - 3.8 nm/min
	Fe	3.1 - 3.2 nm/min	2.8 - 3.2 nm/min	3.2 - 3.5 nm/min	2.7 - 3.2 nm/min	3 - 3.3 nm/min
	Mg	5.7 - 6 nm/min	5.8 - 6.1 nm/min	5.8 - 6.3 nm/min	6.2 - 5.6 nm/min	5.9 - 5.9 nm/min

Fast Etch Profile {2.3 to 3.6 Times the rate of the 'Slow' Etch Profile}

Profile file 'Fast-300-125-36.pfl'

Profile: Beam V = 300 V
Beam I = 125 mA
Accel V = 36 V

Fast	Cu	20 - 22.4 nm/min	20.6 - 22.4 nm/mi	20.8 - 21 nm/min	18.2 - 19 nm/min	18.6 - 19.2 nm/min
	Au	26.8 - 29 nm/min	24.8 - 25.6 nm/mi	24.4 - 25 nm/min	25.6 - 25.6 nm/mir	27.4 - 28.4 nm/min
	Si	5.6 - 6.2 nm/min	7 - 7 nm/min	6.3 - 6.3 nm/min	7 - 7 nm/min	7 - 7.4 nm/min
	Al	7.2 - 7.5 nm/min	7.8 - 9.25 nm/min	7.5 - 8.25 nm/min	8 - 8 nm/min	7 - 6.25 nm/min
	SiO2	10.5 - 11.6 nm/mi	9.3 - 10 nm/min	7.3 - 10.9 nm/min	7.3 - 7.6 nm/min	5.8 - 9 nm/min
	Ti	6.7 - 7 nm/min	6 - 6.7 nm/min	5.8 - 6.7 nm/min	5.6 - 7.2 nm/min	6.4 - 6.4 nm/min
	TiW	8.4 - 9.2 nm/min	7.4 - 8.5 nm/min	7.4 - 8.4 nm/min	6.9 - 8 nm/min	7.8 - 8.4 nm/min
	Si3N4	6.4 - 6.6 nm/min	7.1 - 7.8 nm/min	7.7 - 7.6 nm/min	7.7 - 8.2 nm/min	7.2 - 7.7 nm/min
	PMMA C4	18.1 - 18.8 nm/mi	17.5 - 17.3 nm/mi	17.5 - 18.8 nm/mi	17.1 - 18.1 nm/mir	16.4 - 16.8 nm/min
	ZEP	5 - 5.2 nm/min	5.4 - 5.6 nm/min	5.1 - 5.6 nm/min	7.1 - 7.6 nm/min	6 - 7.2 nm/min
	MgO	3.4 - 4.4 nm/min	5.1 - 5.4 nm/min	3.6 - 4.3 nm/min	3.6 - 4.5 nm/min	4.1 - 4.6 nm/min
	Co	9 - 10.1 nm/min	9 - 11.3 nm/min	9.6 - 9.9 nm/min	8.8 - 9 nm/min	10.1 - 10.3 nm/min
	Fe	8.8 - 9.2 nm/min	7.7 - 8.4 nm/min	8.4 - 8.7 nm/min	8.2 - 8.5 nm/min	8.3 - 8.3 nm/min
	Mg	20 - 23.4 nm/min	22.8 - 18.4 nm/m	23 - 17 nm/min	27 - 18.4 nm/min	31 - 20.8 nm/min