IIT Bombay Nanofabrication Facility

Tool Name: Raith Short (RAITH 150 Two)

Standard Operating System (SOP)

INDEX

Contents

Tool's Overview

Fig. Raith Long

Checklist (Before starting the tool)

Sample Holders Used

There are 3 Universal Sample Holders for different substrates

General Purpose Holder

1. All samples (after contamination check) - Quartz, Sapphire, Copper, Germanium, Diamond. Samples or Sample preparation having Na+, K+ ion content, CNT's, Graphene, 2D materials. Samples from other departments, Samples undergone processing outside CEN.
2. Si Holder: Silicon substrates - processed in CEN only
3. III-V Holder: GaN, GaAs, Sapphire having any III-V material deposited on it - processed only in CEN

Limitations/ Restrictions

SEM Imaging*:* Powdered samples- will be considered on case by case basis,6-top down samples [size if: 1/4th of 2” wafer or less] and 3 cross-sectional samples [size if: 10mm x 6mm]

Please use EVO SEM for imaging if your features are above 0.5um, substrate and material on top is conducting.

EBL: mainly for features <= 10um

GIS: deposition for features <= 5um

For any special case please get permission from the faculty in-charge of the tool

Re-Authorization policy:

If there has been a gap of one month or more for system usage, the user needs to give a demo to the SO. As per the user’s performance, SO decides, if the User needs to undergo any practice sessions and whetherhe needs give a, b or c

a. Practical test

b. Practical test + viva

a. Written test + practical test + viva

Violation policy

1. If there is any mishandling of the system by the AU and it is not reported to the SO on time by the user: he/she will be barred from using the system for 3 weeks and he/she has to attend 2 consecutive cleaning sessions plus one day to assist the facility team in their work.
2. If the logbook entry is missed, it will be reported to CENIITB as violation.
3. Auto-cancellation: 2 warnings will be given for each violation and for the 3rd time one will be de- authorized.

Cleaning Protocol for Raith

1. Use lint free cloth and IPA only.
2. Clean the instrument body, working table with IPA soaked cloth. (To be done carefully)
3. The top of the instrument should be cleaned by the cleaner with the lint free cloth. Once he is done with the top cleaning please ask him to keep the stool out of the Nano lab. It should not remain in Nano lab.
4. Clean all the tweezers, General purpose holder and the Silicon holder
5. Clean all stains resist marks etc completely and very carefully
   Please take help of cleaners wherever necessary. Please take care of the cables and boxes while the cleaner is cleaning the system and the area nearby.

N2 Cylinder Change

1. Bring N2 pressure regulator inside the lab to 0 mbar
2. inform one of the facility team member to change the cylinder
3. open the cylinder and set the line pressure between 4~6 bar
4. inside the lab set the pressure in the N2 regulator to 330 mbar
5. Perform a loading procedure with a substrate holder: Check for pressure changes in the regulators both inside (by yourself) and outside (by facility team member) the lab
6. if there are any changes set it again to the above mentioned values
7. Start your run

Common Errors observed while using the system:

Occurs during sem s/w start up:

1. Sem: Stage 5v supply failed

2. Sem: Stage is not initialized

Solution: Please ignore the error

Occurs during the process:

1. Sem: EO scan 24v Pos supply failed

2. Sem: EO scan 24v Neg supply failed

Solution: Minimize the EM server window **Please do not close the EM server window**

Occurs while loading:

Outer arm position not initialized/ Initialization error

Solution:

1. Go to load-lock icon on the right hand side of Raith software
2. Select Advanced Tab
3. Select Status
4. Check the status of LED's
5. If **GREY,** restart the Raith S/w and check again
6. If **GREEN**, start the loading procedure.

If any problem arises in the system while you are working:

1. Please Make a note of it in the logbook
2. Call either of the system owners and inform them
3. Place a note near the system
4. Inform the users who have booked the next slots (mail/phone)
5. Please do not try anything to rectify the problem **unless** you are with an **experienced AU** or **SO** / or you have be instructed by the SO to do so.

Restart of PC:

1. Exit Raith s/w
2. Exit sem s/w
3. Close em server
4. Log off training login
5. Restart pc
6. Login training
7. Double click in column control s/w
8. Login user name password (front page of log book)
9. Login raith s/w

This sequence is to be maintained strictly. If you are not sure if Raith s/w is closed or not please

check itin the task manager and then only close the sem s/w

SOP

Check all the facilities connected to the system in service corridor

1. Status of compressor - [8 bar- on black scale or 100 on red scale]
2. lab chiller – pressure and valve status - At present the tool is connected to the Lab Chiller,Hence you need to check the valve positions, Filter and gauge.
3. Status of the UPS - **[Line Mode]** - normal cases else [Battery Mode] - when there is power cut
4. N2 cylinder:
    a. Cylinder pressure >= **10**
    b. Line pressure (between **4~6 bar**)

5. Status of Backing pump The Display should show **0.0 mbar and Turbo Mode**
6. Enter the Nano lab-litho room with proper gowning - **wearing gloves and goggles**
7. Check the dehumidifiers - empty the buckets if full.
8. Check the compressor (**6~6.2bar**) pressure gauge and cylinder (**300~330mbar**) pressure gauge
9. Tool is on 24x7 with Smart SEM software running (Monitor-1)
10. Start the Raith Software with your login ID
11. Go to the load lock Icon - Advanced Tab - select Status - and check the LED status- They should begreen
    - Outer initialize **- green**
    - Inner initialize **- green**
    - Outer position **- green**
12. If the LED is **GREY** or inactive restart the Raith software and check again.
13. If the above mentioned LED's are green then move to the next step that is loading.
14. Check the sample holder status in TV mode and position of the load lock icon (it should be green: pointing towards the chamber [➢])
15. Depending on the sample substrate select the sample holder to be used
16. Take a clean lint free cloth and place it on the working table of Raith
17. Place the holder on lint free cloth and mount samples on the holder as per the observations to be done i.e. surface, cross-section or 45 degrees
18. Place the holder in the load lock chamber, taking care of the stoppers and notch provided on the robot arm to place the holder correctly
19. Click on the load button in the Raith s/w
20. Observe the loading procedure taking place step by step Read the pop up messages properly thatappear during this procedure and click on "ok" or "cancel" as per requirement.
21. Observe the load / unload icon to check the completion of procedure (it should be brown: pointingtowards load lock [➢]).
22. Change the Z (stage height) in the Stage Control menu as per the observations to be done (20z forsurface imaging and 18z for cross-sectional or 45Deg) : **[xy/uv Icon - stage control - drive tab- command line]**
23. Check the EHT voltage and set it to a value required for Imaging or EBL
24. Switch on EHT - it should ramp up completely.
25. Go to SEM mode.
26. Raith s/w - File - Open Wafer map and move to the sample to be observed first by clicking (control +right click) on the map.
27. Observe the sample at lower magnification (50X /100X) and Locate a particle on the sample
28. Try to focus the particle at a higher magnification (2kX/5kX).

29. On achieving maximum focus, do the Stigmation correction and Aperture alignment.

For Imaging

30. Now go to the area that needs to observed and imaged Repeat steps 18, 19, 20, 21 and 22 if required.
31. On achieving best possible focus go for 3rd or 4th scan [Sem s/w - Icon bar] and freeze the image.
32. Save the image with appropriate name in a folder of respective date.
33. Same procedure is to be followed for other samples loaded on the holder.
34. When doing cross-sectional or 45 degree samples change the stage height to 18z
35. As the imaging is complete, switch off the beam.
36. Turn off the EHT
37. Move to TV mode
38. Make a note of all parameters used in the Log Book
39. Unload the sample holder
40. Take it out from the load lock and place it on a lint free cloth on the working table.
41. Unmounts the sample from holder and keep it back in respective sample boxes
42. Place the holder in its box or in the rack adjacent to the LL chamber

For EBL

43. All the above steps till 22 are to be followed as they are Switch on the cross wire
44. Set the write field (WF) for writing.
45. Select a straight edge of the wafer and move the cross wire to one or corner of the wafer along thatedge.
46. Open the **xy/uv menu**
47. Select **Origin** correction tab.
48. Press the adjust button. (This corner becomes the origin of sample)
49. Now select the angle correction tab
50. Press the read button for 1st point
51. Move along the straight edge of the sample using joystick
52. Select 2nd corner of the sample or any point along the straight edge as per the size of the sample
53. Press the read button for 2nd point
54. Now press the adjust button of the angle correction tab
55. Decide the co-ordinates where writing is to be done
56. Go to a point 0.5 mm less than the writing coordinates
57. Repeat steps 19, 20, 21 and 22
58. Burn a spot and again repeat steps 20 and 21 with the spot
59. Do write field alignment using the spot
60. Go to Faraday cup (Exposure Menu- Measure)
61. Measure the beam current in the Faraday cup
62. Select the exposure menu
63. Enter the required dose and step size
64. Calculate the dwell time and press ok
65. Open new position list
66. Drag the GDSII design to be written in the position list
67. Right click on the selection.
68. Select properties from the drop down list
69. Select the layer to be written
70. Enter the co-ordinates where the design is to be written

71. Press the exposure parameter button and click on time to find the total writing time.
72. On doing so and checking all the parameters again press the scan button.
73. The writing starts
74. Switch to TV mode
75. Make a note of all parameters used in the Log Book
76. Switch off the EHT
77. Unload the sample holder
78. Take it out from the load lock and place it on a lint free cloth on the working table.
79. Unmount the sample from holder
80. Place the holder in its respective box
81. Develop the written sample and observe it in optical microscope or SEM depending on the featuresizes

For GIS:

82. Use the universal flat sample holder
83. Mount your sample on the holder
84. Place it in the load lock chamber
85. Load the holder
86. Once the loading is complete change stage height to 18z
87. Turn on the heaters of the material to be deposited
88. Set the EHT at 3KV
89. Focus the sample as instructed in steps 18,19,20,21
90. Once focusing is done switch off the EHT
91. Close the column chamber valve
92. Check the status of all the heaters (reservoir, capillary and nozzle)
93. Check the system vacuum (it should be in the range of 3~4 e-6 mbar)
94. Once the heaters are on and the required system vacuum is achieved one can start the outgas procedure
95. Before **out gassing** please verify that the **EHT is off** and **column chamber valve is closed**.
96. Each injection line is to be out gassed independently.
97. Select the details button in the outgas menu and set the on time as 0.3s
98. Press the outgas icon
99. Keep a check on the system vacuum; it should not exceed 1e-5 mbar
100. Wait for the system vacuum to reach 3 ~ 4e-6 mbar
101. Do the out gas procedure of 0.4, 0.5, 0.6, 0.7 seconds respectively
102. Open the valve of respective material and check the vacuum (e.g. for Pt and W it should be between 4-8 e-6mbar)
103. Close the valve
104. Open the column chamber valve
105. Turn on EHT
106. Move the micro positioner from park position to standby
107. Now view the sample and try to adjust the contrast, brightness and focus on the sample
108. Make the pattern where the deposition is to done using surface editor facility
109. Move the positioner such that the nozzle of the material is just above area where the deposition is totake place
110. Feed in the loops to deposit the material
111. Calculate time
112. Open the valve of the material to be deposited
113. Check the system vacuum
114. As the vacuum goes above 4e-6 mbar start the deposition
115. As the deposition is complete close the valve
116. Move arm to park position
117. Go to TV mode and return to Sem mode
118. Open beam window
119. Image and check the deposition done.

120. Take images if required
121. If no more depositions are to be done switch off the reservoir heater
122. Turn off the EHT
123. Make a note of all parameters used in the Log Book Turn off the EHT
124. Swith off the capillary and nozzle heaters after 20mins
125. Send the manipulator arm to PARK position.
126. Unload the sample holder
127. Unclamp the sample from the holder and keep it in the sample box
128. Place the holder in its respective box or the holder rack next to load Lock
129. Please note the process parameters in the process logbook

The system is always on and is shut down only during maintenance / any emergency / servicing. So the steps given below should be followed only when any such situation arises and in consultation with one of the SO's.

System Start up

1. Check all the electrical, gas and cooling water supply connections are present and within specifications.
2. Press Yellow "Standby" button on the front of the system
3. Wait for 10secs
4. Press Green "On" button on the front of the system
5. Press the Enter key on keyboard
6. Wait for 5 sec
7. Login as Training
8. Start Column s/w [column control]
9. Check the vacuum values in chamber and column
10. Accordingly open the column chamber valve
11. Start Raith s/w
12. On achieving the necessary column vacuum Switch On the GUN
13. On achieving the necessary system vacuum Switch On the EHT
14. Check the LED's of the loadlock if all are initialized in the Advanced Load Lock tab.
15. Let the system stabilize for 1-2 hrs before you start working with the system.

System Shut down

1. Check that no sample holder is inside the chamber or load lock
2. Turn off EHT
3. Turn off Gun (Admin Login required)
4. Exit Raith s/w
5. Log off Smart Sem s/w
6. Close EM Server
7. Shut down PC
8. Press Yellow "Standby " button on the front of the system
9. Wait for 10secs
10. Press Red "Off" button on the front of the system

Emergency shutdown (During power cut)

1. System is connected to UPS
2. The lab UPS lasts for 2 hrs.
3. One can use the system for 1hr utmost after power failure
4. If the power is not back within an hour
5. Switch EHT Off
6. Unload your samples
7. Inform any one of the SO to switch off the GUN and the System
8. Pl try to get in touch with anyone of the SO's, you can with shut down if SO's guides you.
9. Exit off both the s/w (**Smart Sem and Raith**)
10. Shut down the PC.
11. If the power is not back put the system in standby mode.
12. SO will switch on the system when the power is back
13. Let the system and column vacuum reach the necessary values
14. SO should initialize the load lock
15. One should not use the system till the Load Lock is initialized by the SO

SOP for HSQ usage

Over the past one year, we have observed serious issue of solidification of HSQ resist making it useless and leading to huge wastage. To avoid such damage in the future and also to track the HSQ users, we have prepared a standard operating procedure (SOP) for HSQ usage, taking inputs from the literature and also from the past experience. Anyone planning to use HSQ is urged to strictly adhere to the SOP.

1. If you are planning to use HSQ, drop a mail to the SO stating the same.
2. If you are a first time HSQ user, it is mandatory that you have a one-to-onediscussion with the SO at-least once.

Inside the lab

3. Take the disposable plastic pipette and blow N2 properly in and out of the pipette.
4. Take out the HSQ bottle from the refrigerator as and when you are ready. Remember that the chemical is highly sensitive to humidity as well as temperature. So, do not keep the bottle open and outside for more than a minute while taking the resist in the pipette. Also, be extra cautious not to take the bottle near the hot plate.
5. Be careful not to take the resist more than required in the pipette. It is a general observation that we tend to over-estimate the quantity of resist required. The images shown below gives an approximate idea about the amount of resist required for 1x1 cm^2 and 0.5x0.5 cm^2 of sample size.

More than enough resistto spin coat 1x1 cm^2

More than enough resistto spin coat 0.5x0.5 cm^2

1. Be extra cautious so that glass and metals do not come in contact with the resist in the bottle.
2. If you observe some sign of solidification of the chemical in the bottle, inform the concerned person immediately.