



IIT Bombay Nanofabrication Facility

Tool Name: Raith Long (RAITH 150 Two)

Standard Operating System (SOP)

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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: All samples(after contamination check) - Glass, Quartz, Sapphire, Copper, Samples or Sample preparation having Na⁺, K⁺ ion content, CNT's, Samples from other departments, Sample on which any part of the processing has be done outside CEN,

Si Holder: Silicon substrates - processed in CEN only

III-V Holder: GaN, GaAs, Sapphire having any III-V material deposited on it - processed in CEN only.

Limitations / Restrictions:

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]

EBL: only for features $\leq 10\mu\text{m}$

GIS: deposition for features $\leq 5\mu\text{m}$

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

Training Procedure:

Please bring the Training log sheet along with you for each session and get it filled from the AU training you.

One theory + demo session (complete system is demonstrated along with the facilities) 2 demo

sessions (one week) – 1. Student observes the User handling the system

2. User gives instruction of handling the system practically 2 hands on sessions

(one week) - Student handles the system under AU user's guidance

2 practice sessions (one week) – Student handles the system under AU user's supervision

1 Written test- Depending on the performance of written test it will be decided whether to take another written test or to proceed to next level.

1 Practical test + viva- Depending on the performance it will be decided whether the student needs more practice sessions or can be authorized to use the system independently or not eligible for independent handling (authorization)

Please submit the training log sheet to the SO conducting your Test

1-2 days - to complete all the tests.

If the student is regular and his/her pick up is good - One session for each training step can be followed.

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 whether he 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 one fails to attend 2-3 cleaning sessions consecutively that too without informing your cleaning partner or SO, one has to attend back to back cleaning sessions for the next two weeks
3. If the logbook entry is missed, it will be reported to CENIITB as violation.
4. 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.
6. 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 urself) 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:

- Sem: Stage 5v supply failed
- Sem: Stage is not initialized

Solution: Please ignore the error

Occurs during the process

- Sem: EO scan 24v Pos supply failed
- Sem: EO scan 24v Neg supply failed

Solution: Minimize the EM server window

Please do not close the 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 traing
7. Double click in column control s/w
8. Login user name password (front page of SEM log book)
9. Login raith s/w

This sequence is to be strictly maintained. If you are not sure if Raith s/w is closed or not please check it in the task manager and then only close the sem s/w

SOP

Check all the facilities required by the system in the service corridor

- a. Status of compressor - [8 bar- on black scale or 100 on red scale]
- b. 2 chillers (cover and main): currently connected to lab chiller
 - Water level in reservoir - if low - fill in Di Water
 - Temperature(19 degree for cover and 20 degrees for mains)
 - Pressure(20-25psi)

At present the tool is connected to the Lab Chiller, Hence you need to check the valve positions

c. Status of the UPS - [Line Mode]- normal cases / [Battery Mode] - when powercut

d. N2 cylinder:

- Cylinder pressure ≥ 10
- Line pressure (between 4~6 bar)

e. Status of Backing pump (whether it's warm and vibrating)

1. Enter the Nano lab-litho room with proper gowning and wearing gloves
2. Check the dehumidifiers - empty the buckets if full.
3. Check the compressor (6bar)pressure gauge and cylinder (300mbar)pressure gauge
4. Raith system is always in on condition with Smart SEM software alwaysrunning(Monitor-1)
5. Start the Raith Software
6. Go to the load lock Icon - Advanced Tab - select Status - and check the LED status-They should be green

* outer initialize - green

* inner initialized - green

* outer position - green

If the LED are grey / inactive restart the Raith software and check again.

8. If the above mentioned LED's are green then move to the next step of loading.

7. Check the sample holder status in TV mode and position of the load lock icon (it should be green: pointing towards the chamber[➤])
8. Depending on the sample substrate select the sample holder to be used
9. Take a clean lint free cloth and place it on the working table of Raith
10. Place the holder on lint free cloth and load samples on the holder as per the observations to be done i.e. surface, cross-section or 45 degrees
11. 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
12. Click on the load button in the Raith s/w
13. Observe the loading procedure taking place step by step Read the pop up messages properly that appear during this procedure and click on "ok" or "cancel" as per requirement
14. Observe the load / unload icon to check the completion of procedure(it should be brown: pointing towards load lock[➤])
15. Change the Z (stage height) in the stage control menu as per the observations to be done (20z for surface imaging and 18z for cross-sectional or 45) : [xy/uv Icon - stage control - drive tab-command line]
16. Check the EHT voltage and set it to a value required for Imaging or EBL

17. Switch on EHT - it should switch on completely
18. Go to SEM mode
19. Raith s/w - File - Open Wafer map and move to the sample to be observed first by clicking (control + right click) on the map
20. Observe the sample at lower magnification (50X /100X) and
21. Locate a particle on the sample
22. Try to focus the particle at a higher magnification (2kX/5kX)
23. On achieving maximum focus possible, do the Stigmation correction and Aperture alignment

For Imaging

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

For EBL

37. All the above steps till 22 are to be followed as they are
38. Switch on the cross wire
39. Set the write field (WF) for writing
40. Select a straight edge of the wafer and move the cross wire to one or corner of the wafer along that edge
41. Open the xy/ uv menu
42. Select Origin correction tab
43. Press the adjust button. (This corner becomes the origin of sample)
44. Now select the angle correction tab
45. Press the read button for 1st point
46. Move along the straight edge of the sample using joystick
47. Select 2nd corner of the sample or any point along the straight edge as per the size of the sample
48. Press the read button for 2nd point
49. Now press the adjust button of the angle correction tab
50. Decide on the co-ordinates where writing is to be done
51. Go to a point 0.5 mm less than the writing coordinates
52. Repeat steps 19, 20, 21 and 22
53. Burn a spot and again repeat step 20 and 21 with the spot
54. Do write field alignment using the spot

55. Go to Faraday cup (Exposure Menu- Measure)
56. Measure the beam current in the Faraday cup
57. Select the exposure menu
58. Enter the required dose and step size
59. Calculate the dwell time and press ok
60. Open new position list
61. Drag the GDSII design to be written in the position list
62. Right click on the selection.
63. Select properties from the drop down list
64. Select the layer to be written
65. Enter the co-ordinates where the design is to be written
66. Press the exposure parameters button and click the on time to find out the writingtime.
67. On doing so and checking all the parameters again press the scan button.
68. The writing starts
69. As the writing is complete switch off the EHT
70. Move to TV mode
71. Make a note of all parameters used in the Log Book
72. Unload the sample holder
73. Take it out from the load lock and place it on a lint free cloth on the working table.
74. Unclamp the sample from holder and keep it back in the sample box
75. Place the holder in its respective box
76. Develop the written sample and observe it in optical microscope or SEM depending on the feature sizes

For GIS:

77. Use the universal flat sample holder
78. Mount your sample on the holder
79. Place it in the load lock chamber
80. Load the holder
81. Once the loading is complete change stage height to 18z
82. Turn on the heaters of the material to be deposited
83. Set the EHT at 3KV
84. Focus the sample as instructed in steps 18,19,20,21
85. Once focusing is done switch of the EHT
86. Close the column chamber valve
87. Check the status of all the heaters(reservoir, capillary and nozzle)
88. Check the system vacuum(it should be in the range of 3~4 e-6 mbar)
89. Once the heaters are on and the required system vacuum is achieved one can start the outgas procedure
90. Before out gasing please verify that the EHT is off and column chamber valve is closed.
91. Each injection line is to out gassed independently.
92. Select the details button in the outgas menu and set the on time to 0.3s
93. Press the outgas icon
94. Keep a check on the system vacuum, it should not exceed 1e-5 mbar
95. wait for the system vacuum to reach 3 ~ 4e-6 mbar

96. Do the out gas procedure of 0.4, 0.5, 0.6, 0.7 seconds respectively
97. Open the valve of respective material and check the vacuum (e.g. for Pt and W it should be between 4-8 e-6mbar)
98. Close the valve
99. Open the column chamber valve.
100. Turn on EHT
101. Move the micro positioner from park position to standby
102. Now view the sample and again try to adjust the contrast, brightness and focus on the sample
103. Make the pattern in which the deposition is to be done using surface editor facility
104. Move the positioner such that the nozzle of the material is just above area where the deposition is to take place
105. Feed in the loops to deposit the material
106. Calculate the time
107. Open the valve of the material to be deposited
108. Check the system vacuum
109. As the vacuum goes above 4e-6 mbar start the deposition
110. As the deposition is complete close the valve
111. Move arm to park position
112. Go to TV mode and come back to Sem mode
113. Switch on the beam
114. Image and check the deposition done.
115. Take images if required
116. If no more depositions are to be done switch off the reservoir heater
117. Turn off the EHT
118. Make a note of all parameters used in the Log Book
119. Switch off the capillary and nozzle heaters after 20mins
120. Send the manipulator arm to PARK position.
121. Unload the sample holder
122. Unclamp the sample from the holder and keep it in the sample box
123. Place the holder in its respective box or the holder rack next to load Lock
124. 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
4. Close the column chamber valve.
5. Exit Raith s/w
6. Log off Smart Sem s/w
7. Close EM Server
8. Shut down PC
9. Press Yellow "Standby" button on the front of the system
10. Wait for 10secs
11. Press Red "Off" button on the front of the system

Emergency shutdown (During power cut)

- system is connected to UPS
- The lab UPS lasts for 2 hrs.
- one can use the system for at the most 1hr after power failure
- if the power is not back within an hour
- switch EHT Off
- unload your samples
- close the column chamber valve
- Inform any one of the SO to switch off the GUN and system
- If you are unable to get in touch with anyone of the SO's , You can shut down both the s/w's (Smart Sem and Raith)
- Shut down the PC.
- If the power is not back put the system in standby mode.
- SO will switch on the system when the power is back
- Let the system and column vacuum reach the necessary values
- SO should initialize the load lock
- One should not use the system till the Load Lock is initialized by the SO

Recipes:

A. **Resist Type:** PMMA (+ve) e-beam resist
 Supplier order code: NANO 950 PMMA A4 (4% solid contents)Molecular weight: 950 K
 Solvent: in Anisole
 Dehydration bake: 1 minute at 170 deg.

Spinning: Program G on PMMA spinner

Speed: 4000rpm, Speed: 3000 rpm (for lift-off) [Please check the data sheet if one needs some other resist thickness]

Pre bake: 90 sec at 180 deg.

Exposure:

Acc voltage: 10KV

Dose: 80uC/cm²

Write field: 100um

Developer: IPA: MIBK:: 3:1,

Developing time: 30 s

Stopper: 2-propanol (IPA) pure,

Stopping time: 15 s

Dry: with a low-nitrogen flow

PMMA thickness vs RPM

| Speed (rpm) | Thickness (nm) |
|-------------|----------------|
| 1500 | 754.75 |
| 2000 | 517.685 |
| 2500 | 275.0025 |
| 3000 | 247.435 |
| 3500 | 232.66 |
| 4000 | 212.62 |

B. Resist Type: HSQ (-ve) e-beam resist Supplier order code: Dow Corning XR -1541 - 6%

Solvent: MIBK

Dehydration bake: 15 minutes at 170 deg.

Spinning: Program H on spinner 2

Speed: 4000rpm

Pre bake: 2 min at 250 deg. Exposure:

Acc voltage: 10KV

Dose: 200uC/cm²

Write field: 100um

Developer: 25% TMAH,

Developing time: 15s

Rinse: Flowing DI-Water,

Rinsing time: 30s

Dry: with a low-nitrogen