

OPERATION SPECIFICATION  
FOR  
**TESCAN MIRA3 ELECTRON BEAM LITHOGRAPHY**

Rev.	Date	Prepared by
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## 1 SCOPE

- 1.1 The purpose of this document is to describe requirements and basic operating instructions for the TESCAN MIRA 3, E-Beam Lithography tool. This tool is intended for nano-patterning by electron beam.

## 2 SAFETY

- 2.1 Must be trained and signed off to use this equipment.
- 2.2 Record the tool malfunction, breakage, etc. in the log-sheet and send an email to staff. Never try to fix anything by yourself.

## 3 APPLICABLE DOCUMENTS, MATERIALS AND REQUIREMENTS

- 3.1 For more information about the detailed operation of this tool refer to the TESCAN factory manual – “DRAWBeam for Electron Beam Lithography” File name: TESCAN MIRA 3 Manual.pdf.

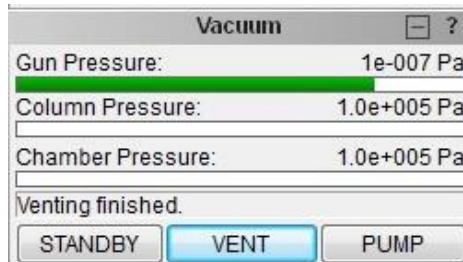
## 4 OPERATION

### 4.1 Loading the sample

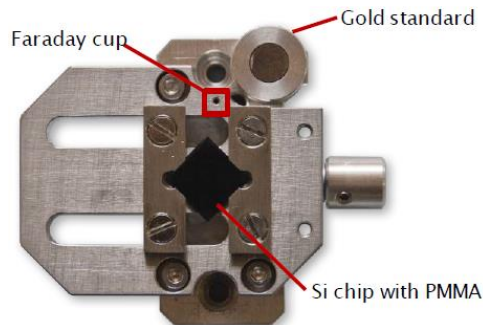
- 4.1.1 Log into **Mira-TC** software by clicking on MIRA3-TESCAN icon and entering user name and password.



4.1.2 Vent the chamber by clicking on the **VENT** button on the Vacuum Panel and wait to reach “**Venting finished**” status. (**Note:** make sure the stage is at **home** position (X=0; Y=0; Z=40; Rot & Tilt = 0°) before you vent the chamber. If not, click on Home button in stage control panel).

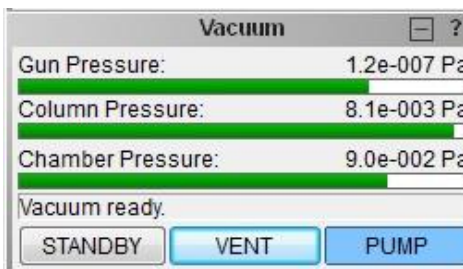


4.1.3 Open the chamber gently and load the sample onto sample holder. **User must have clean gloves on while loading and unloading the sample.**



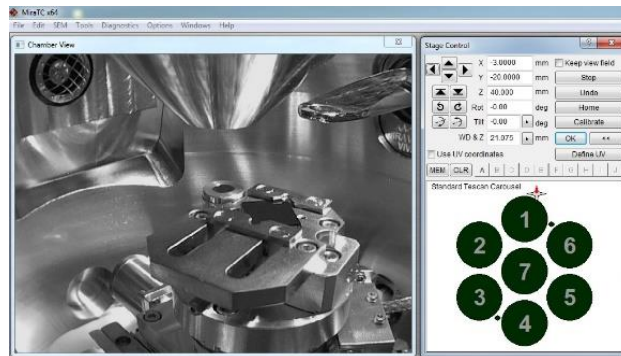
4.1.4 Gently close the chamber and hold the chamber's door.

4.1.5 Pump the chamber by clicking on the **PUMP** button on the Vacuum Panel and wait to reach “**Vacuum ready**” status.

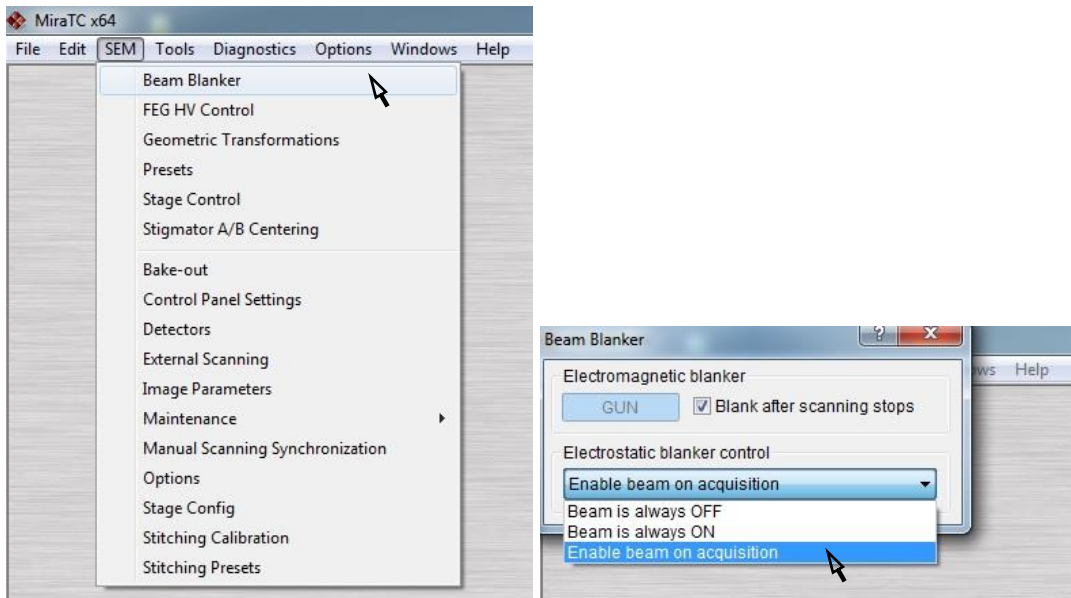


## 4.2 Turning on the electron beam

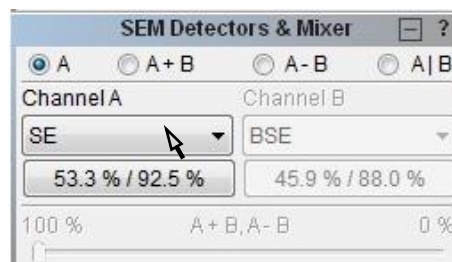
### 4.2.1 Move the stage above **gold standard** position



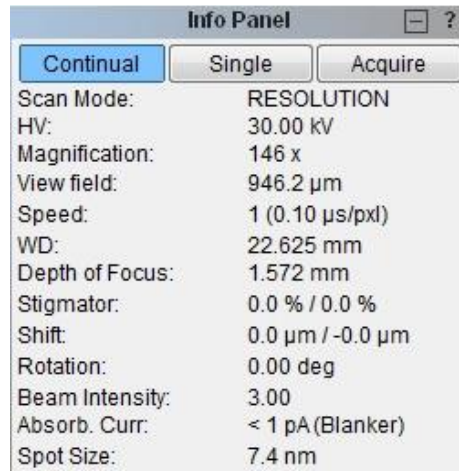
### 4.2.2 Open the “**Beam Blanker**” panel in the main SEM menu and select “**Enable beam on acquisition**”.



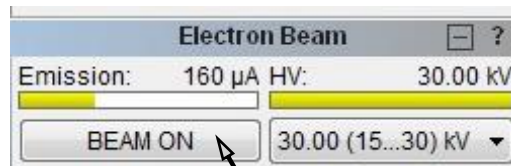
### 4.2.3 Select **SE** detector in the SEM Detectors & Mixer panel. Make sure the BSE detector is retracted.



4.2.4 Set the exposure parameters including acceleration voltage (**HV**; 30 kV is recommended) and **Beam Index** (BI; less than or equal to 5 is recommended) in Info Panel. (Note: for large patterns where both dimensions are in the range of few tens of microns and resolution is not as critical, use BI 8-10 to reduce the exposure time (higher BI is equivalent to higher beam current)).



4.2.5 Turn the electron beam on by clicking on the **BEAM ON** button on the Electron Beam panel.



4.2.6 Perform focus on gold standard at 50kx by turning WD knob on Control Panel. Once the gold standard is focused, gradually decrease WD&Z in stage control panel (WD&Z = 15, 10, and then 6.0) and re-perform focus until gold standard is focused at **WD  $\cong$  6.0**.






### 4.3 Electron Column Alignment


4.3.1 Perform fine focusing at magnifications  $\geq 200\times$ .

4.3.2 Perform gun centering by automatic procedure. Click on **AUTO GUN CENTERING** on the Electron Beam panel.



4.3.3 Perform Column Centering (Centering the aperture) manually. Click on  icon on

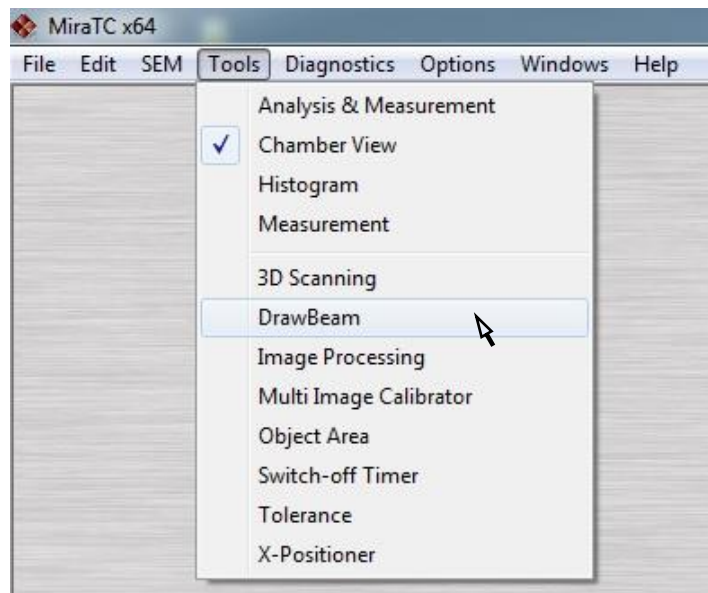
the toolbar and use control panel knobs ( for X and  for Y) or the trackball to center the aperture.

4.3.4 Correct Astigmatism (Correcting non-circularity in electron beam). Click on  icon on the toolbar and use control panel knobs or the trackball.

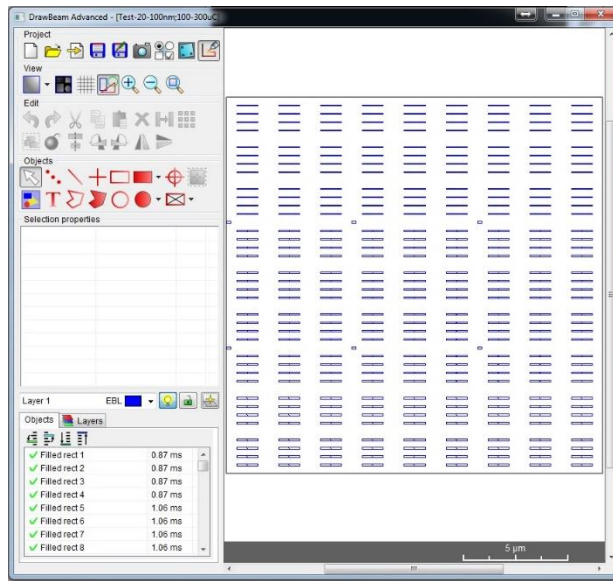
4.3.5 Re-Perform focusing.


### 4.4 Exposure

4.4.1 Open the DrawBeam panel in the main Tools menu.



4.4.2 Create a new project/open a saved project/ import from GDSII format by clicking on the

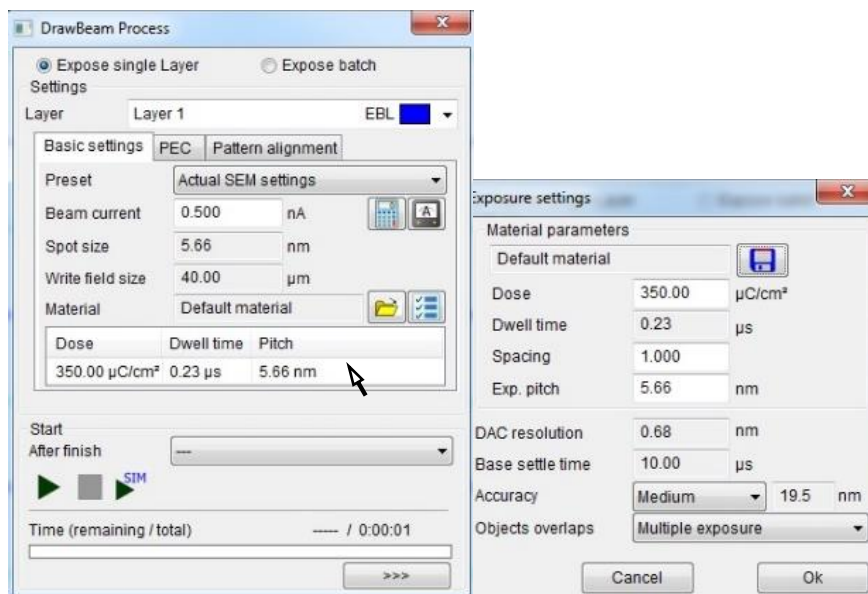


4.4.3 Click on the  icon in the DrawBeam panel to open the DrawBeam Process panel.


Enter the suitable Dose(s) and Spacing by double click on **Dose window**. (Note: keep the spacing at minimum possible value;

(1) Exp pitch should be  $\geq 4 \times \text{DAC resolution}$  (DAC resolution depends on view field)

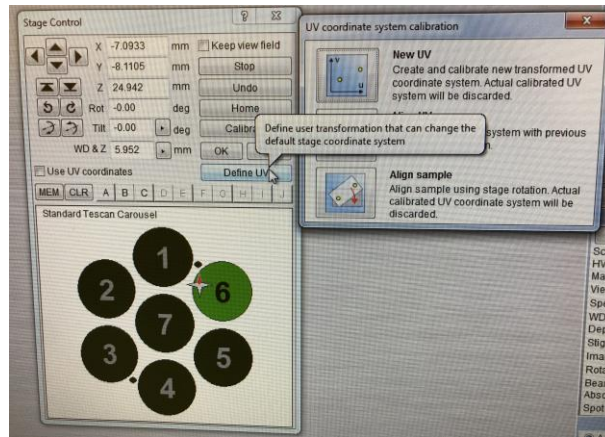
(2) Exp pitch = spot size  $\times$  spacing



- 4.4.4 Move the stage to the faraday cup. Magnify to 50kx (the entire screen should be black; i.e. all the electrons should be collected by faraday cup). Measure the **beam current** by

clicking on  icon in the DrawBeam Process panel. The correct value of the beam current will be automatically inserted in the panel.

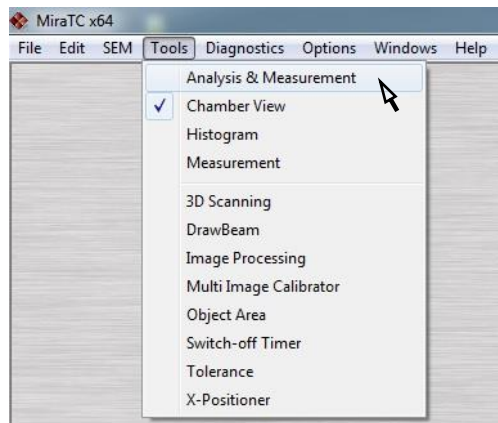
- 4.4.5 Move the stage to the edge of the sample and find the scratch you made on sample after spin coating. Click on Define UV and then Align sample to align sample with x and y directions.




- 4.4.6 Go to the tip of the scratch. Take caution not to expose the sample. Find a tiny particle and try to bring the particle on focus **without changing WD**. In order to do that you

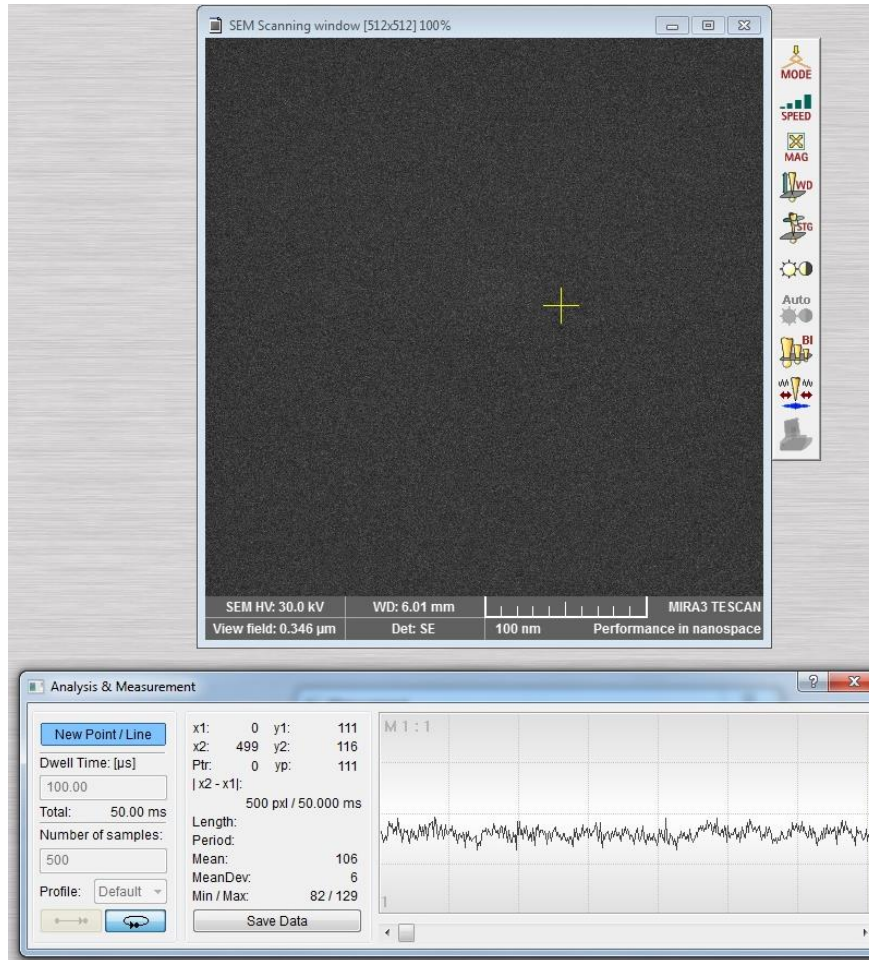
need to change Z. Keep changing Z using  buttons until you see a clear image of the particle.

- 4.4.7 Open the **Analysis & Measurement** panel in the main Tools menu (steps 4.4.7-4.4.9 are optional if step 4.4.6 is performed properly).

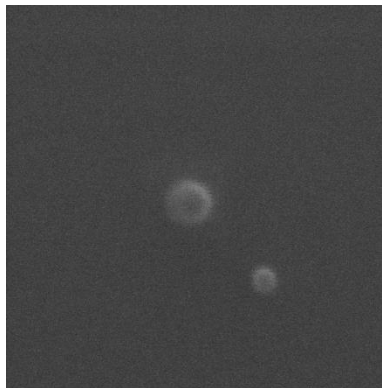




- 4.4.8 Click on the New Point/line button and place the point (Magnification should be 400kx). Start and stop the burning by clicking on the  icon. The burning time is 10-20 seconds.




- 4.4.9 Perform final focusing and astigmatism correction on the spot to achieve an ideal circular spot. Repeat burning and focusing, if necessary.



4.4.10 Blank the beam by clicking on the **Single button** on the Info Panel.



4.4.11 Move the stage to exposure location by entering new X and/or Y coordinates.

4.4.12 Start the exposure by clicking on  button in the DrawBeam Process panel. Move the stage and start another exposure, if needed.

4.4.13 After exposure is finished, turn the beam off by clicking on the **BEAM ON** button on the Electron Beam panel.

## 4.5 Unloading the sample

4.5.1 Move the stage to home location by clicking on **home** button in Stage Control Panel.

4.5.2 Vent the chamber by clicking on the **VENT** button on the Vacuum Panel and wait to reach "**Venting finished**" status.

4.5.3 Open the chamber gently and unload the sample.

4.5.4 Gently close the chamber and hold the chamber's door.

4.5.5 Pump the chamber by clicking on the **PUMP** button on the Vacuum Panel and wait to reach "**Vacuum ready**" status.

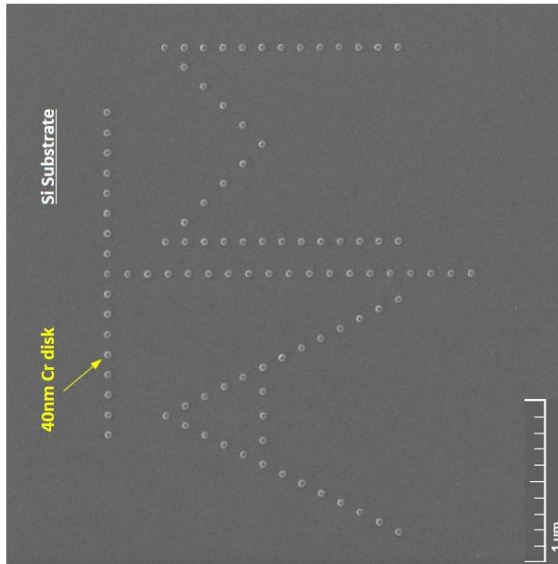
4.5.6 Log off the software. Click on the log off in the main tools menu. You will be asked two question: 1) do you really wish to log off: **Yes** 2) Go to the STANDBY mode: **No**

4.5.7 Fill out the log-sheet.

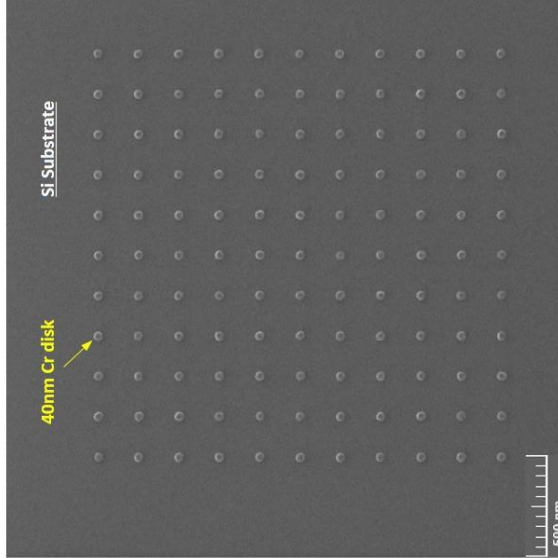
## Appendix A:

Some Examples for writing circles, lines, rings, and texts

## Nano-patterning of Circles



Nanofabrication of Texas A&M logo with 40nm-diameter lifted-off chromium disks

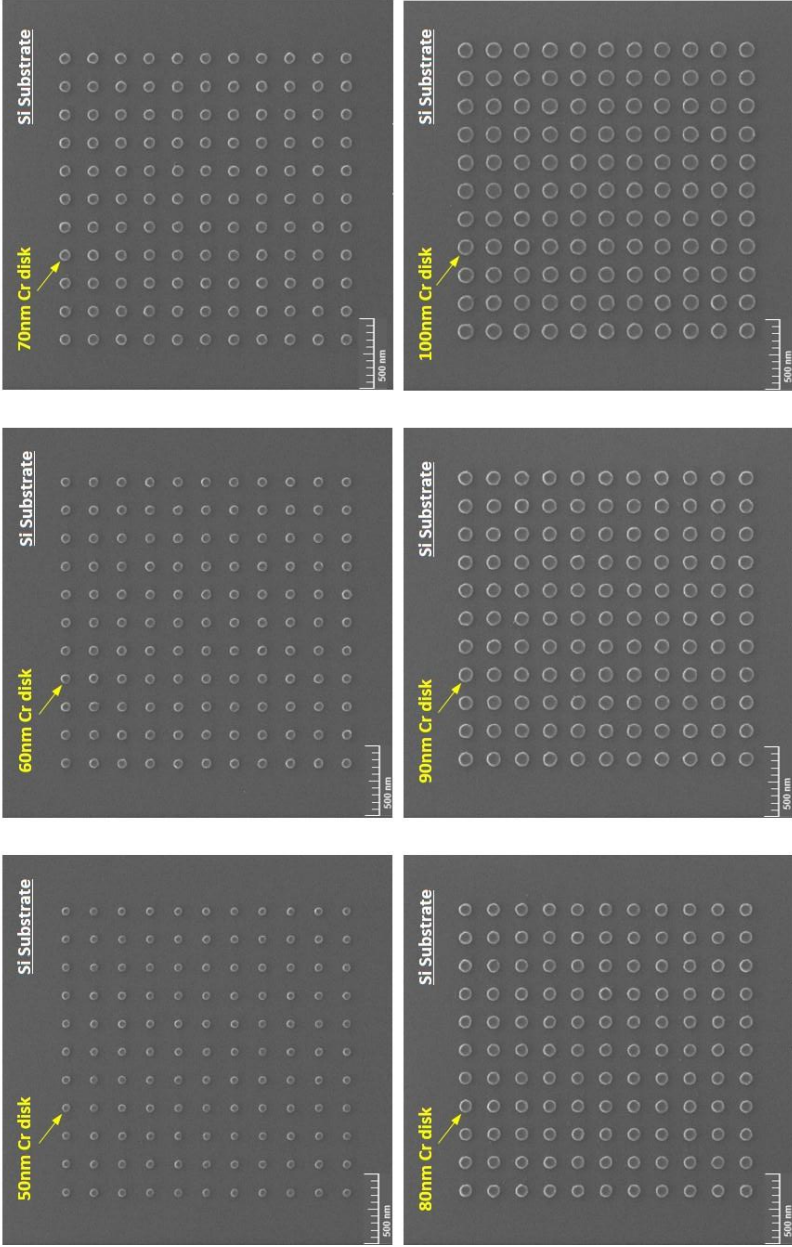


Nanofabrication of an array of 40nm-diameter lifted-off chromium disks with 200nm pitch

### Process Summary

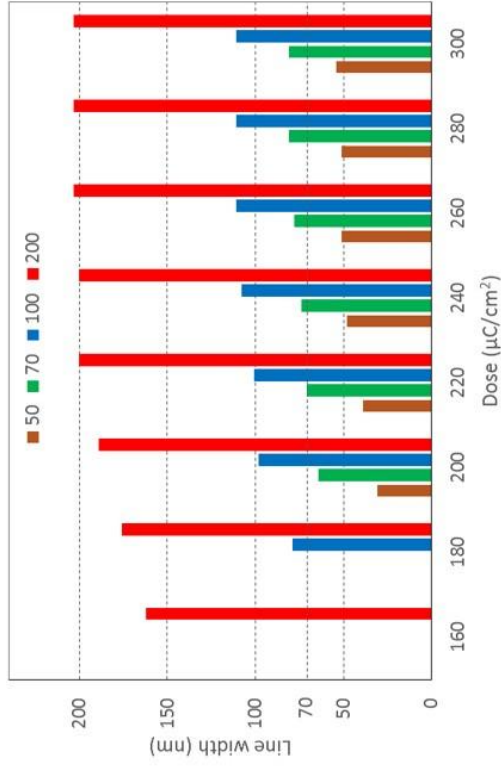
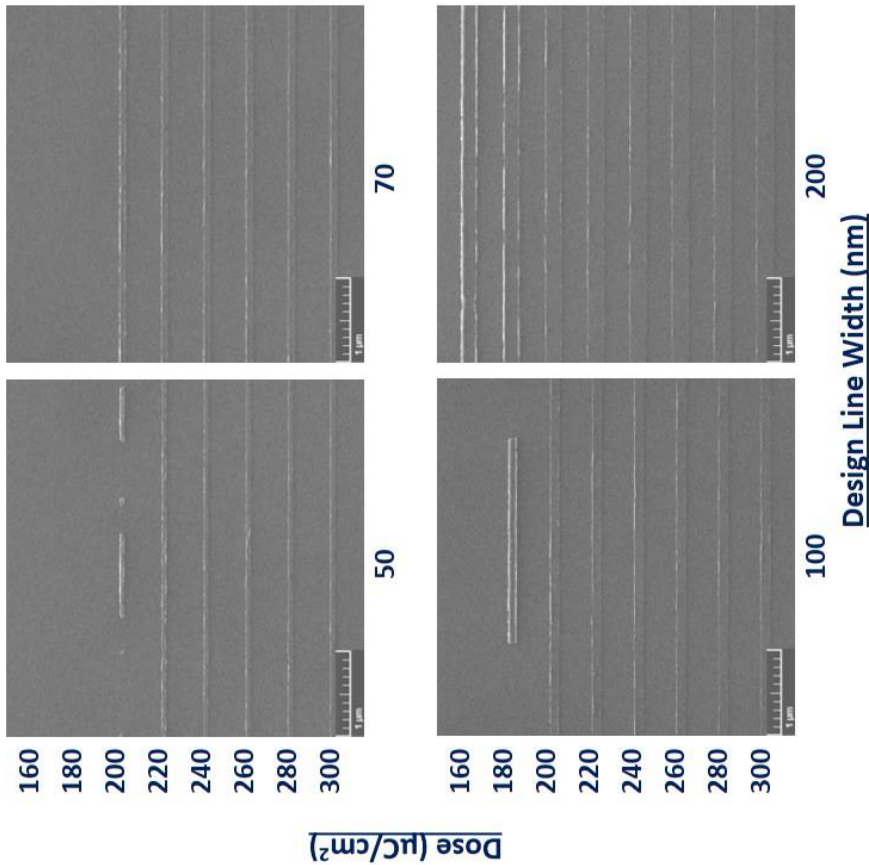
1. Resist: 950 PMMA A2
2. Dose: 350  $\mu\text{C}/\text{cm}^2$
3. Developer: MIBK:IPA - 1:3
4. Metallization: 10nm Cr
5. Lift off: Acetone

# Nano-patterning of Circles



Nanofabrication of an array of 50, 60, and 70-nm (top row ; left to right) and 80, 90, and 100nm-diameter (bottom row ; left to right) lifted-off chromium disks with 200nm pitch

# Nano-patterning of Lines – Dose Chart



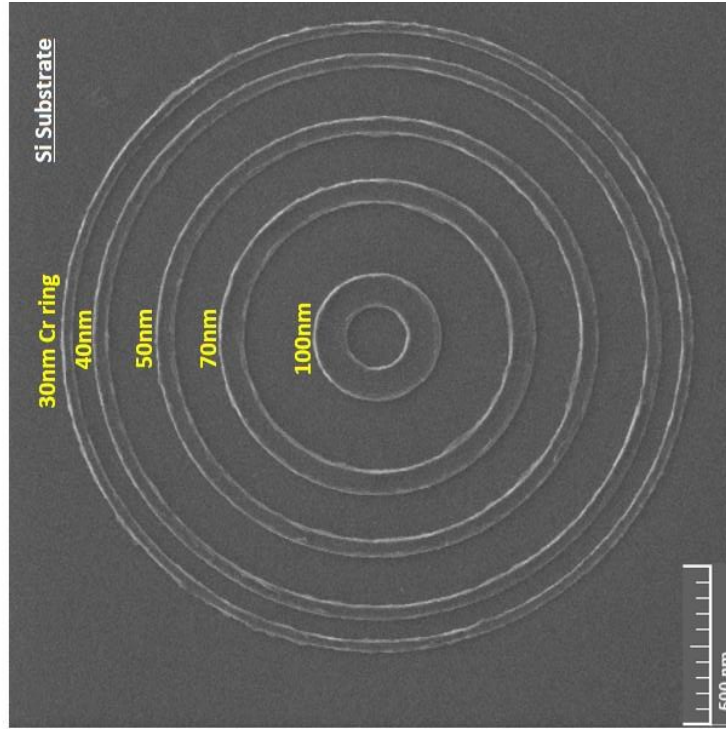
Patterned line width vs. Dose for 50, 70, 100, and 200 nm design line widths

### Process Summary

1. Resist: 950 PMMA A2
2. Developer: MIBK:IPA - 1:3
3. Metallization: 10nm Cr
4. Lift off: Acetone

**Note:** line load and spacing affect patterned line width

## Nano-patterning of Rings

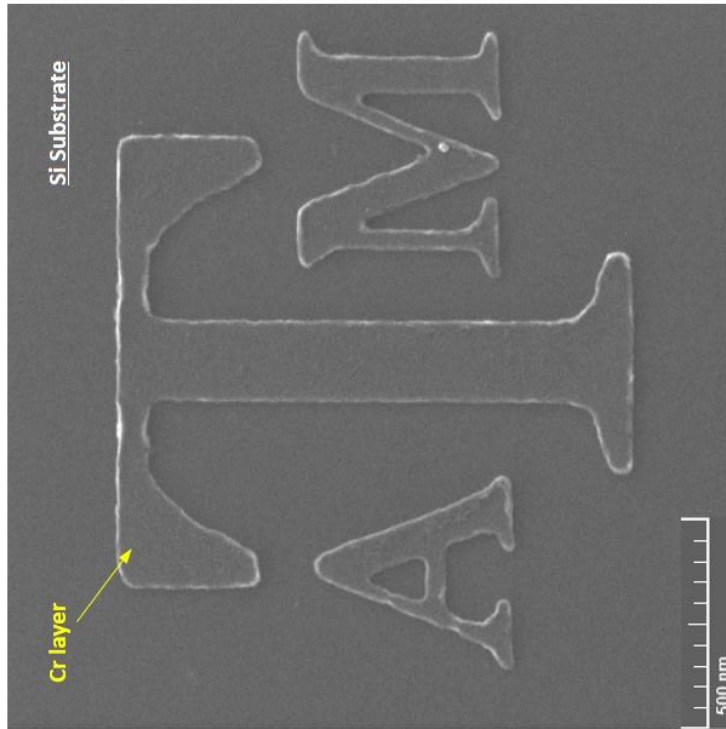


Nanofabrication of 30, 40, 50, 70, and 100nm-width lifted-off chromium rings

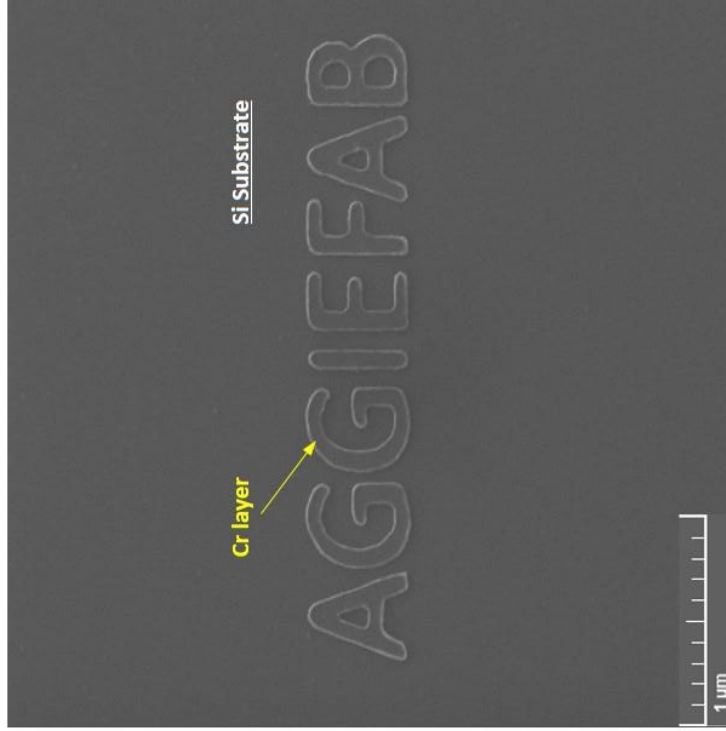
### Process Summary

1. Resist: 950 PMMA A2
2. Dose: 250  $\mu\text{C}/\text{cm}^2$
3. Developer: MIBK:IPA - 1:3
4. Metallization: 10nm Cr
5. Lift off: Acetone

## Nano-patterning of Text



Nanofabrication of Texas A&M logo  
with 15nm-thick lifted off chromium layer



Nanofabrication of Aggiefab  
with 15nm-thick lifted off chromium layer

### Process Summary

1. Resist: 950 PMMA A2
2. Dose: 325  $\mu\text{C}/\text{cm}^2$
3. Developer: MIBK:IPA - 1:3
4. Metallization: 15nm Cr
5. Lift off: Acetone



## Appendix B:

### PMMA Spin Coating and Developing

PMMA is purchased from Micro Chem

Spin Coating:

Step 1: 500 rpm, 5 seconds, 100 rpm/s

Step 2: 3000 rpm, 45 seconds, 500 rpm/s

Soft baking: 185 C for 90 seconds

Thickness: 950 PMMA A2: ~ 80 nm ; 950 PMMA A4: ~ 240 nm

Developer: 1:3 MIBK:IPA (MIBK: 4-Methyl-2-pentanone; purchased from Sigma Aldrich)

Develop time: gently shaking for 60 seconds

Wash thoroughly with DI Water after develop

Dry with N<sub>2</sub>.