Denton SJ20C E-Gun SOP

Purpose and Scope

This document provides job breakdowns and reference information for the Denton SJ20C E-Gun.

Table of Contents

Reference Documents

Reference Documents	SOP Number or link
User Guide	HTTPS://WWW.NANOFAB.UTAH.EDU/DOCUMENTS/2016/02/SMBB-USER-GUIDE.PDF/

Acronyms, Abbreviations and Definitions

Term	Description
SOP	Standard Operating Procedure

Equipment and Supplies

Description	
Denton SJ20C E-gun	Located in the sputter bay
Wafer/sample	Located next to the E-gun
Target materials	Located next to the E-gun
Glass microscope slides	Located next to the E-gun
Kapton tape	Located next to the E-gun

Description	
Aluminum foil	Located next to the E-gun
Crucible, (standard size)	Located next to the E-gun
Crucible, (small size)	Located next to the E-gun

Safety

Follow all Nanofab safety procedures.

Following deposition, exercise caution when touching any items inside the process chamber. They may be HOT.

Safety alert symbol

The Safety Alert Symbol is used in conjunction with signal words to convey a personal injury hazard is present.

Signal words

DANGER	Indicates an imminently hazardous situation, which if not avoided, will result in death or serious injury. The Safety Alert Symbol should always be used.
WARNING	Indicates a potentially hazardous situation, which if not avoided, may result in death or serious injury. If the safety alert symbol is NOT used in conjunction with this signal word, then the hazard conveyed is severe equipment or material damage.
CAUTION	Indicates a potentially hazardous situation, which if not avoided, may result in minor or moderate injury. If the safety alert symbol is NOT used in conjunction with this signal word, then the hazard conveyed is minor equipment or material damage.

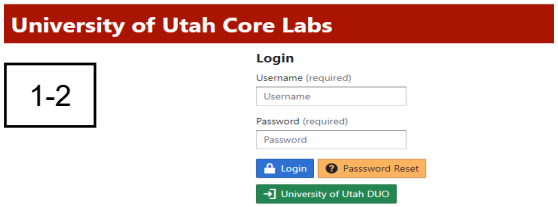
Forms

Training Form

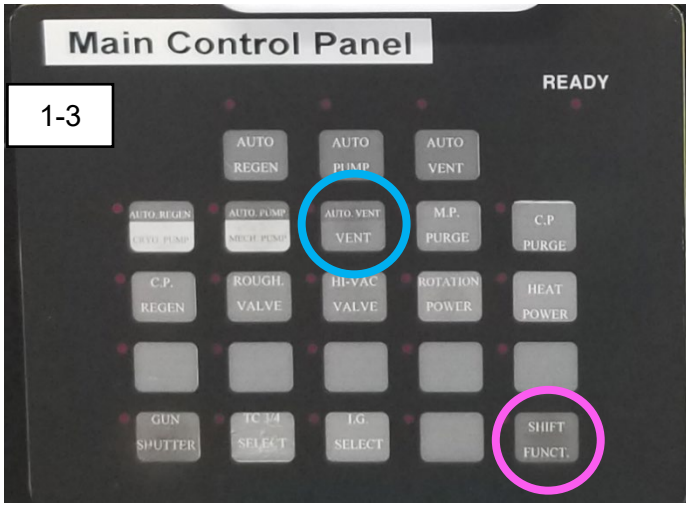
Trainee:			
Area:			
This person has been declared qualified to train others ☐ *(check if "Yes")*			
Item #	Task	Date Training Completed	Trainer
1	JB1 Enabling Tool in HSC and Tool Checks		
2	JB2 Power off Subsystems and Vent Chamber		
3	JB3 Check Chamber, Load Samples and Crucible(s)		
4	JB4 Pumping Down Chamber		
5	JB5 Substrate Heating (Optional)		
6	JB6 Program Deposition Controller		
7	JB7 Rotation (Optional, but recommended)		
8	JB8 Power up for processing		
9	JB9 Reset the crystal monitor		
10	JB10 Material Deposition		
11	JR1 Subsystem Power On/Off		
12	JR2 Locking in HSC and Data Collection Form		

Training Notes (Optional)									
Run completion dates:	1)		2)		3)		4)		5)	

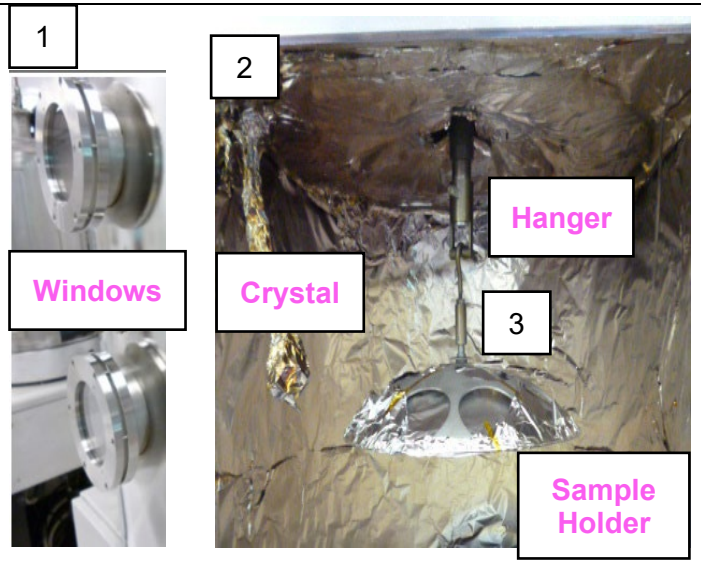
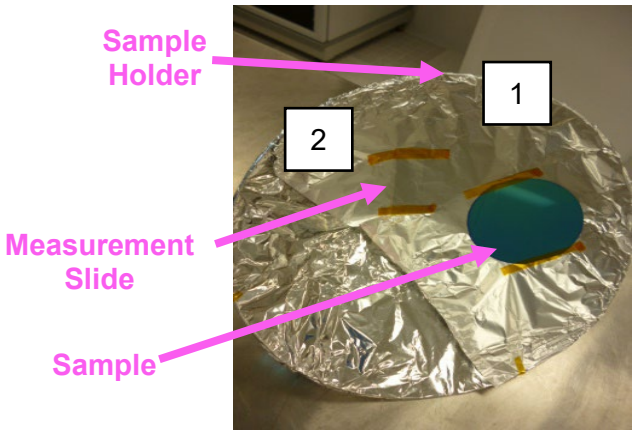
Job Breakdown 1 – Enabling Tool in HSC and Tool Checks (1 of 1)

A	**Enabling tool in HSC** 1. Log into HSC and reserve the E-gun for the desired time. 2. Unlock the tool in HSC to enable the Main Control Panel. *Note: The tool can only be enabled if there is an active reservation.*	 1-2	☐
B	**Check the crystal and cryo.** 1. Check that the Cryo pump temperature is less than 20k degrees. 2. Ensure the chamber is in high vacuum (E-06 range) by using the on/off button to the right of the Top gauge. Only turn on the top gauge if the center and bottom gauges display in the E-04 range. Top gauge (1) = Ion , Center (2) = Chamber, Bottom (3) = Fore-line 3. Turn on the Deposition Controller. 4. Check the lower right corner of the crystal monitor display. If it displays "XTAL FAIL", contact lab staff. 5. Press the C button. 6. Press the 1 button to show the crystal % at the bottom of the display. *Note: If the resonance frequency more than 70%, contact Staff to replace the crystal.* 7. Turn off the Deposition Controller and the Ion gauge.	 1  2 7  3-6 7	☐

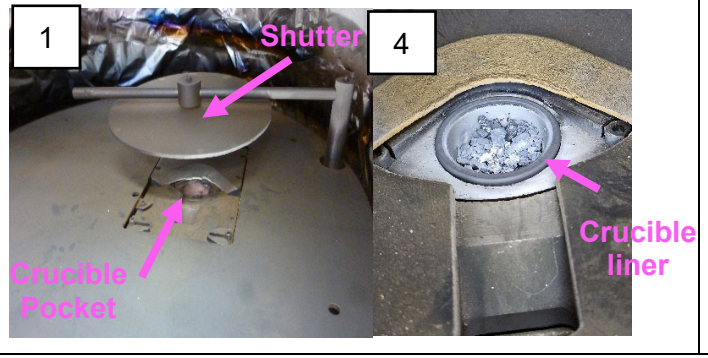
Job Breakdown 2 – Power off Subsystems and Vent Chamber (1 of 1)

A	**Power off Subsystem Power** Refer to Job Reference 1 – Subsystem Power On/Off. Ensure each of the following components are turned Off. 1. Controller (TT-3/6 Control) 2. Function Generator (XY Sweep) 3. High Voltage Main Power Source (TT-3) 4. ION Gauge Controller 5. Deposition Controller 8. HEAT POWER on the Main Control Panel should be off. 9. ROTATION POWER on the Main Control Panel (the corresponding LED should be OFF,)	Refer to Job Reference 1 to ensure subsystems are power ed off.	☐
B	**Vent the Chamber** On the Main Control Panel: 1. Press the SHIFT FUNCT button (the corresponding LED should be ON). 2. Press the AUTO VENT button. On the top row, the "AUTO VENT" LED will turn on. 3. Wait for the chamber to vent (approximately 5 minutes). *Note: When the chamber is vented (you will hear the vent gas more loudly), open the chamber door.* *The vent gas will turn off.* *If the door does not open, the chamber is not fully vented. Do NOT force it open. Wait a little longer and try again.* ***Components may still be hot after deposition. Allow items to cool before handling.***		☐

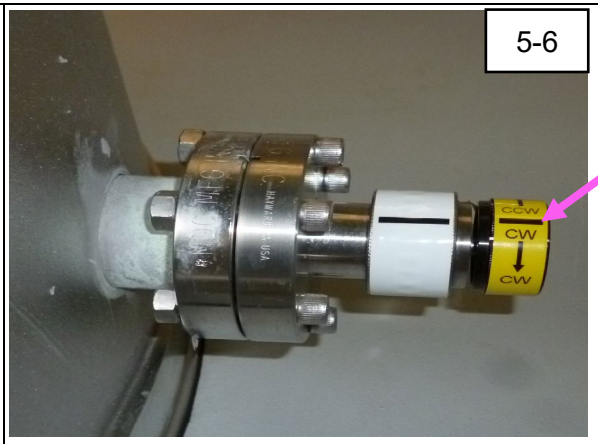
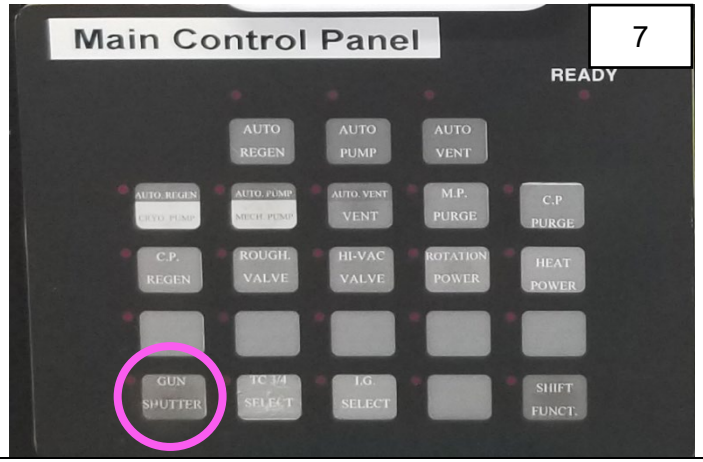
Job Breakdown 3 – Check Chamber, Load Samples & Crucible(s) (1 of 3)

A	**Check Chamber** 1. Verify the upper and lower glass windows are not opaque. If either window is opaque, notify staff. 2. Verify there is no flaking on any surface inside the chamber, including the shutter. If any flaking is observed, notify staff. 3. Remove the sample holder from the hanger. *NOTE: Note: Be careful not to bump the crystal when removing the sample holder.*		☐
B	**Load Samples** 1. Using Kapton tape, mount the samples/wafers on the holder. 2. If the final thickness will not be measured on the sample/wafer, mount a glass microscope slide on the holder. 3. Replace the sample holder on the hanger.		☐

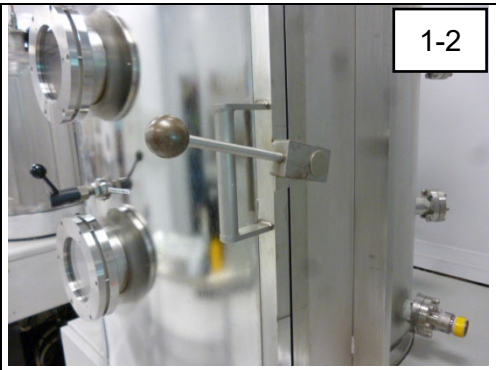
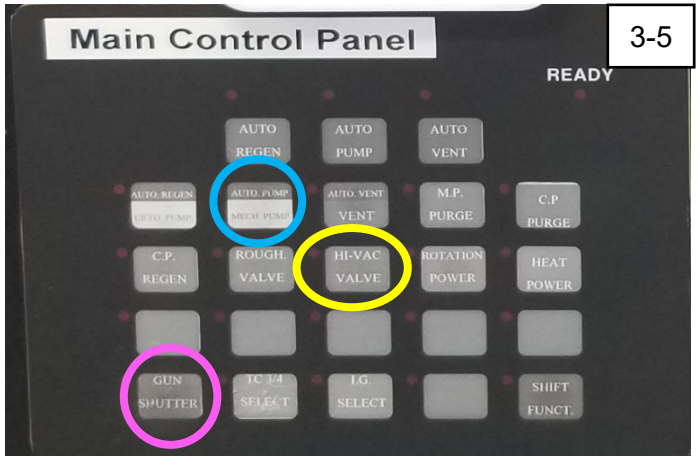
Job Breakdown 3 (Continued) – Check Chamber, Load Samples & Crucible(s) (2 of 3)

C	**Load Crucible(s)** 1. On the Main Control Panel press the GUN SHUTTER button to open the shutter. 2. Inspect the crucible pocket. If there is any material or residue in the pocket, contact Lab Staff. 3. Obtain the crucible liner(s) for the material to be deposited. *NOTE: For some materials (i.e., gold) a smaller crucible is placed inside the standard crucible.* 4. Inspect the crucible liner(s) and material(s). If there are any cracks, defects, or overflow of melted material, do not use the crucible, obtain a new crucible and place the material to be deposited into the crucible. Do not fill crucible over 1/3 full.	 	☐

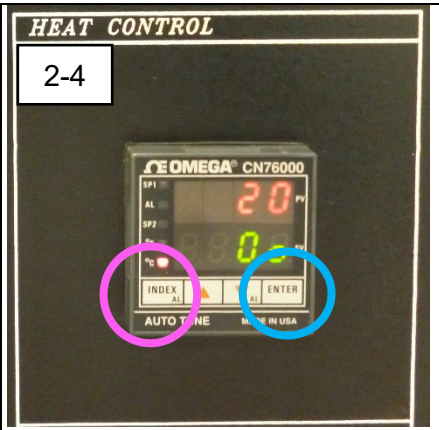
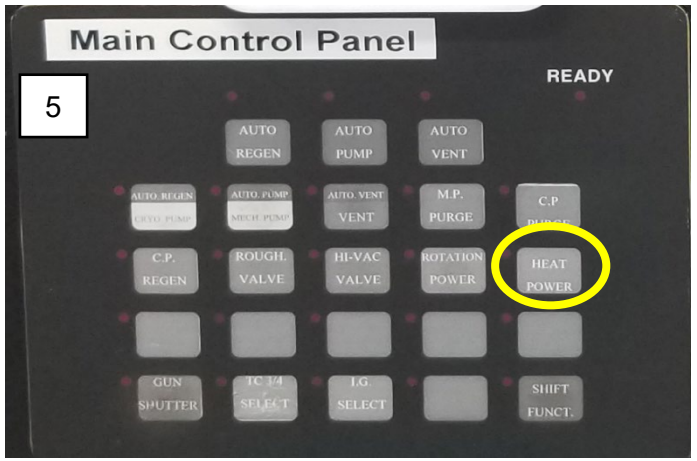
Job Breakdown 3 (Continued) – Check Chamber, Load Samples & Crucible(s) (3 of 3)

D	1. Rotate the crucible selection knob until a pocket is centered and unobstructed by the crucible shielding. *NOTE: The lines should be aligned.* 2. Place the crucible in the centered pocket position. If multiple materials will be used, turn the crucible pocket selection knob on the right side of the chamber to an available pocket. Repeat steps 4 through 6. Ensure you know which material is in which pocket. *NOTE: There are 4 crucible pockets. One full rotation of the pocket selection knob will move to the next position. The arrows on the label refer to the rotation direction of the knob, while the text refers to the rotation direction of the crucible pockets (CW = clockwise; CCW = counter-clockwise).* 3. On the Main Control Panel GUN SHUTTER button to close the shutter.	 	☐

Job Breakdown 4 – Pumping Down Chamber (1 of 1)

A	**Pump Down Chamber** 1. Close the chamber door. 2. Rotate the door locking handle to the latch position slightly past 90°. 3. On the Main Control Panel press the SHIFT FUNCT button and ensure the LED is on. 4. On the Main Control Panel, press the AUTO PUMP button. *The "Auto Pump" LED light will turn on. When the vacuum reaches 150 mTorr (approximately 10 minutes), the High-Vac Valve will open automatically).* 5. Ensure the HI VAC LED on the Main Control Panel comes on. Contact Lab Staff is the light does not come on. 6. Wait a minimum of 45 minutes after the Hi-Vac Valve opens for the chamber to fully pump down to base pressure. *Note: A desired base pressure is below 5.0 E-06 Torr and can take as long as 180 minutes to achieve. Refer to JB1 Section B for vacuum gauge details.*	 1-2  3-5	☐

Job Breakdown 5 – Substrate Heating (Optional) (1 of 1)

A	**Substrate Heating (optional)** 1. If substrate heating is desired, adjust the setpoint of the OMEGA CN76000 temperature controller to the desired value. Note: Do not exceed 150C for temperature. 2. Press the INDEX button until the upper display reads 1SP1. 3. Use the Up and Down arrows (▲, ▼) until the lower display shows the desired temperature setpoint value. 4. Press the ENTER button. 5. On the Main Control Panel), press the HEAT POWER button (LED will be ON.) 6. Wait until the temperature reaches setpoint.	 	☐

Job Breakdown 6 – Program Deposition Controller (1 of 1)

A

Program the Deposition Controller

1. Turn on the DEPOSITION CONTROLLER.
2. Program the parameters for the material to be deposited.
3. Using **TABLE 1, COMMON MATERIAL PROPERTIES** or the VEM Thin Film Evaporation Guide 2017, find the Density and Z-Ratio of the material to be deposited.
4. On the DEPOSITION CONTROLLER press the PROG button.
5. Press the C or E button until the cursor is at Density.
6. Enter the Density value.
7. Press the E button.
8. Enter the Z-Ratio.
9. Press the E button.
10. Press the PROG button.

Note: Scroll through the Density and Z-Ratio to make sure the values held.

1

4-10

3

TABLE 1, COMMON MATERIAL PROPERTIES

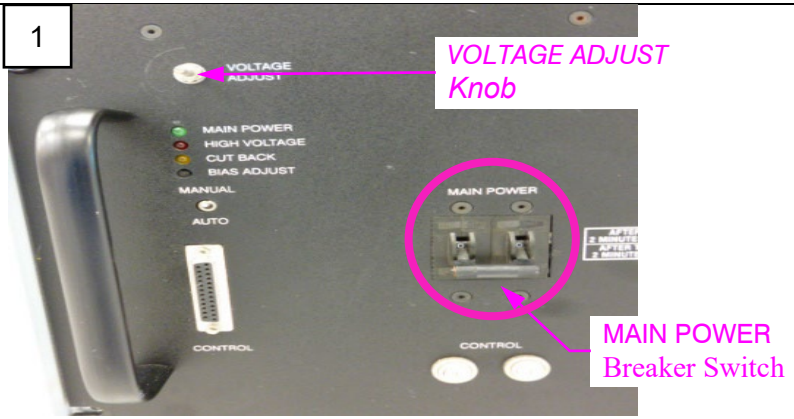
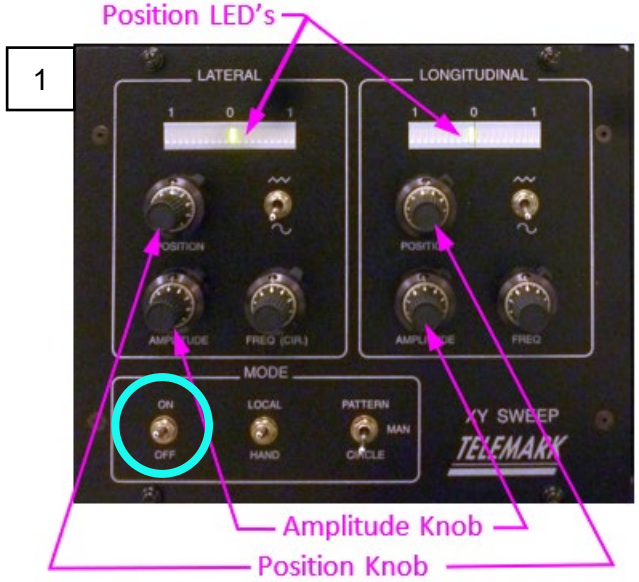
Material	Symbol	Density (bulk, g/cm³)	Z-Ratio	Current (Amps)	Dep Rate[1] (Å/sec)
Aluminum	Al	2.7	1.08	0.100	15.0
Chromium	Cr	7.2	0.305	0.035	3.0
Copper	Cu	8.92	0.437	0.100	4.0
Gold	Au	19.32	0.381	0.040	2.0
Nickel	Ni	8.91	0.331	0.100	0.5
Platinum	Pt	21.45	0.245	0.100	0.5
Silver	Ag	10.49	0.529	0.040	3.0
Titanium	Ti	4.5	0.628	0.070	1.0

[1]Approximate deposition rate. Actual rate could vary ±50%.

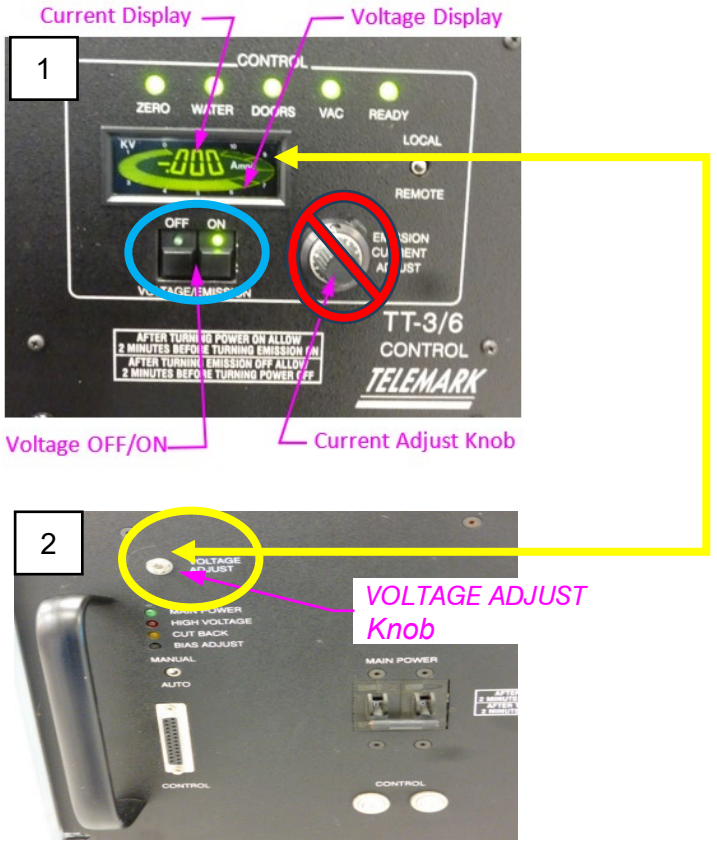
Job Breakdown 7 – Rotation (Optional, but recommended) (1 of 1)

A	1. On the Main Control Panel press the ROTATION POWER button to start the sample rotation. 2. Adjust the ROTATION CONTROL SPEED knob for the desired rotation speed. *NOTE: Note: There should be at least 10 full rotations during the deposition cycle*	1  2 	☐

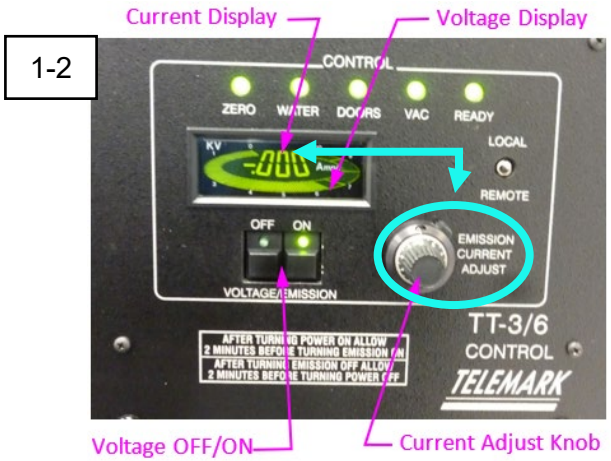
Job Breakdown 8 – Power up for processing (1 of 4)

A	**Main Power** 1. Turn on the High Voltage Main Power Source (TT-3) by lifting the breaker switch. Wait a minimum of 2 minutes.	1 	☐
B	**Function Generator** 1. Turn on the Function Generator (XY-SWEEP). Wait a minimum of 2 minutes.	1 	☐

Job Breakdown 8 (Continued) – Power Up for Processing (2 of 4)

C	**Voltage** 1. On the Current Controller (TT-3/6 CONTROL) press the VOLTAGE/EMISSION on button to turn on the controller. Wait a minimum of 2 minutes. 2. On the High Voltage Main Power Source (TT-3), slowly rotate the VOLTAGE ADJUST knob clockwise until the outer display on the Current Controller (TT-3/6 CONTROL reads 6.5 KV. *NOTE: Note: Do not adjust the Emission Current Knob at this time.*		☐

Job Breakdown 8 (Continued) – Power Up for Processing (3 of 4)

D	**Verify Beam Position** 1. On the Function Generator (XY SWEEP), ensure both the LATERAL and LONGITUDINAL position LED's are near 0 and green in color. If the lit LED is yellow (not near 0), adjust the POSITION knob until the lit LED is green and near 0. ***Once the beam initialization is started, DO NOT LEAVE THE SYSTEM UNATTENDED! You must closely monitor and adjust the current, voltage, beam location, and deposition rate until the beam is turned off.***	1 	☐
E	**Initialize Beam** 1. On the Current Controller (TT-3/6), slowly turn the EMISSION CURRENT ADJUST knob clockwise until the current is 0.020 Amps. ***Note: This step should take 1 minute.*** 2. Wait a minimum of 5 minutes for the melt/crucible to glow orange. 3. Use the data collection form to note all the parameters that must be collected after locking the tool. Failure to comply may result in losing access to the tool. A laminated copy is with the SOP for your convenience.	1-2 	☐

Job Breakdown 8 (Continued) – Power Up for Processing (4 of 4)

E	**Verify Beam** 1. Using UV light protection, open the upper view shutter of the chamber and look at the melt/crucible. 2. If the beam size is not 50 – 75% the size of the melt/crucible, adjust the AMPLITUDE knob of the LATERAL and/or LONGITUDINAL control on the Function Generator (XY SWEEP). 3. If the beam is not centered on the melt/crucible, adjust the POSITION knob of the LATERAL and/or LONGITUDINAL control on the Function Generator (XY SWEEP). *NOTE: Rotating the LATERAL knob clockwise will move beam to the left. Rotating the LONGITUDINAL knob clockwise will move the beam away from the door toward the back of the chamber.* ***Do not allow the beam to hit the edge of the crucible or the hearth. Sparks will be visible. Adjust the beam, as necessary, to center and size the beam.***	2-3 	☐

Job Breakdown 9 – Reset the Crystal Monitor (1 of 1)

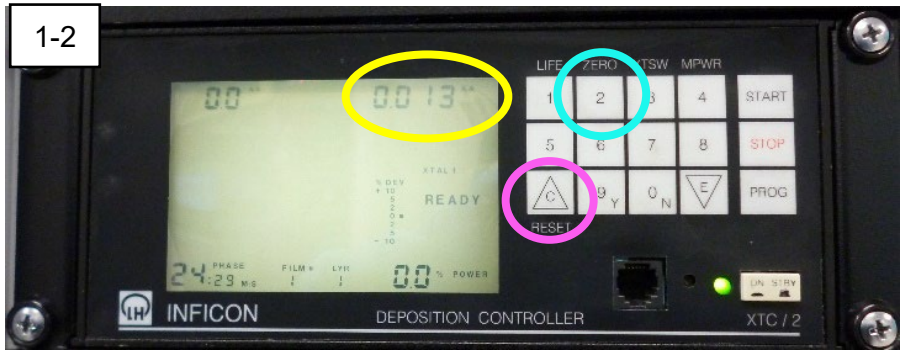
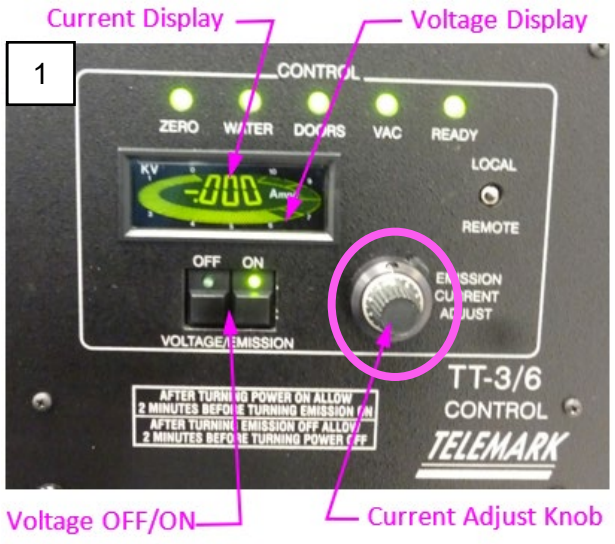
A	**Reset Crystal Thickness Monitor** 1. On the DEPOSITION CONTROLLER press the C button. 2. Press the 2 button to zero the thickness display. *Note: The crystal thickness is displayed in kiloAngstroms (1.000 KÅ = 1000Å = 100 nm = 0.1 um).* **TABLE 2, UNIT CONVERSIONS** *can be used for conversion between units.*	1-2 	☐

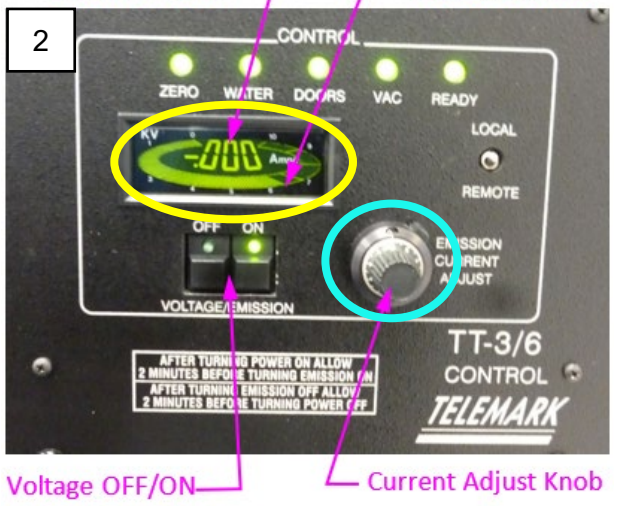
TABLE 2, UNIT CONVERSIONS

Angstrom (Å)	Nanometer (nm)	Micron (µm)	kiloAngstrom (kÅ)
10	1	0.001	0.010
20	2	0.002	0.020
30	3	0.003	0.030
40	4	0.004	0.040
50	5	0.005	0.050
60	6	0.006	0.060
70	7	0.007	0.070
80	8	0.008	0.080
90	9	0.009	0.090
100	10	0.010	0.100
200	20	0.020	0.200
300	30	0.030	0.300

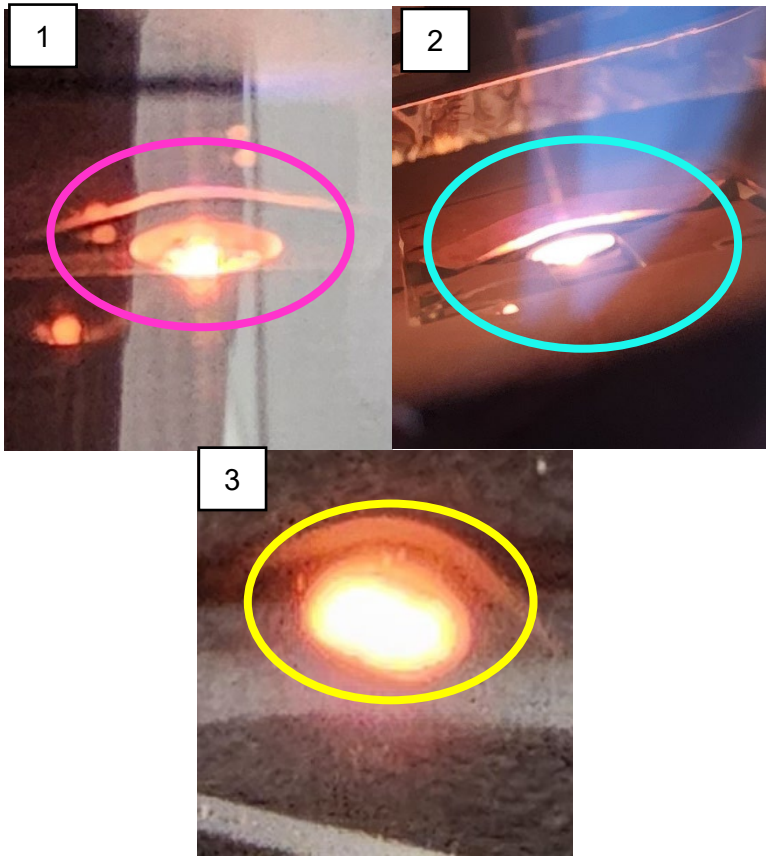
Job Breakdown 10 – Material Deposition (1 of 5)

A	**Material Deposition** ***Never adjust the current above 0.100 amps without Staff approval. High current settings can damage crucibles and/or the equipment.*** ***Note: This step should take 1 minute.*** 1. VERY slowly increase the current knob to one half the initial current setting found in table 1 and allow the material to melt for 2 minutes. *Note: The pressure will rise slightly as the material begins to melt and evaporate. The necessary temperature and current to melt varies by material.*	1  	☐
B	1. On the Main Control Panel, press the GUN SHUTTER button to open the shutter and begin deposition. 2. Using UV light protection glasses, open the upper view shutter of the chamber and ensure the beam is scanning nicely across the material in the crucible. If necessary, adjust the POSITION and AMPLITUDE knobs.	1  	☐

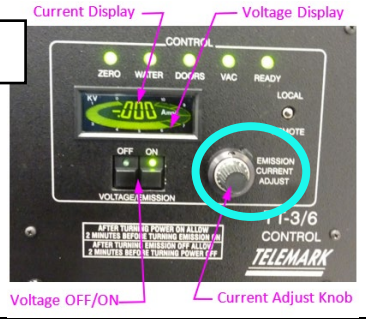
Job Breakdown 10 (Continued) – Material Deposition (2 of 5)

C	1. While watching the upper left corner of the DEPOSITION CONTROLLER, VERY slowly turn the EMISSION CURRENT ADJUST knob on the Current Controller (TT-3/6) until the desired deposition rate is achieved. *Note: The effect of the current change on the material and deposition rate will be delayed approximately 15 seconds.* *Note: Typical deposition rates for common materials are shown in* **TABLE 1, COMMON MATERIAL PROPERTIES**. *Materials with higher melting points may have a lower deposition rate. If the actual deposition rate is much lower than typical, it is likely the crucible is cracked.* *Note: During deposition, the chamber pressure will rise to approximately 1.0 x 10-6 Torr.* 2. Verify the voltage on the Current Controller (TT-3/6) is still set for 6.5 KV. If necessary, adjust the voltage. *NOTE: Note: The voltage adjustment knob for the High Voltage Main Power Source (TT-3) is on the bottom rack of the tool.*	1  2 	☐

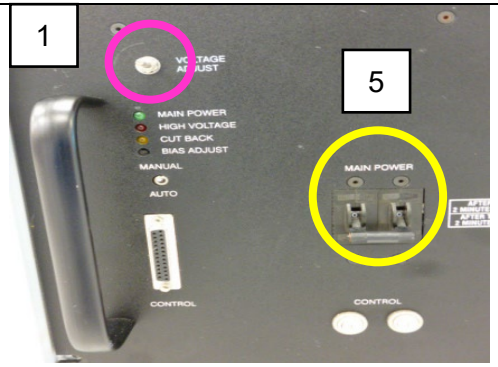
Job Breakdown 10 (Continued) – Material Deposition (3 of 5)

D	1. Using the provided UV safety glasses, frequently verify the deposition rate, material quantity in the crucible, and the beam position. The beam is centered in the crucible. There are no sparks present. The beam is not hitting the crucible or anything outside the crucible. If necessary, adjust the beam position, using the LATERAL and LONGITUDINAL knobs on the Function Generator (XY SWEEP). Refer to JB8 secton E. If the deposition rate drops dramatically**,** immediately stop deposition by closing the shutter. *Note: During the warm up process the pellets will melt and form a small liquid puddle. This puddle is the volume used to supply the deposition rate. The deposition rate is affected by the position of the beam, the power supplied to the beam and the amount of material melted. The rate may change over the entire deposition, constant monitoring of beam position and current is necessary during the whole process.*		☐

Job Breakdown 10 (Continued) – Material Deposition (4 of 5)

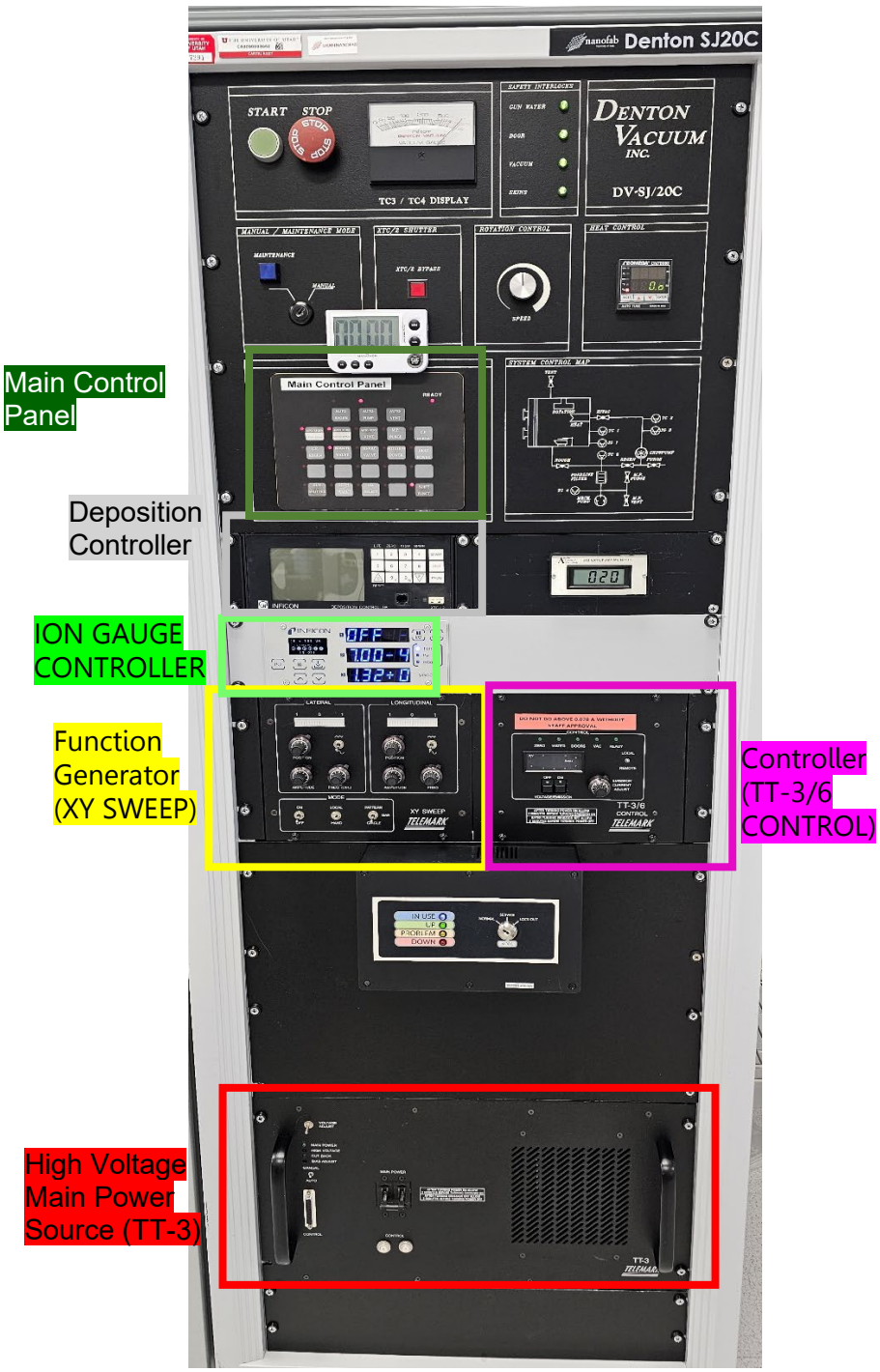
E	**Stop Deposition** 1. Wait until the desired thickness is displayed on the upper right corner of the DEPOSITION CONTROLLER. 2. On the Main Control Panel, press the GUN SHUTTER button to close the shutter and stop deposition. 3. On the Current Controller (TT-3/6), slowly turn the EMISSION CURRENT ADJUST knob counter-clockwise until the current is 0.000 Amps. ***Note: This step should take 1 minute.*** 4. Wait a minimum of 5 minutes for the melt/crucible to cool.	1  2  3 	☐
F	**Deposit Additional Material(s) (Optional)** 1. If another material is to be deposited, turn the crucible pocket selection knob to rotate the desired crucible pocket to the active position. 2. Repeat JB6, JB9 and JB10 for desired materials. *Note: When running multiple materials, the wait steps for Main Power and Function Generator are not necessary.*		☐

Job Breakdown 10 (Continued) – Material Deposition (5 of 5)

G	1 On the High Voltage Main Power Source (TT-3), slowly rotate the VOLTAGE ADJUST knob counter-clockwise until the outer display on the Current Controller (TT-3/6 CONTRO) reads 0.0 KV. 2 Wait a minimum of 2 minutes. 3 On the Current Controller (TT-3/6 CONTROL), press the VOLTAGE/EMISSION OFF button to turn the controller off. 4 Turn off the XY sweep. 5 Turn off the TT-3 power breaker switch. 6 Turn off the deposition controller. 7 Wait 5 minutes. 8 Refer to JB2 to vent the system. 9 Refer to JB3 to remove samples and crucible(s). 10 Clean up the area and items used for deposition. 11 Refer to JB4 to pump down the system. 12 Refer to JR2 to for data collection and locking in HSC.	   	☐

Job Reference 1 – Subsystem Power On/Off.

System Component Locations



1. Vacuum gauge controller.

   Top gauge = Ion gauge – press on/off button to cycle power.

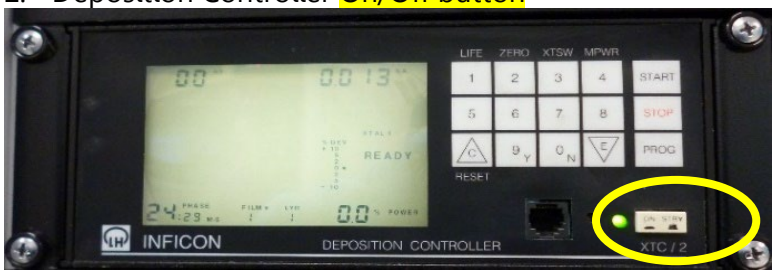
   Center gauge = Chamber gauge

   Bottom gauge = Fireline gauge

Note: It may take approximately 2 minutes for the Ion gauge to stabilize after turning on.

On Off

2. Deposition Controller On/Off button

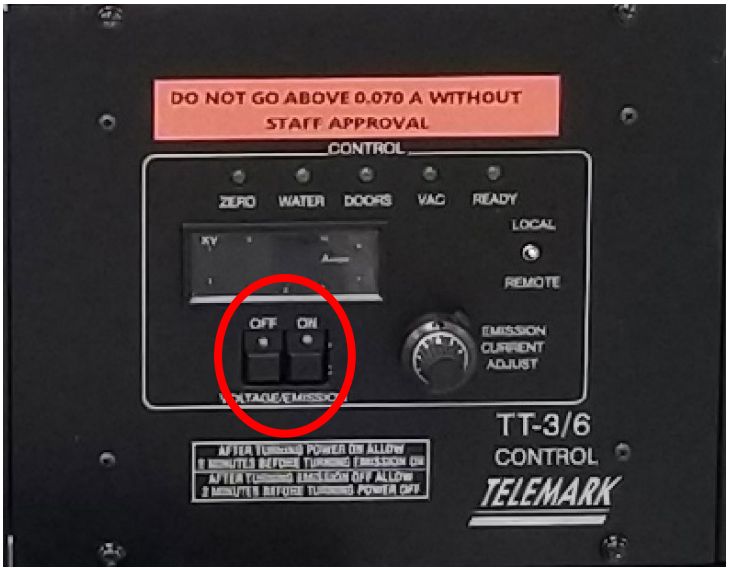


3. High Voltage Main Power Source (TT-3)

   Allow 2 minutes for power supply to warm up after turning on.

4. Current Controller (TT-3/6 CONTROL)

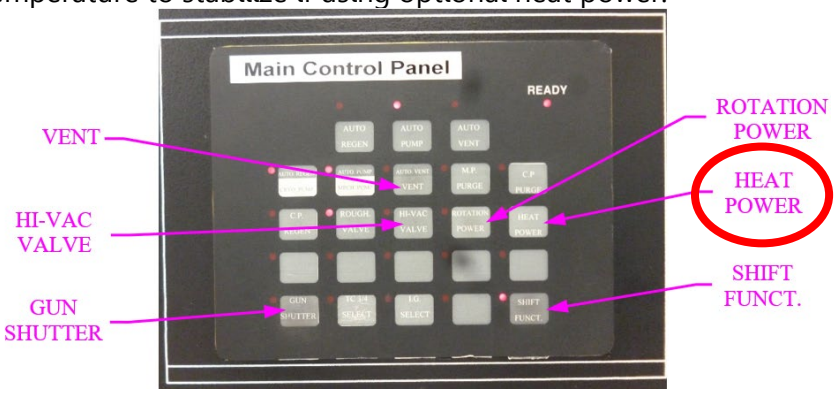
   Allow 2 minutes for power supply to warm up after turning on.



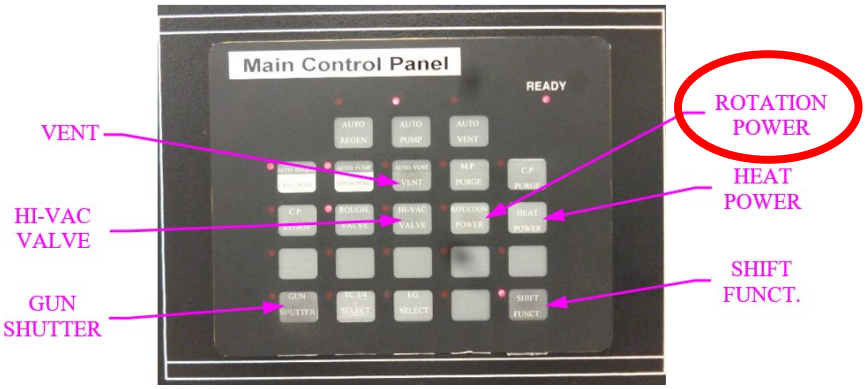
5. Telemark Sweep Controller

   Allow 2 minutes for power supply to warm up after turning on.

6. Heat Power is on the Main Control Panel the corresponding LED is on when power is on and off when power is off. Allow temperature to stabilize if using optional heat power.



7. Rotation Power is on the Main Control Panel the corresponding LED is on when power is on and off when power is off.



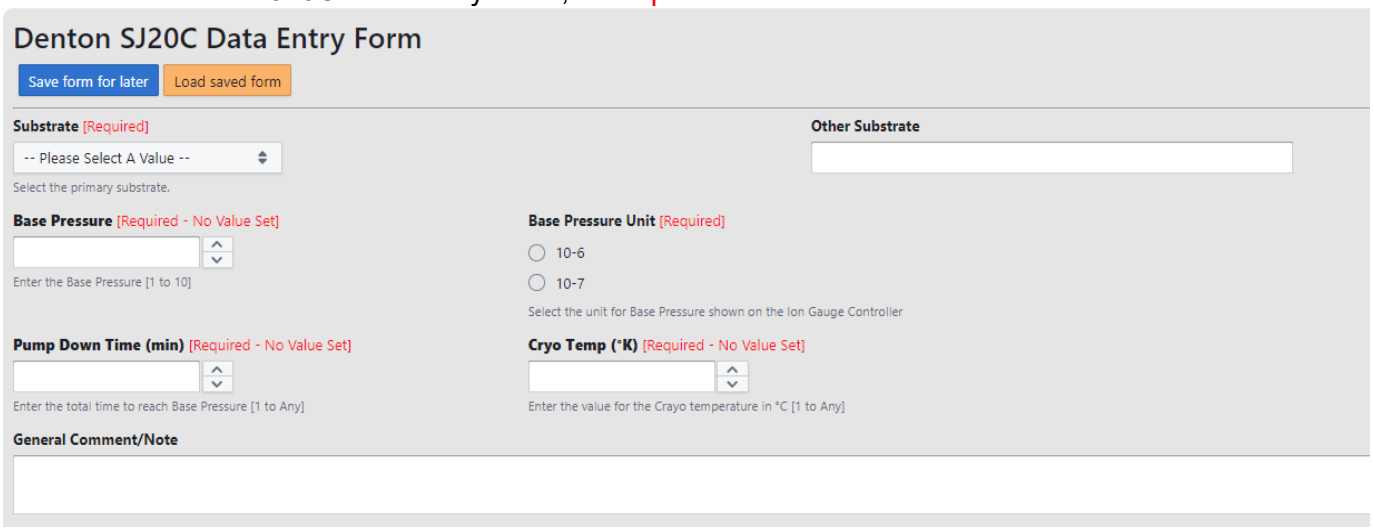
Job Reference 2 – Locking in HSC and Data Collection Form.

NOTE: Note: This step is mandatory and a requirement to use the tool.

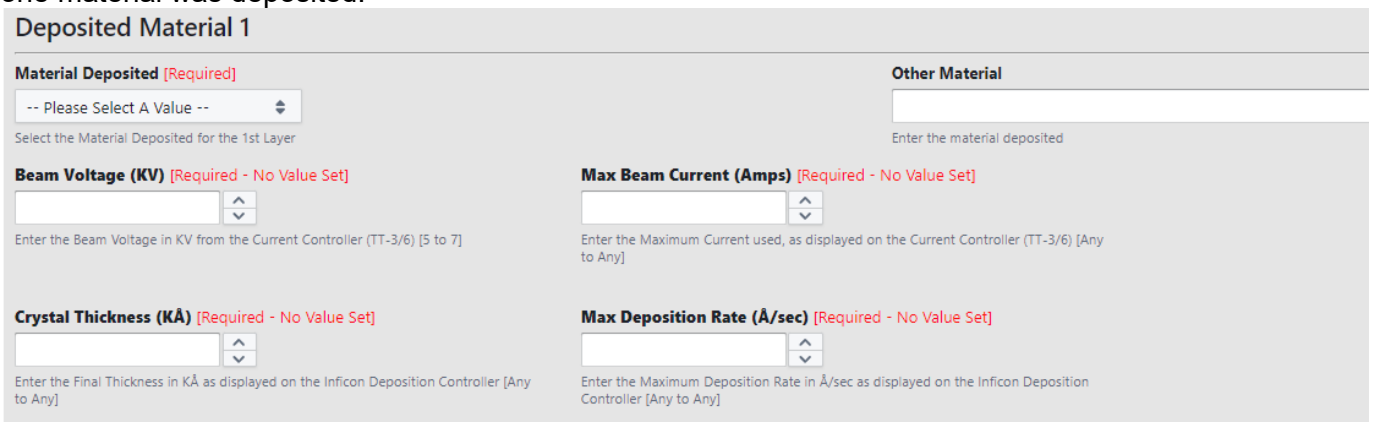
1 Log into HSC and select the lock tool button. A link will appear to the data collection page, click the link. If the link or the data collection page does not appear, contact Staff.

NOTE: Note: If necessary, the form can be saved for later entry under the users HSC account.

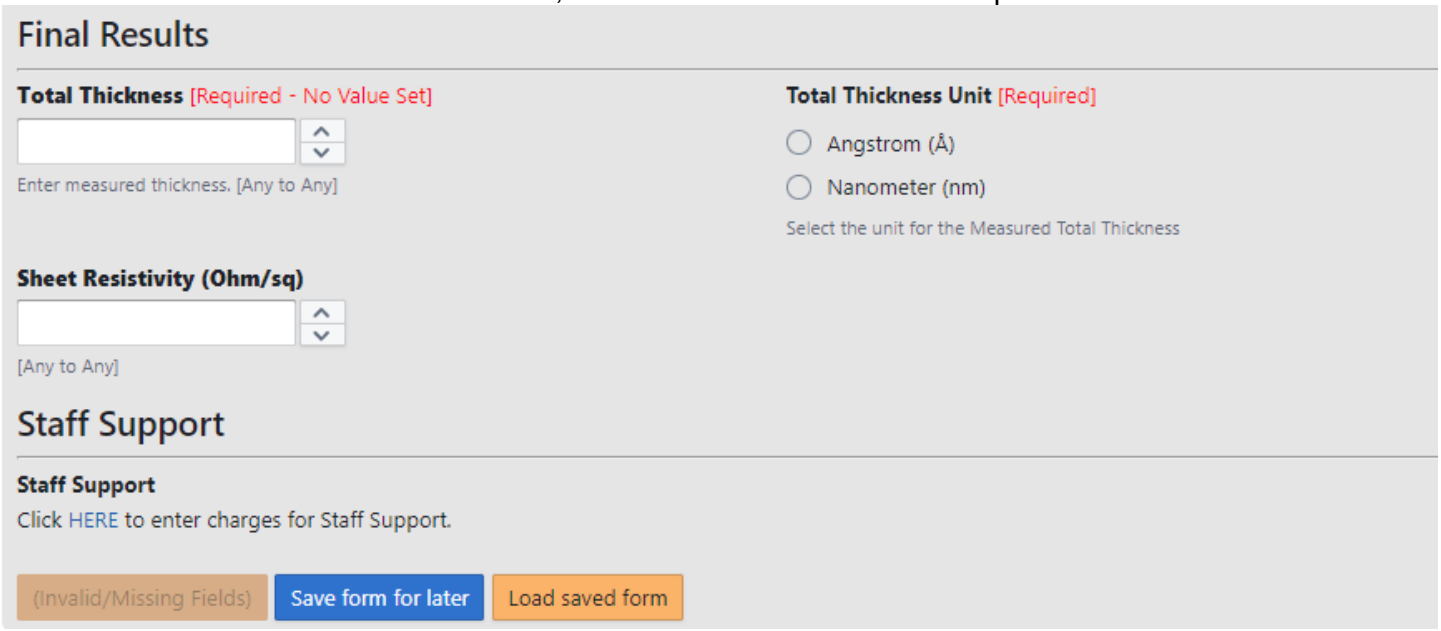
2 Fill out the Denton SJ20C Data Entry Form, all required data must be entered.



3 Fill out the information for Deposited Material(s) 1 through 4. Select “none” on Material Selection 2 if only one material was deposited.



4 Fill out the information for the Final Results, a total measured thickness is required.



Appendix

Process Notes

Thickness and Uniformity

In October of 2003, aluminum was deposited on a glass slide in the middle of the sample holder (planetary) and another on the edge.

Rotation was used during the deposition cycle.

The thickness as measured by the crystal (Deposition Controller) was 1.000 micron.

Using a profilometer, the glass slide at the middle of the sample holder measured 1.2 microns.

Using a profilometer, the glass slide at the edge of the sample holder measured 0.93 microns.

TABLE 3, COMMON MATERIAL PROPERTIES

Material	Symbol	Density (bulk, g/cm^3)	Z-Ratio	Current (Amps)	Dep Rate[1] (Å/sec)
Aluminum	Al	2.7	1.08	0.100	15.0
Chromium	Cr	7.2	0.305	0.035	3.0
Copper	Cu	8.92	0.437	0.100	4.0
Gold	Au	19.32	0.381	0.040	2.0
Nickel	Ni	8.91	0.331	0.100	0.5
Platinum	Pt	21.45	0.245	0.100	0.5
Silver	Ag	10.49	0.529	0.040	3.0
Titanium	Ti	4.5	0.628	0.070	1.0

[1]Approximate deposition rate. Actual rate could vary ±50%.

TABLE 4, UNIT CONVERSIONS			
Angstrom (Å)	**Nanometer (nm)**	**Micron (µm)**	**kiloAngstrom (kÅ)**
10	1	0.001	0.010
20	2	0.002	0.020
30	3	0.003	0.030
40	4	0.004	0.040
50	5	0.005	0.050
60	6	0.006	0.060
70	7	0.007	0.070
80	8	0.008	0.080
90	9	0.009	0.090
100	10	0.010	0.100
200	20	0.020	0.200
300	30	0.030	0.300
400	40	0.040	0.400
500	50	0.050	0.500
600	60	0.060	0.600
700	70	0.070	0.700
800	80	0.080	0.800
900	90	0.090	0.900
1000	100	0.100	1.000
2000	200	0.200	2.000
3000	300	0.300	3.000
4000	400	0.400	4.000
5000	500	0.500	5.000
6000	600	0.600	6.000
7000	700	0.700	7.000
8000	800	0.800	8.000
9000	900	0.900	9.000
10000	1000	1.000	10.000
20000	2000	2.000	20.000
30000	3000	3.000	30.000
40000	4000	4.000	40.000
50000	5000	5.000	50.000
60000	6000	6.000	60.000
70000	7000	7.000	70.000
80000	8000	8.000	80.000
90000	9000	9.000	90.000
100000	10000	10.000	100.000

Revision History

Rev	Date	Originator	Description of Changes
6	1 Nov 2023	J. Pierce	Update format add additional requirements and details.
5	10 Jun 2019	T. Olsen	Update document format.
4	02 Jan 2019	T. Olsen	Major Rewrite.
3	01 Jun 2014	Brian Baker	Move to SMBB.
2	8 Dec 2010	Sam Bell	Added 6.2 & 6.3.3
1	19 Jan 2010	Sam Bell	Initial Release