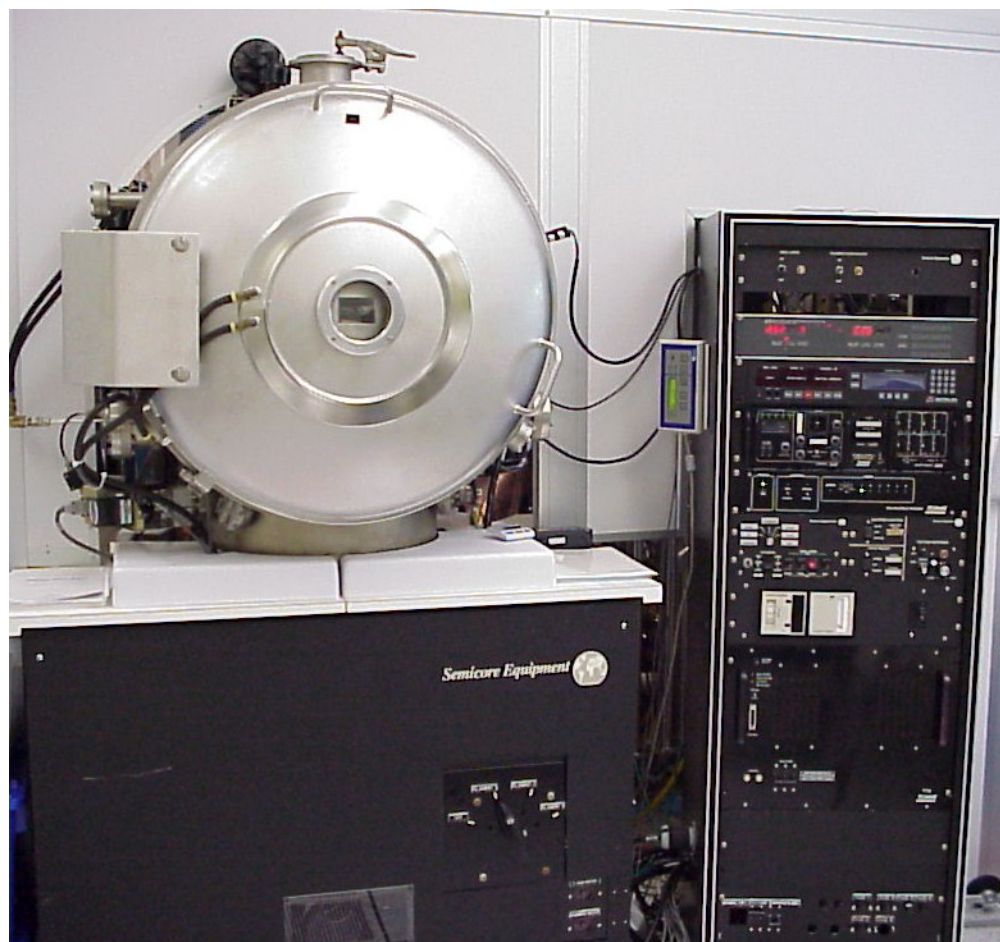


Semicore E-gun/Thermal Evaporator Instructions

Updated: 4/18/2007 1:06:00 PM



Staff Contact Information

For training & user assistance:

Andrzej Miekowski
191 MRI 865-0325
Axm154@psu.edu

Joe Lonjin
190 MRI 865-9284
JL13@psu.edu

Table of Contents

1. Overview of the Evaporator	1
2. Checking the Evaporator	3
3. Venting the Chamber	4
4. Loading Sources and Samples	5
4.1. Loading the e-gun Evaporation Source Crucibles	6
4.2. Loading Thermal Sources	7
4.3. Sample Loading	8
5. Evacuating the Chamber	9
6. Evaporating	10
6.1. Evaporating using the e-gun Source	12
6.2. Evaporating Using the Thermal Source	15
7. Final Check List	16
7.1. Venting the Chamber	16
7.2. Unloading Metal and Samples	16
7.3. Evacuating the Chamber	16
8. Training Check List	17
9. Troubleshooting	20

Table of Figures

Figure 1-1: System Overview	1
Figure 1-2: Vacuum Chamber Interior	2
Figure 1-3: Mirror Arrangement.....	2
Figure 3-1: Vacuum valve switches.....	4
Figure 3-2: Vacuum Process Controller System at high vacuum.....	4
Figure 3-3: Vacuum Process Controller with ion gauge 1 (IG1) off. Error! Bookmark not defined.	
Figure 4-1: Maxtex Deposition Controller	5
Figure 4-2: Maxtex Deposition Controller close up of controls	5
Figure 4-3: Telemark Crucible Indexer	6
Figure 4-4: Thermal Sources	7
Figure 4-5: Sample holder – releasing “catch”	8
Figure 5-1: Vacuum Process Controller showing vacuum less than 200mTorr (173mTorr). ...	9
Figure 6-1: Telemark TT-6 Power Supply.....	12
Figure 6-2: Shutter Control and Fixture Rotation.....	12
Figure 6-3: Telemark Power Controller interlocks.....	13
Figure 6-4: Telemark Power Supply Controller	13
Figure 6-5: Telemark Power Supply Controller with high voltage on.	14
Figure 6-6: Post selector	15

1. Overview of the Evaporator

The Semicore evaporator has:

E-gun source with four pockets, load up to (4) 7cc crucibles of different or like materials.

One thermal source to be used with tungsten boats

A planetary design which can hold a large number of samples. There are four planetary holders and any three can be put in the system at a time. So any three of the following may be loaded into the system:

- 3" planetary hold 25 wafers
- 4" planetary holds 8 wafers
- 6" and small parts planetary holds 6 wafers or many small parts
- 6" and small parts planetary with one high density screw-down plate holds 6 wafers or many small parts

An automated deposition controller for easy repeatable evaporations

- ! If you evaporate non-approved materials in this tool, your usage privileges will be suspended.
- ! If you are found using this system before a staff member responsible for the tool has formally trained you, your usage privileges will be suspended.

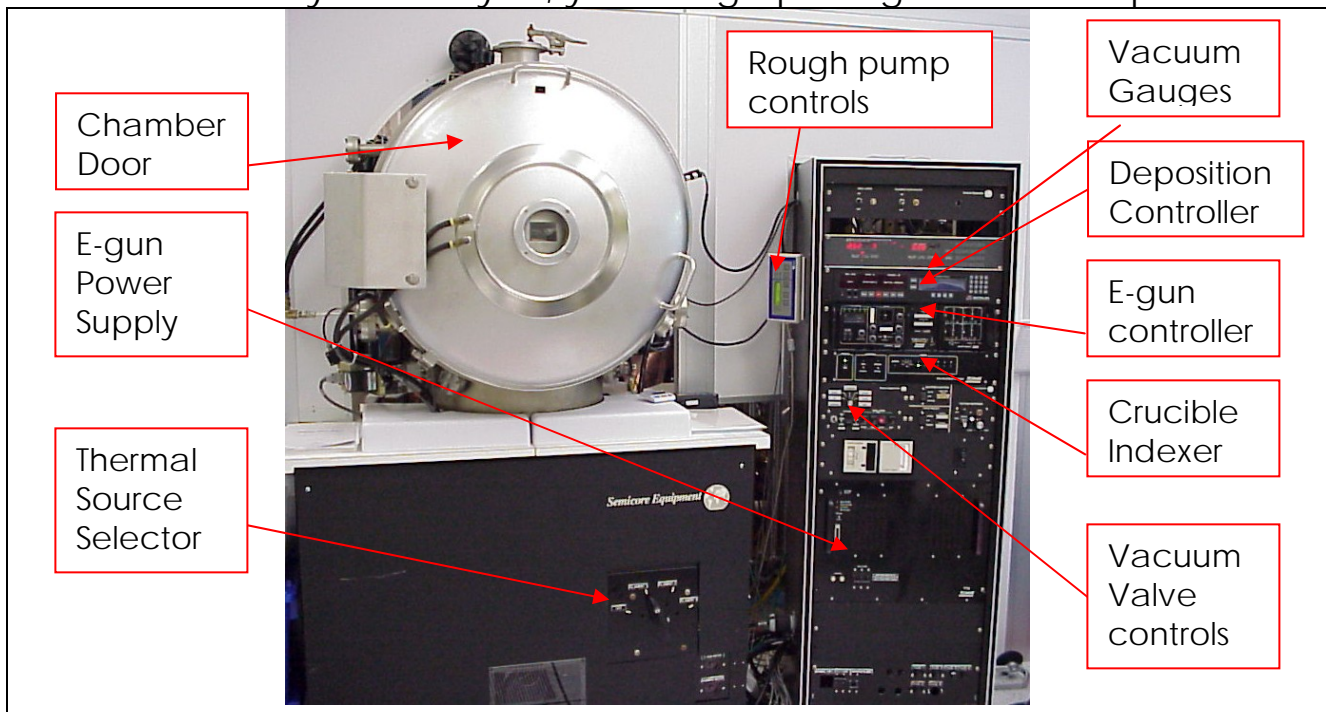


Figure 1-1: System Overview

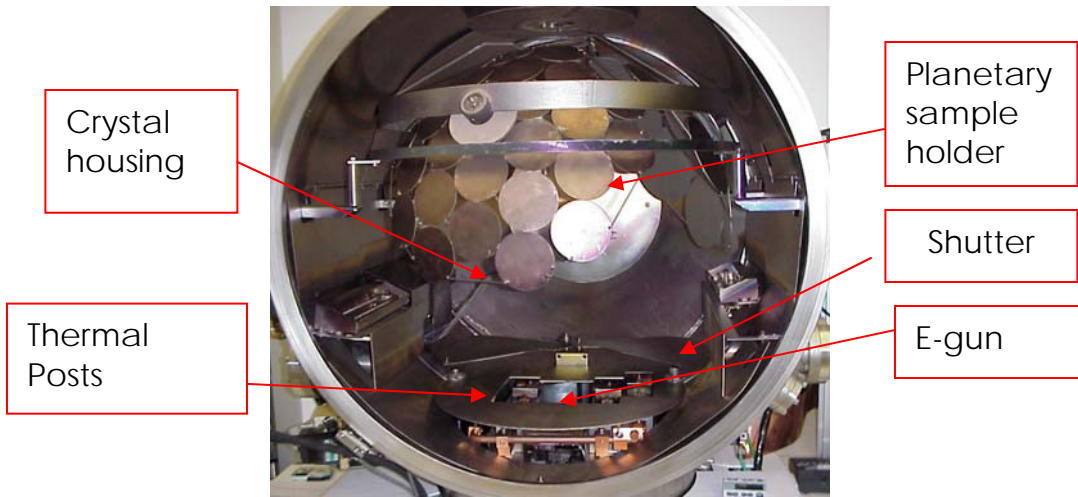
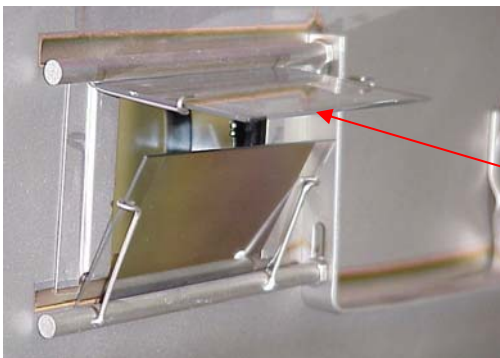


Figure 1-2: Vacuum Chamber Interior



Mirror system protects viewport from deposition, but allows you to view the sources.

Figure 1-3: Mirror Arrangement

The evaporation process has 8 main steps:

- Checking the system State
- Venting the Chamber
- Loading Metal and Samples
- Evacuating the Chamber
- Evaporating
- Venting the Chamber
- Unloading Metal and Samples
- Evacuating the Chamber

These steps are described in detail below on the following pages.

2. Checking the Evaporator

When you first arrive at the system the following conditions should be true:

- High Vac Valve is OPEN
- Ion Gauge (IG1) is on
- System pressure will be lower than 5×10^{-5} Torr (UNLESS the previous user finished within an hour of your start time.)
- EGUN and THERMAL supplies should be OFF
- HEATING and SAMPLE ROTATION are OFF

If the previous user did not leave the system in the above condition, please send a detailed trouble call on the portal.

3. Venting the Chamber

Currently the vacuum valves are operated using the manual switches. See Figure 3-1.

NOTE: ONLY one valve open at a time, NEVER open more than one valve.

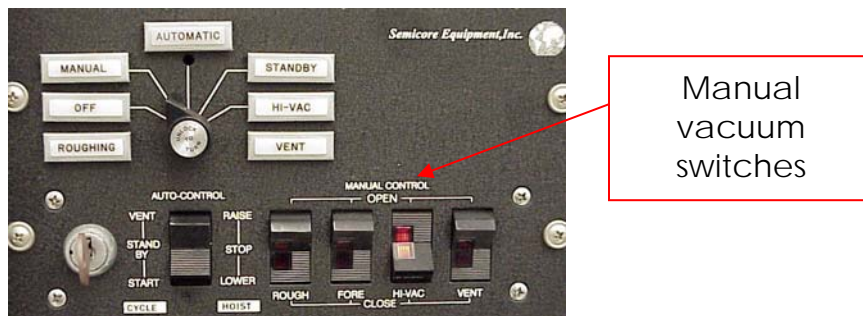


Figure 3-1: Vacuum valve switches

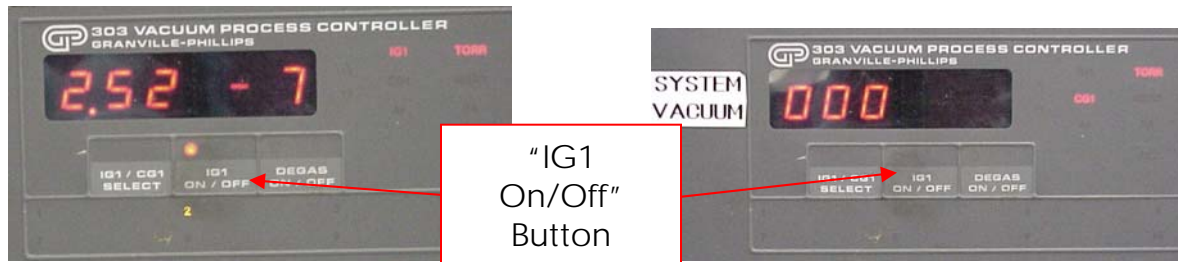


Figure 3-2: System at high vacuum

Figure 3-3: Vacuum Process Controller with ion gauge off

1. **Vacuum Process Controller:** Turn off the high vacuum ion gauge by pressing “IG1 ON/OFF” once. See Figure 3-2. You should see “000” on gauge 1(**SYSTEM VACUUM**). See Figure 3-3.

Vacuum Switches: Close the high vacuum valve by switching the “Hi-Vac” to the closed position. **Wait** ~10 seconds for valve to completely close.

Vacuum Switches: Open the vent valve by switching the “Vent” to the open position.

NOTE: You must be logged in on the PORTAL for the vent to operate.

Vacuum Process Controller: Monitor CRYOPUMP VACUUM, if this begins rising above 000 and continues to rise, close “VENT” and contact a staff member/submit TROUBLE CALL.

System Door: When Gauge 1(**SYSTEM VACUUM**) displays 700 Torr or above begin holding the system door handle. During venting the door may pop open suddenly as the pressure reaches atmosphere (760 Torr).

Vacuum Switches: After door is open, close the vent valve by switching the “Vent” to the off position.

System Door: Door gasket will fall off when door is opened, catch gasket, wipe with Isopropanol on a wiper and reinstall on door edge.

4. Loading Sources and Samples

There are general procedures as well as specific procedures for loading sources and samples. Please follow the instructions carefully.



Figure 4-1: Maxtek Deposition Controller



Figure 4-2: Maxtek Deposition Controller close up of controls

1. **Maxtek Deposition Controller:** Turn on power toggle switch. See Figure 4-1.
Maxtek Deposition Controller: Press the “RESET” button. See Figure 4-2.
Maxtek Deposition Controller: Open the shutter by pressing the “SHUTTER” button. See Figure 4-2.

4.1. Loading the e-gun Evaporation Source Crucibles

Check: The crucible liners must always fit tightly in pocket. If they are not in complete contact with the pocket, the liner could melt during the evaporation. If you cannot get the liner to fit tightly in the pocket **do not use and contact a staff member for assistance, and SEND A TROUBLE CALL using the portal.**

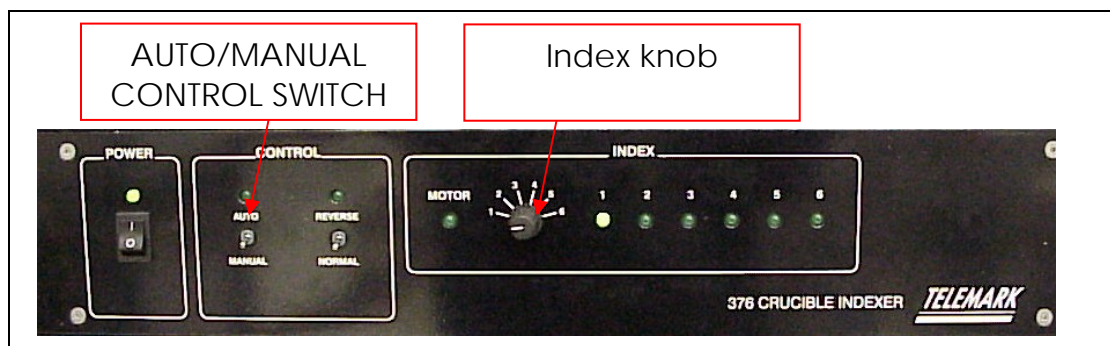


Figure 4-3: Telemark Crucible Indexer

1. **376 Crucible Indexer:** Switch control to “Manual”. See Figure 4-3.

376 Crucible Indexer: Rotate **Index knob** to the pocket number you want to load with a crucible and then wait for the pocket to rotate into place. Note that only index positions 1 through 4 are used. See Figure 4-3

CHECK that the pocket does not have debris in it by feeling it with your finger.

Vacuum out any debris using a clean room vacuum.

Check crucible level once in the pocket. Fill crucible if needed.

NOTE: Refer to metals information chart on appropriate fill levels for each crucible/metal.

Warning: Do not overfill the crucibles because this is a leading cause for failure of the crucibles.

Make a note of the pocket number for the metal you just loaded on the log sheet.

To load addition E-gun metals return to step 2.

Maxtex Deposition Controller: Close the shutter by pressing the “SHUTTER” button.

4.2. Loading Thermal Sources

We encourage the use of the e-gun source over the thermal source. The highest amount of metal that can be evaporated out of a tungsten boat is about 800A. At this time the only recipes loaded for thermal materials are Aluminum and Silver.

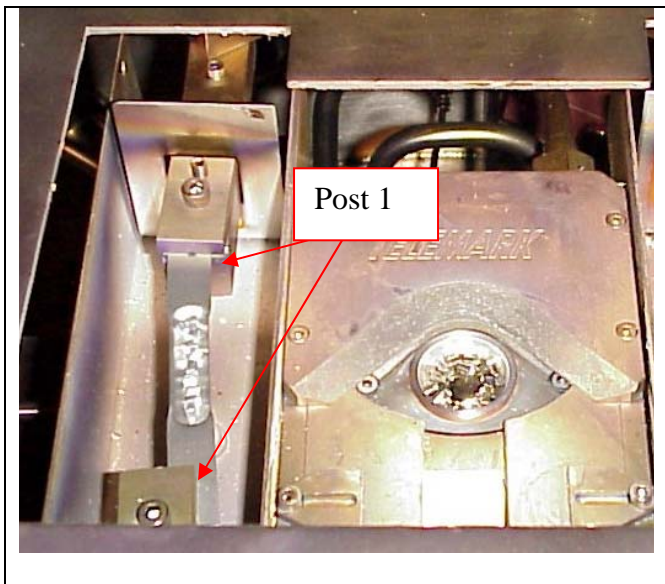


Figure 4-4: Thermal Sources

1. **Maxtex Deposition Controller:** Open the shutter by pressing the shutter button. See Figure 4-2.
2. Place the thermal boats under the copper plates and finger-tighten the bolts snugly.

Place the metal pellets in the boat(s). See Table 2 for recommended number of pellets and estimated thicknesses. Record how many pellets you use and what thickness you deposit in the logbook and on the PORTAL.

Maxtex Deposition Controller: Close the shutter by pressing the shutter button.

Table 1: Thermal boat setup

Metal	MAX # Pellets in boat	Average thickness/pellet
Al	8	150A
Ag	8	150A

4.3. Sample Loading

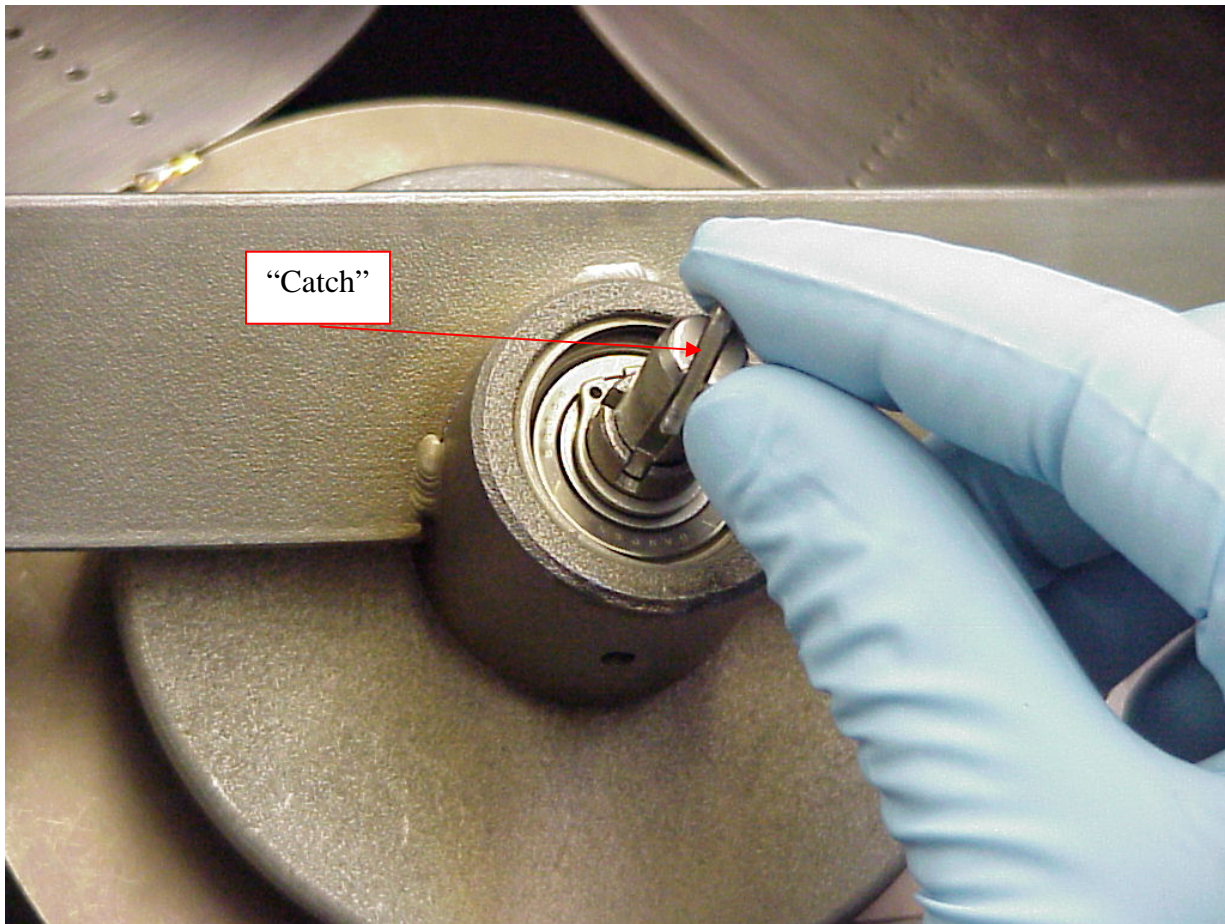


Figure 4-5: Sample holder – releasing “catch”

1. Release the sample holder from its mount by pushing it up and flipping the small “*catch*” to align with the shaft of the holder. See Figure 4-5. Then slide the shaft down.

Position your sample(s) on one of the sample holder’s and secure them with washers and screws, springs, or Kapton tape.

Load the sample holder back into the planetary.

5. Evacuating the Chamber

WARNING: ONLY **one** valve is opened at a time. **NEVER** open more than one valve.

1. **Check** the O-ring(s) of the door for particulates. Clean with IPA on a clean wiper if necessary. If the chamber has loose metal flakes, use the clean room vacuum located aside of the evaporator or in the toggging room to vacuum them up.

Check that the roughing pump is running: The rough pump controller (see Figure 1-1) should show current being drawn by the pump (Number higher than 0). If it does not press the “Start” button.

Vacuum Switches: While holding the chamber door closed open the roughing valve by switching “Rough” to the open position. See Figure 3-1.

CHECK: You will not be able to open the door as soon as the valve opens. If the door can be opened, there is either a leak or the roughing pump is off. Turn on the roughing pump if necessary and try again.



Figure 5-1: Vacuum Process Controller showing vacuum less than 200mTorr (173mTorr).

Vacuum Process Controller: Monitor the System Vacuum until it is less than 200mtorr (2.00×10^{-1}) which take 5-10 minutes. See Figure 5-1.

Vacuum Switches: Close the roughing valve by switching “Rough” to the closed position. See Figure 3-1.

Vacuum Switches: Open the high vacuum valve by switching “Hi-Vac” to the open position. See Figure 3-1.

Vacuum Process Controller: Wait for one minute *after* the System Vacuum shows “000” Torr and then press IG1 ON/OFF” once. See Figure 3-2.

If you are pumping down the chamber after *unloading* your samples, then turn off the **Maxtex Deposition Controller**

Heating: Chamber heating should be used to decrease pumping time, unless your samples cannot be exposed to temperatures up to 100C.

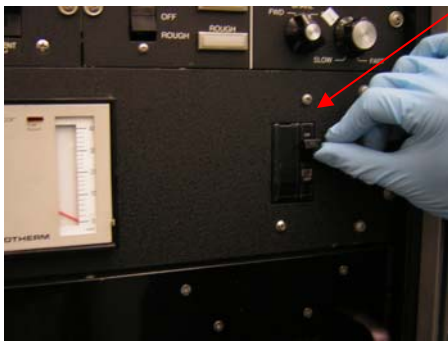
- Heat should be set to 100C for 20mins; this should be done immediately after the Ion Gauge is turned on. Follow instructions in 5.1 **HEATER OPERATION**

The pressure should reach low 10^{-6} Torr range in about 1.5 hours.

5.1 Heater Operation

Heating Chamber to Decrease Pump Time

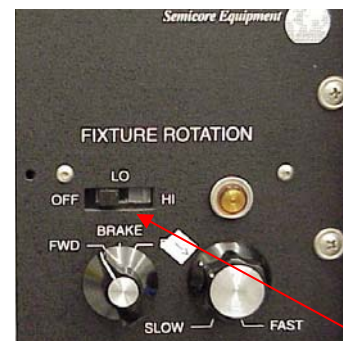
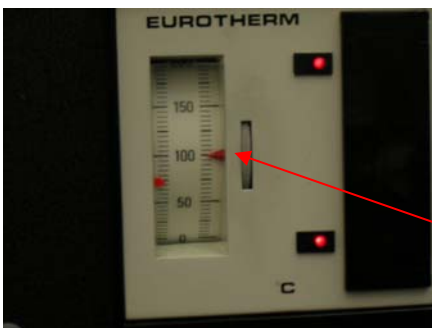
- 1. Heater Control Panel:** Locate power breaker and ensure it is in the ON position. Check for tripped condition (Orange color in clear window), reset if necessary by turning OFF then ON again.



- 2. Heater Set Point Control:** Locate set point control screen, and use knob to adjust set point to ZERO (0).



- 3. HEAT LAMP POWER SWITCH:** Locate and turn on Power Switch. Light will illuminate on Panel to verify power is on.



- 4. Heater Set Point Control:** Adjust set point to 100C. Turn on FIXTURE ROTATION if using planetary, and leave on for 20 minutes. Then return heater set point to Zero (0) and turn off **HEAT LAMP POWER SWITCH**. Turn off fixture rotation if used.

NOTE: While heater is on lamps can be seen glowing in the chamber.

6.

7. Evaporating

NOTE: You should wait until the system pumps down to the low 10^{-6} Torr range before evaporating. For example: 2×10^{-6}

WARNING: Most metals will oxidize quickly in the range of 10^{-5} Torr or higher.

7.1. Evaporating using the e-gun Source

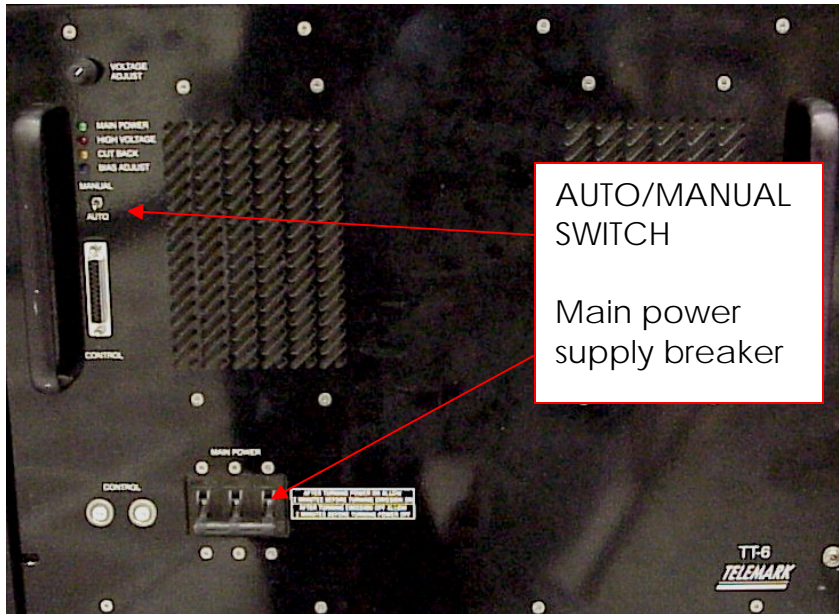


Figure 7-1: Telemark TT-6 Power Supply

1. **TT-6 TELEMARK:** Turn on “Main Power”. See Figure 6-1.

Check:

- **TT-6 TELEMARK** is switched to “AUTO”. See Figure 6-1.
- **376 Crucible Indexer** is switched to “MANUAL”. See Figure 4-3.
- **SHUTTER CONTROL** is switched to “AUTO”. See Figure 6-2.

FIXTURE ROTATION: Slide switch to “LO” position. Note that the knob is pointed to the arrow. See Figure 6-2.

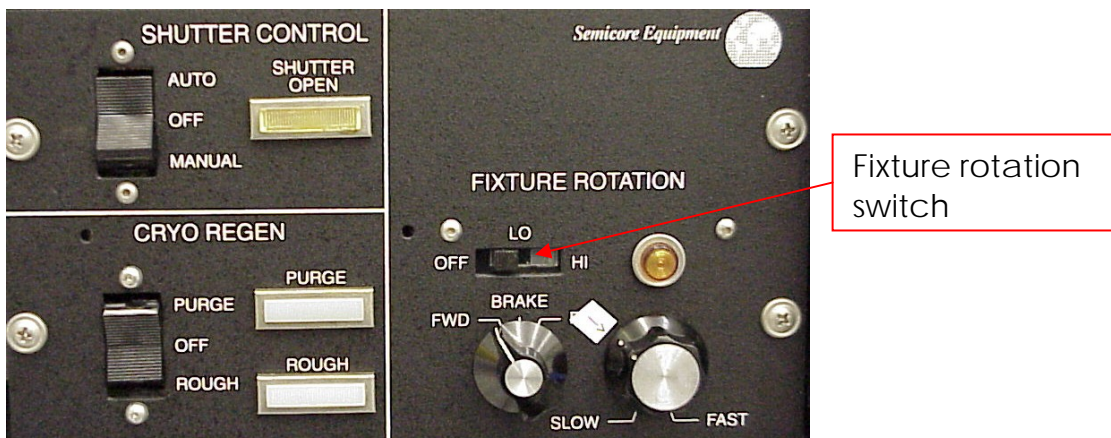


Figure 7-2: Shutter Control and Fixture Rotation



Figure 7-3: Telemark Power Controller interlocks

Check that all 5 of the interlock lights on the **TELEMARK POWER SUPPLY CONTROLLER** are on. If not, stop and find a

staff member. See Figure 6-3.

POWER SUPPLY CONTROLLER TELEMARK: Turn on small power toggle switch. See Figure 6-4.

POWER SUPPLY CONTROLLER TELEMARK: Switch small toggle switch to “SWEEP SELECT”. See Figure 6-4.

SWEEP SELECT TELEMARK: Turn selector knob to correct sweep number based on Table 2.

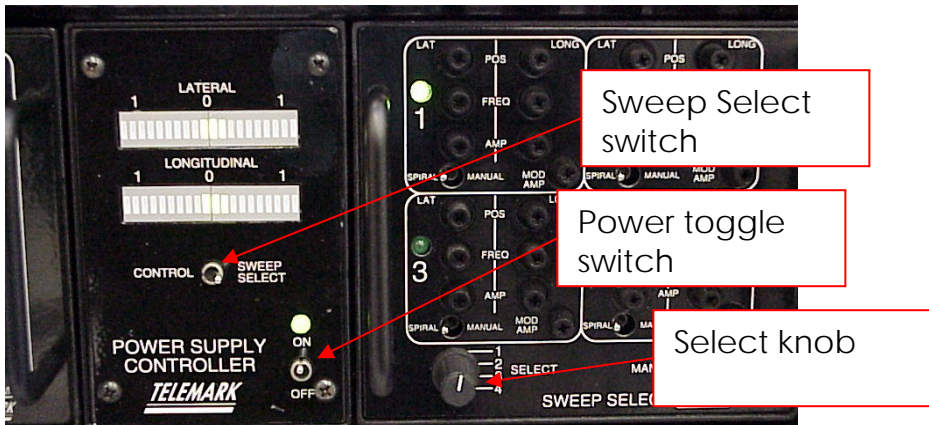


Figure 7-4: Telemark Power Supply Controller

Table 2: Sweep Select

Sweep Select	Materials	Notes
1	Al, Ag, Au, Pt, Ta, Ti, NiCr	Average sweep magnitude
2	Cr, SiO ₂ , C, Al ₂ O ₃	Wide sweep for materials that sublime
3	Ni (in copper), W	Tight sweep for high power & protect crucible
4	Co	Medium sweep

MAXTEK DEPOSITION CONTROLLER: Press “Reset”. See Figure 4-2.

MAXTEK DEPOSITION CONTROLLER: Press “Start” and use the arrow keys to select the recipe. See Figure 4-2.

MAXTEK DEPOSITION CONTROLLER: Press “Start” again.

Follow the instruction on the **MAXTEK DEPOSITION CONTROLLER** to select the correct source by rotating the index knob on the **376 CRUCIBLE INDEXER** to the correct setting. See Figure 4-3.

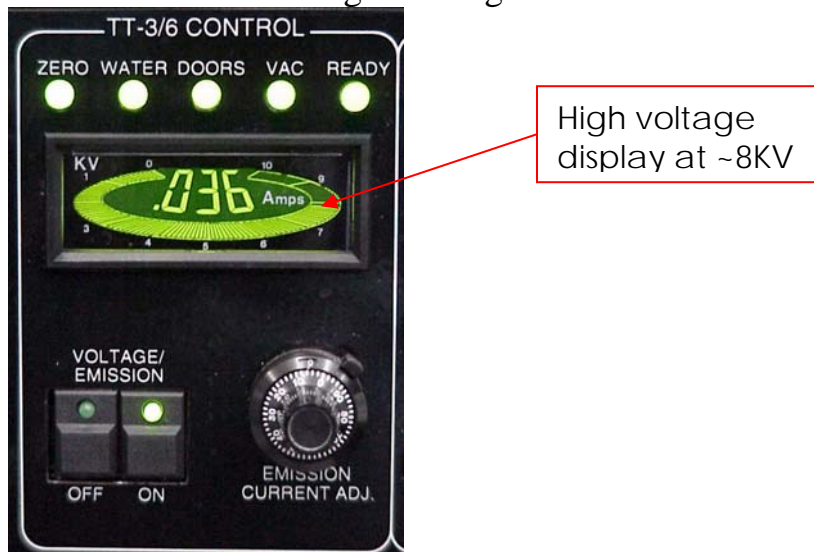


Figure 7-5: Telemark Power Supply Controller with high voltage on.

376 CRUCIBLE INDEXER: Wait for the correct pocket to be lighted then press “START” again on the **MAXTEK DEPOSITION CONTROLLER**.

- Now the deposition controller brings up the power:

CHECK: The High Voltage should ramp up to between 7.5kV and 8.5kV. See figure 6-5

- **WARNING:** DO NOT ADJUST this voltage, it will change the beam centering position.
- Record the base pressure in the log book
- **CHECK:** Put on dark safety glasses. Make sure the beam centered in the crucible. If it is not, use the latitude and longitude position adjustment knobs for the sweep # you are using.

WARNING: You must always stay with the tool during evaporation.

WARNING: Do not under any circumstances continue an evaporation if the beam is not centered. You could ruin the crucible and possibly heat up the crucible pocket and drill in to the waterlines! Seek staff help! If no staff are available press “ABORT” key on the **MAXTEK DEPOSITION CONTROLLER**.

WARNING: If the deposition rate drops even while power is increasing before reaching the desired thickness, abort the run by pressing the “ABORT” key on the **MAXTEK DEPOSITION CONTROLLER**. Please notify a **staff member**. You may attempt to start over with the last soak cycle. Abort if it still malfunctions.

Record the number of Angstroms evaporated in the log book and on the Portal.

If you wish to Electron Beam evaporate another material go back to step 7.

If you wish to Thermally Evaporate another material go to Section 7.2

FIXTURE ROTATION: Slide switch to “OFF” position. See Figure 6-2

POWER SUPPLY CONTROLLER TELEMAR: Turn off small power toggle switch. See Figure 6-4.

Wait at **LEAST 30 minutes for the system to cool down before proceeding / venting chamber**. For depositions of more than 2000A consider waiting up to an hour.

TT-6 TELEMAR: Turn off “Main Power”. See Figure 6-1

If finished go to section 8 “Final Check List”

7.2. Evaporating Using the Thermal Source

Check post selector, only one post is used! **Filament 1 ONLY**

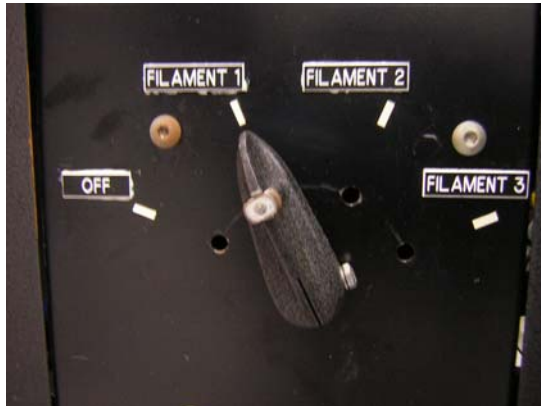


Figure 7-6: Post selector

Turn on the power to the thermal source by flipping on the FILAMENT EVAPORATOR toggle switch at the top of the control rack.



On Maxtek:

- Modify process/recipe as needed for your material - see MAXTEK CONTROLLER INSTRUCTIONS **Section 6**
- press **start**, highlight a thermal recipe for your material
- press **start** again, verify post is on Filament 1
- press **start** again. The Maxtek controller will now begin the soak/ramp and deposition cycle.

Monitor system during deposition, if boat runs out of material system will self abort after 1 min of no deposition rate. If you see material has run out please press abort to avoid unnecessary and excess heating of boat.

When finished press reset on Maxtek Controller and turn off the Main Power toggle switch.

Record the number of Angstroms evaporated in the log and on the Portal. If you wish to E-gun evaporate a material go to the section “Evaporating Using the E-gun Source”

Wait 30 minutes to allow the system to cool. You should wait longer than 30 minutes if you evaporated more than 1000 Angstroms.

Go to section 7 “Final Check List”

8. Final Check List

8.1. Venting the Chamber

Before venting, wait at least 30 minutes to let the system interior cool down. See section 3 to vent the chamber

8.2. Unloading Metal and Samples

1. Remove the sample holder from the system. See Section 4.3

Remove your sample(s) from the sample holder.

Open shutter.

Remove/dispose of thermal boat and put them in their proper place (dispose of any boats that do not have gold in them).

Remove e-gun crucibles and put them in their containers

Maxtex Deposition Controller: Turn off power toggle switch. See Figure 4-1

NOTE: Users are responsible for cleaning up after themselves. Vacuum the chamber interior through the door, as needed. Use the clean room vacuum located next to the evaporator or in the gowning area.

8.3. Evacuating the Chamber

See section 5 to pump down the chamber. Please leave the system in high vacuum.

9. Training Check List

- Overview of the system
- Venting system
- Loading samples
- Loading sources (including adding metal to e-gun crucibles)
- Evacuating the chamber
- Evaporating using the e-gun source (including melting in new metal)
- Evaporating using the thermal source
- Changing the thickness monitoring crystal
- Cleanup!
- Add to List on Portal

10. Trouble Shooting

This section contains the most common problems encountered on the evaporator

10.1. Low water flow on roughing pump

The roughing pump is sensitive to drops in cooling water flow. It will go into alarm. If the alarm sounds you may press the reset button to clear the error. Note that the pump will continue to run as long as the error is temporary. You will know it is running because the display will show the current draw and look something like “MP: 7.2A”, and the “MP Run” light will be lit. If the alarm does not clear, contact staff.

10.2. Maxtek lights blink when trying to start evaporation

The system has an interlock that only allows deposition after a certain vacuum level has been achieved. This level is 5×10^{-6} , if you try before vacuum reaches this level the controller will not allow a recipe to be started. Press the “STATUS” button on the Maxtek controller repeatedly until you see the True/False screen, then look beside “HIGH VAC”. If it reads T then the condition is true and deposition can begin, if it reads F then the condition is false, the vacuum level is not low enough to deposit.

11. E-Gun Metals Information Sheet

Metal	Notes	Sweep (Amp)	Sweep #	Crucible	Crucible	Max Rate (A / sec)
Al		0.5	1	Intermetallic		5.0
Au		1.0	1	VC		
Ag		0.7	1	VC		5.0
C		1.4	2	VC		
Cr	2,3	1.4	2	VC		8.0
Cu		1.0	1	VC		
Fe	1	1.2	1	VC		
Ge	5	1.0		VC		
Mg		1.0				
Mo	2, 4, 6	0.8		VC		
Ni	1, 7	1.0	3	Al ₃ O ₂		
Ni	1	0.5	3	Cu		1.9
Ni	1	1.0	3	VC		
Pd	2, 4	1.0	1			
Pt		0.8	1	C		
Si		1.0	2	VC		
SiO ₂		1.4	2	VC		
Ta	6	0.8	1			
Ti	2, 3	1.0	1	VC		
ZnS		1.2				
ZnSe		1.2				

Notes:

Magnetic material: will deflect beam until material melts
 Out gasses: chamber pressure will rise
 Getters: chamber pressure will fall
 Spits: small pieces of metal will jump from crucible
 Will form crystals in crucible
 Max rate is 0.8 Angstrom/second
 Rate will suddenly shoot up once the metal melts

Crucible Lines:

Cu = Copper
 VC = Vitreous Carbon
 C = Carbon
 Intermetallic = TiB₂ – BN alloy

Thermal Boats:

W = Tungsten
 Mo = Molybdenum