CHA E-Beam Evaporator Operation Manual

Description:

The CHA is a multi-pocket electron beam evaporator. It is a high vacuum (10-^{6} Torr) e-beam evaporation system that can be used to deposit metals and dielectrics. The system can accommodate up to six crucibles at a time to allow multiple and sequential deposition. The planetary wafer holder of the system can hold up to 12 four inch wafers. Wafer fragments or dice can be mounted to carrier wafers with Kapton tape. The system is equipped with a quartz crystal microbalance for deposition rate control and thickness monitoring.

The following materials are routinely used in this system: Au, Ag, Al, Ti, Cr, Ni, and $Si0_2$. NCNC staff should approve the use of any new material.

Safety:

1. Before using this tool, users must be properly trained and certified by Lab Staff.
2. Only vacuum compatible materials are allowed in the system (Please contact NCNC staff if you are not sure about the materials vacuum compatibility).
3. Never touch anything inside the chamber with bare hands or contaminated gloves.
4. Do not touch any hot metals or hot crucibles, may cause severe burns.
5. Observe all safety precautions when you come into contact with dangerous substances.
6. Stay away from moving parts especially when the chamber is rising and lowering.

Emergency Shut Off:

If the machine malfunctions any time during the process, complete the following steps:

1. Turn **OFF** the high voltage supply.
2. Turn **OFF** the key.
3. Call NCNC staff
   a. Lab Phone 2-9831
   b. Bob Prohaska 2-1094

System Operation

Initial System Checks:

1. Check the logbook to verify if the last entry was okay.
2. See Appendix A: Figure 1& 2 to get familiar with the switches and panel boards of the system.
3. Chamber down and under vacuum. The pressure reading of IG1 or IG@ should be approximately ~5E^{-6} Torr (see Appendix A: figure 3) Switch
4. Vacuum/Hoist switched to **START/LOWER**, the vacuum controller should always be set to automatic (see Appendix A: figure 4)
5. Main power supply **OFF** (see Appendix A: figure 6)
6. Deposition rate controller **OFF** (see Appendix A: figure 2)

Preparing Chamber for Deposition

1. Turn OFF the ion gauge by pressing the IG1 and IG2 on the ion gauge controller (see Appendix A: figure 3)
2. Switch the Vacuum/Hoist switch to the **VENT/RAISE** position (see Appendix A: figure 4)
3. The Vent valve will automatically open, vent the chamber, and the hoist will raise the chamber. Wait about 1-2 minutes.
4. Check the chamber for any material particles. Wipe or vacuum the particles if necessary.

Load Evaporation Materials

1. During this step, the wafer holder planetary should be at the **OFF** position and at least one wafer holder should be removed from the system to get access to the crucibles.
2. Open the shutter (see Appendix A: figure 1)
3. Set the pocket selector dial to the desired pocket number. The hearth will rotate until the proper pocket is exposed. See the picture below to locate the dial (see Appendix A: figure 5).
4. Check if there is enough material to run the process and refill the crucible if necessary.
5. Place the material to be evaporated inside the pocket. (Aluminum and Titanium will always be in place). Make sure the pocket is clear of debris; use a vacuum cleaner if necessary. Pocket 1 is dedicated to Aluminum with 2% silicon; pocket 2 is dedicated to Titanium. All other materials must have a liner. **DO NOT** over fill the crucible. See picture 3.
6. Turn the shutter to the **AUTO** position.

Load Substrate

1. Remove the planetary and load the wafers.
    a. Two ways:
        i. Wafers are held flush with the planetary hemisphere for shadow masking processes such as lift-off (2 planetaries-12 wafer locations total) and
        ii. Wafers are held at a 45° angle to the planetary hemisphere (1 planetary-6 locations total). Used for producing conformal coatings over surface features.
2. After replacing the planetary with the wafers, make sure that all items are clear of the chamber and planetary motion is free to rotate.

Chamber pump down

1. Switch the vacuum/hoist control to **STANDBY/STOP**, and then **STOP/LOWER**. The system will automatically lower the chamber, rough pump the chamber and then switch to hi-vac (see Appendix A: figure 4).
2. Note the time it takes the chamber to pump from roughing to hi-vac in the logbook.
3. Shortly after the system switches to high vacuum, turn **ON** the chamber ion gauge by pressing the **IG2** button on the pressure gauge controller. When IG2 reads $<5 \times 10^{-6}$ Torr, evaporation may begin.

Preparing the Deposition rate controller

Deposition run parameters may be set while the chamber is pumping down.

Definitions:

Film # - A film # represents a specific material. Each material requires a different set of deposition parameters.

Process - A process is a set of commands that directs the controller to deposit one or more films. Each process step consists of the mode, the film to be deposited, and the thickness of the film. In most cases, only one film is used.

Layer - Layer numbers represent the number of film layers in the process. In most cases a single deposition is done so there will only be one layer. The Sycon rate controller can be programmed with 9 different processes each containing up to 99 steps. It also has storage for up to 9 different film parameter sets. For more information see the Sycon controller manual.

Controller Setup for Deposition

I. Edit the process

Note: Process 1 is programmed to deposit 5000A of Aluminum, film #1, and should not be changed. To locate the program boards see Appendix A figure 1.

1. Press **MENU** then **3**. This places the controller in Process Review mode.
2. Press **MENU** and then the process number to edit (2-9)
3. Edit the process.

In most cases the process will consist of two steps. The first step specifies which film will be deposited and how much. The second step is the END. Assuming this is the case, use the down arrow to advance the cursor to the film column. Enter the desired film number (after the first key is pressed, the computer will ask for the security code). Then advance to the thickness column and enter the desired thickness in K.

4. Press **MENU** then **MENU** to return to the Runtime Display.

II. Activate the Process:

1. Press **MENU** then **2**. You will be asked to enter the security code.
2. Type in the security code, press **ENTER**.
3. Type in the number of the process you wish to activate. This will activate the process and return to the Runtime Display.

The deposition rate controller is now programmed.

III. Set up the film parameters:

1. Press **MENU** then **MENU**.
2. Enter the edit code.
3. Press **MENU** then **1** then the **number of the film to edit**. Most film numbers will be assigned to a certain material; these are listed in Appendix B.
4. Scroll through the menu and adjust the necessary parameters. A list of the parameters can be found in the controller manual.
5. Press **MENU** then **MENU** to go to the main screen.

Deposition

Once the system has been pumped down to **<5x10^{-6}** Torr and the controller has been programmed, the evaporation may begin. Make sure **IG2** is on (not IG1).

1. Turn **ON** the main power supply. This is located on the large gray box next to the e-beam.
2. Switch the shutter control to **AUTO**.
3. Switch the rotation control to **AUTO**. Make sure the rotation direction and speed are set. The direction is controlled by a switch with three positions: Forward/Brake/Reverse. The speed is controlled by a switch with low and high positions and a dial giving analog control of the speed.
4. Switch the pocket selector switch to **MANUAL** (the auto mode is not installed on this system) and confirm that the proper pocket is selected.
5. Switch the filament **ON**. This is done by switching the Gun Control switch to the **ON** position. Verify that there is 0.026 filament current.
6. Turn the key on the High Voltage controller to **ON**. Switch **ON** the high voltage; hold the switch in the ON position for two seconds to ensure that it is turned on. The high voltage should be set to 10KV.
7. Press **START** then **4** on the rate controller, this may need to be done up to 3 times until the controller is switched into start mode.

   There are three possible states for the controller. Busy, when the process is running or an error has occurred. Resting and Stop are the intermediate states. The controller must be in Stop to change processes.

8. Monitor the beam, adjusting the beam position so that the beam is in the center of the melted material. The controller will automatically open the shutter to begin deposition.

   When the process is done, the controller will automatically close the shutter and bring down the power.

Unloading and Chamber Pump down

1. Allow 10-15 minutes for the target to cool down (Metals will cool faster than dielectrics).
2. Turn **OFF** the high voltage and turn the key to the **OFF** position
3. Turn **OFF** the Gun Control (filament current)
4. Turn **OFF** the power to the deposition control.
5. Turn **OFF** the Rotation switch
6. Turn **OFF** main power supply to the CHA controllers.
7. Turn **OFF** the IG2 gauge.
8. Switch the Vacuum/Hoist to **STANDBY/STOP**. Wait until the light on the FORELINE switch comes on, and then switch the Vacuum/Hoist switch to **OPEN**. The chamber will now vent and automatically be raised.
9. Remove wafers, targets, etc.
10. **CLOSE** the Shutter.
11. Switch the Vacuum/Hoist to the **START/LOWER** position.
12. Place the system into idle.
13. Clean up the area.

Appendix A: E-Beam Evaporator Pictures

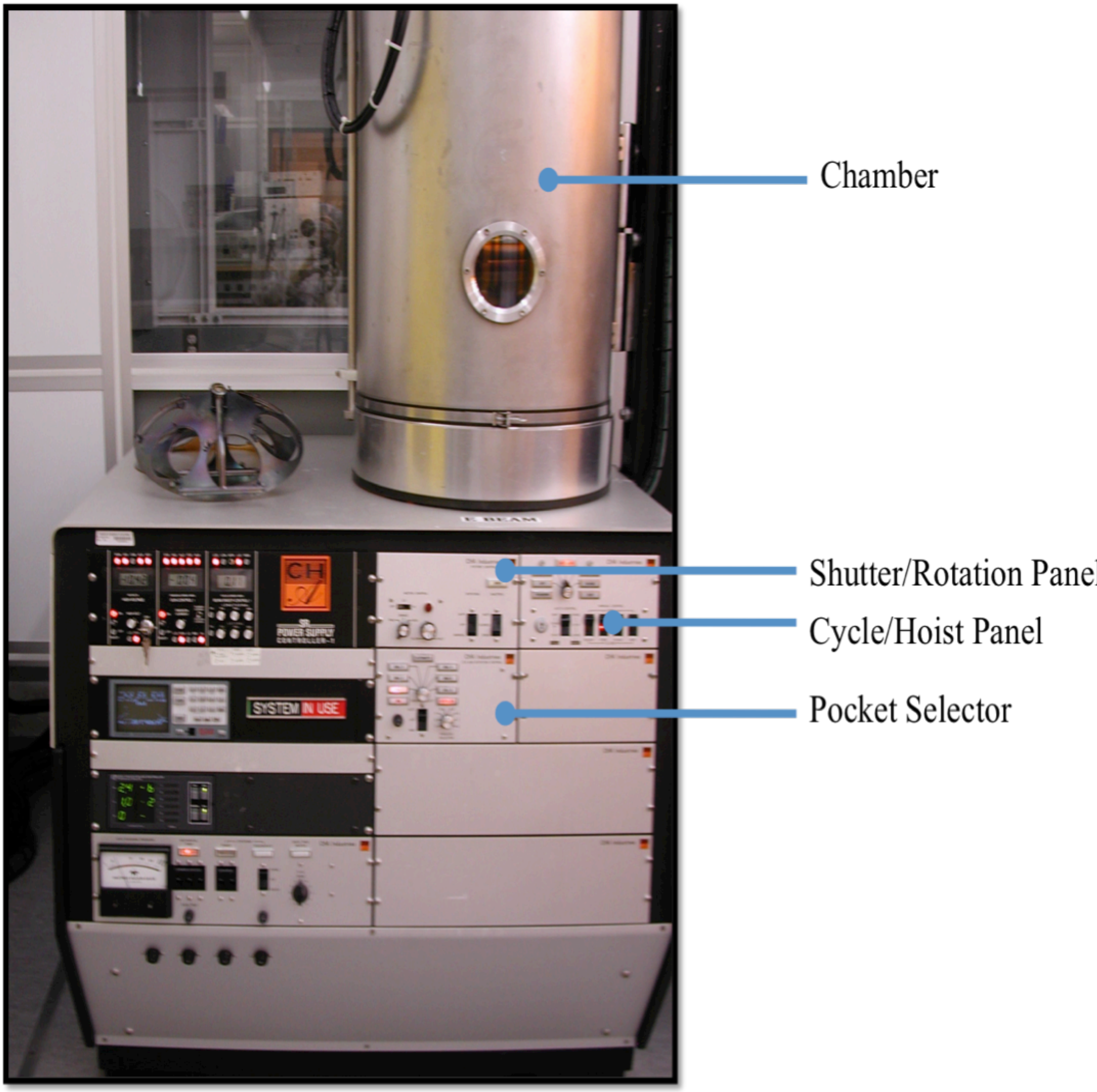

Figure 1: E-Beam Evaporator

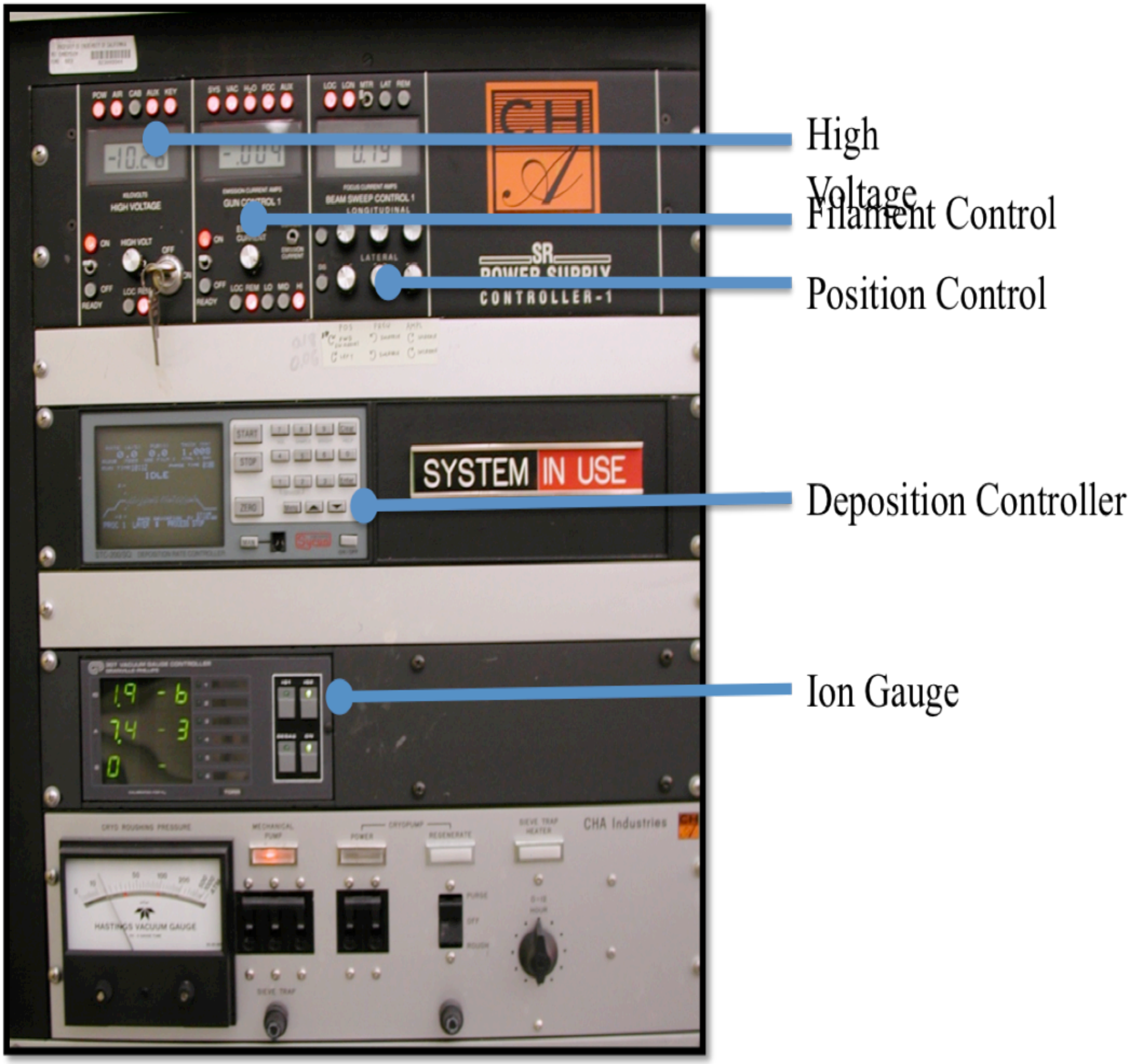

Figure 2: E-Beam Panels

Figure 3: Ion Gauge

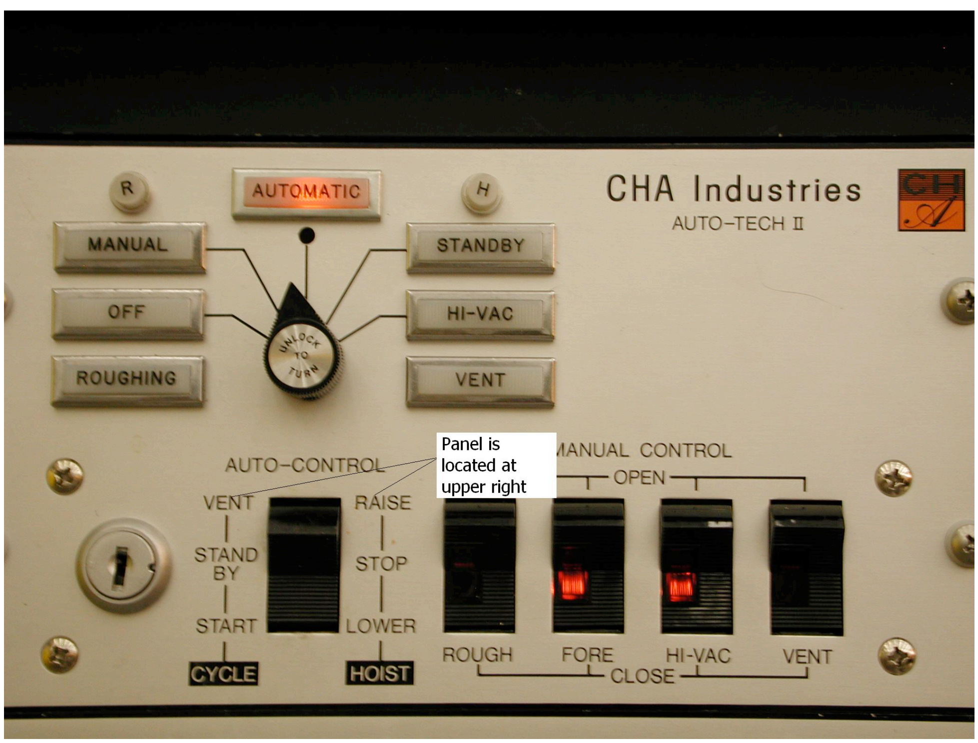

Figure 4: Cycle/Hoist Panel

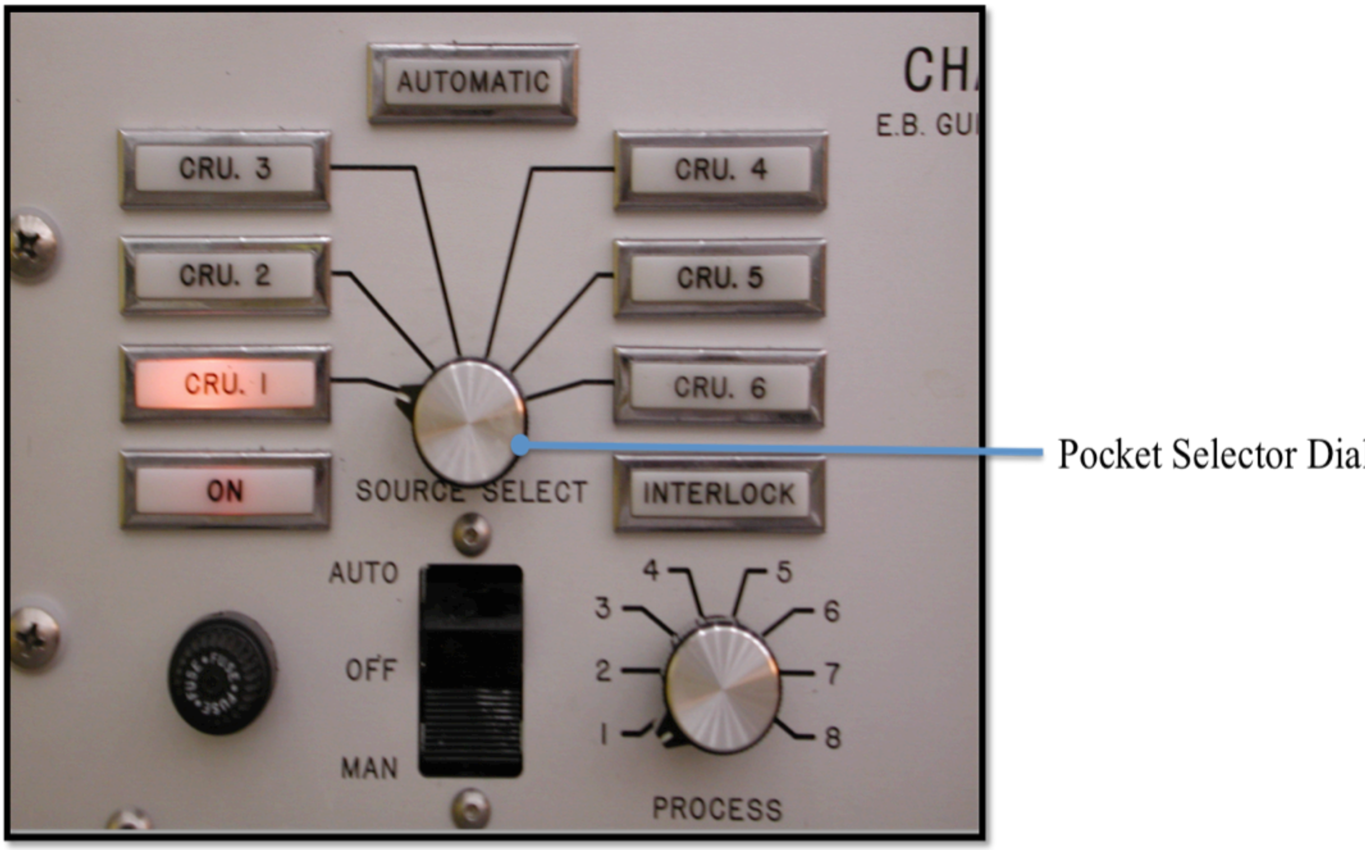

Figure 5: Pocket Selector

Appendix B:

Evaporation Rate Controller Parameters							
Film #	**Material**	**Density**	**Z Factor**	**Soak 1**	**Soak 2**	**Tooling**	**Pocket #**
1	Al	2.73	1.080	25%	28%	100%	1
2 & 9	SiO_2	2.20	1.070	22%	28%	210%	5
3	Cr	7.20	0.305	38%	40%	200%	6
4	Au	19.3	0.381	21%	23%	140%	5
5	Cu	8.93	0.437	18%	20%	100%	5
6	Ti	4.50	0.628	43%	50%	150%	2
7	Ni	8.91	0.331	33%	35%	190%	3
8	Pt	21.40	0.245	40%	43%	204.2%	
	Ag	10.5	0.529				

SECTION 4.3

Bulk Density and Z-Factor Values

Aluminum through Indium

Material Reference Table

Material	Symbol	Bulk Density Gm/cm^3	Z-Factor
Aluminum	Al	2.73	1.080
Aluminum Oxide	Al_2O_3	3.97	--------
Antimony	Sb	6.62	0.768
Arsenic	As	5.73	0.966
Barium	Ba	3.50	2.100
Beryllium	Be	1.85	0.543
Bismuth	Bi	9.80	0.790
Bismuth Oxide	Bi_2O_3	8.90	--------
Boron	B	2.54	0.389
Cadmium	Cd	8.64	0.682
Cadmium Selenide	CdSe	5.81	--------
Cadmium Sulfide	CdS	4.83	1.020
Cadmium Telluride	CdTe	5.85	0.980
Calcium	Ca	1.55	2.620
Calcium Fluoride	CaF_2	3.18	0.775
Carbon (Diamond)	C	3.52	0.220
Carbon (Graphite)	C	2.25	3.260
Cerium (III) Fluoride	CeF_3	6.16	--------
Cerium (IV) Oxide	CeO_2	7.13	--------
Chromium	Cr	7.20	0.305
Chromium (III) Oxide	Cr_2O_3	5.21	--------
Cobalt	Co	8.71	0.343
Copper	Cu	8.93	0.437
Copper (I) Sulfide (A)	Cu_2S (A)	5.60	0.690
Copper (I) Sulfide (B)	Cu_2S (B)	5.80	0.670
Copper (III) Sulfide	CuS	4.60	0.820
Dysprosium	Dy	8.54	0.600
Erbium	Er	9.05	0.740
Gadolinium	Gd	7.89	0.670
Gallium	Ga	5.93	0.593
Gallium Arsenide	GaAs	5.31	1.590
Germanium	Ge	5.35	0.516
Gold	Au	19.3	0.381
Hafnium	Hf	13.1	0.360
Hafnium Oxide	HfO_2	9.63	--------
Holnium	Ho	8.80	0.580
Indium	In	7.30	0.841

Table 4.1: Common Material Reference Table

Material	Symbol	Bulk Density Gm/cm³	Z-Factor
Indium Intimonide	InSb	5.76	0.769
Indium Oxide	In_2O_3	7.18	--------
Iridium	Ir	22.4	0.129
Iron	Fe	7.86	0.349
Lanthanum	La	6.17	0.920
Lanthanum Fluoride	LaF_3	5.94	--------
Lanthanum Oxide	LaO_3	6.51	--------
Lead	Pb	11.3	1.130
Lead Sulfide	PbS	7.50	0.566
Lithium	Li	0.53	5.900
Lithium Fluoride	LiF	2.64	0.774
Magnesium	Mg	1.74	1.610
Magnesium Fluoride	MgF_2	3.00	--------
Magnesium Oxide	MgO	3.58	0.411
Manganese	Mn	7.20	0.377
Manganese (II) Sulfide	MnS	3.99	0.940
Mercury	Hg	13.46	0.740
Molybdenum	Mo	10.2	0.257
Neodynium Fluoride	NdF_3	6.506	--------
Neodynium Oxide	Nd_2O_3	7.24	--------
Nickel	Ni	8.91	0.331
Niobium	Nb	8.57	0.493
Niobium (V) Oxide	Nb_2O_5	4.47	--------
Palladium	Pd	12.0	0.357
Platinum	Pt	21.4	0.245
Potassium Chloride	KCl	1.98	2.050
Rhenium	Re	21.04	0.150
Rhodium	Rh	12.41	0.210
Rubidium	Rb	1.53	2.540
Samarium	Sm	7.54	0.890
Scandium	Sc	3.00	0.910
Selenium	Se	4.82	0.864
Silicon	Si	2.32	0.712
Silicon (II) Oxide	SiO	2.13	0.870
Silicon Dioxide	SiO_2	2.20	1.070
Silver	Ag	10.5	0.529
Silver Bromide	AgBr	6.47	1.180
Silver Chloride	AgCl	5.56	1.320
Sodium	Na	0.97	4.800
Sodium Chloride	NaCl	2.17	1.570
Sulfur	S	2.07	2.290
Tantalum	Ta	16.6	0.262
Tantalum (IV) Oxide	Ta_2O_5	8.20	0.300

Table 4.1: Common Material Reference Table, Continued

Indium Intimonide through Tantalum

Telurium through Zirconium Oxide

Material	Symbol	Bulk Density Gm/cm^3	Z-Factor
Tellurium	Te	6.25	0.900
Terbium	Tb	8.27	0.660
Thallium	Tl	11.85	1.550
Thorium (IV) Fluoride	ThF_4	6.32	--------
Tin	Sn	7.30	0.724
Titanium	Ti	4.50	0.628
Titanium (IV) Oxide	TiO_2	4.26	0.400
Titanium Oxide	TiO	4.90	--------
Tungsten	W	19.3	0.163
Tungsten Carbide	WC	15.6	0.151
Uranium	U	18.7	0.238
Vanadium	V	5.96	0.530
Ytterbium	Yb	6.98	1.130
Yttrium	Y	4.34	0.835
Yttrium Oxide	Y_2O_3	5.01	--------
Zinc	Zn	7.04	0.514
Zinc Oxide	ZnO	5.61	0.556
Zinc Selenide	ZnSe	5.26	0.722
Zinc Sulfide	ZnS	4.09	0.775
Zirconium	Zr	6.51	0.600
Zirconium Oxide	ZrO_2	5.6	--------

Table 4.1: Common Material Reference Table, Continued