University of Minnesota Nano Fabrication Center
Standard Operating Procedure

Equipment Name: CHA Evaporator

Coral Name:	ebevap-cha	**Revision Number:**	9
Model:	SEC 600	**Revisionist:**	L. Matzke
Location:	Bay 3	**Date:**	9/18/2009

1 Description

The CHA Evaporator is a single source electron beam evaporator. It has a lift-off fixture and a planetary fixture for 4" wafers. It can run up to six different materials in a run. The lift-off fixture holds 9 wafers, and the planetary fixture holds 6 wafers each; since there are 3 planetary fixtures that can be used, a total of 18 wafers can be run at one time.

Note: For users that desire to run 6" wafers, NFC has a fixture available which can accommodate up to 3 wafers at once. Ask appropriate NFC staff for details.

2 Safety

- **a.** Use the dark tinted, welder's glass provided when looking directly at the beam if it is too bright, or any tinted safety glasses would work as well.
- **b.** Take care when loading wafers and crucibles. Use a step stool if needed.
- **c.** The crucibles may be hot when unloading. Be careful when handling.

3 Restrictions/Requirements

- **a.** **DO NOT** leave the system during deposition for more than 10 minutes at a time and **ONLY** after the beam is verified to be in the pocket.
- **b.** During a FIRE or lab GAS alarm press F12 on the SEIMENS computer to abort a run if the system is running. You can also press the STOP button on the Inficon computer to stop the process. The RED EMO button should only be pressed if there is eminent danger such as fire, smoke, or a water leak.
- **c.** **Materials are restricted to those listed on the CHA Materials Parameter Sheet located in the CHA Log Book. See Staff for approval of other materials.**
- **d.** **The first 3 pockets are dedicated to Aluminum, Chromium, and Nickel.**
- **e.** **Do not put scotch tape in the CHA! Only use "Kapton" (polyimide) tape**

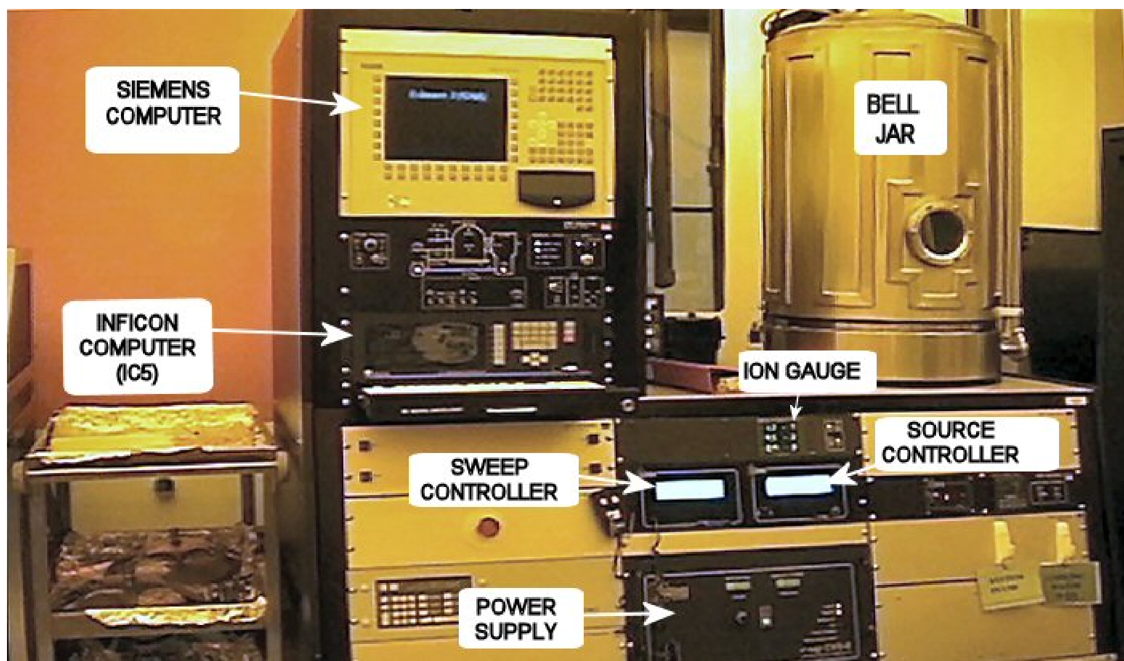
4 Required Facilities

- **a.** Compressed air 80-90 psi
- **b.** Process water
- **c.** Nitrogen gas
- **d.** Electrical 208/240 VAC
- **e.** House Exhaust

5 Definitions

a. **INFICON:** The computer where recipes are written and stored.
b. **SEIMENS:** The computer that is the operator interface. It is controlled by the keyboard and mouse pad as well as the control panel surrounding the monitor. It has a picture of the bell jar as well as all the fixturing and major valves within the system. Buttons that are displayed are used to operate the system.
c. **Source:** This is the E-BEAM source. The CHA has only one source.
d. **Gun:** This refers to the copper hearth that holds each metal to be evaporated.
e. **Crucible:** this is a name used to describe each "gun" position (1 through 6).
f. **Pocket**: this is another name used to describe the "Crucible" position. There are 6 pockets or "Crucible" positions which can hold materials for evaporation.

g. **Equipment Overview:**



6 Setup

a. **Enable the CHA with the CORAL system**.

7 Operating Instructions

a. **VENT THE CHA**

*Check to see that the cooling water valve is in the **OFF** position before venting the CHA*

1. If the system has been pumping down for a while, such that the pressure in the main chamber is at or below 2 x 10 E-6 Torr, a window will be on the screen that says PUMPDOWN COMPLETE.

   If this "PUMPDOWN COMPLETE" message is not on the screen, then there should be a blue banner that reads:
   "IG2 STEPOINT 1 IS BEING MADE"
   To vent the system, **Press F4** to go into standby. **Click "OK"** to acknowledge the standby message when it appears (or **Press A**).

2. **Press F3 VENT** button to begin venting the CHA. The chamber on the screen will gradually fill up with a "blue/green color" indicating that it is venting.

3. When the system has vented, a window will pop up saying the vent cycle is completed. Left click on the **RETURN TO STANDBY** button (or **Press A**). Wait a minute, and then click **"OK"** when the **SYSTEM IN STANDBY** message appears (or **Press A**).

4. An option will appear on the screen allowing you to raise the bell jar:

   BELL JAR UP
   F5

   Press and hold F5 to raise the bell jar. Keep pressing until the bell jar is all the way up (It will stop automatically).

5. When the bell jar has moved up, the "**BELL JAR DOWN**" option pops up, which will be used later to close the bell jar after loading the samples.

   BELL JAR DOWN
   F4

b. LOAD SAMPLES

1. With the bell jar open, load wafers onto the LIFT-OFF dome. Secure the wafers / holders to the dome with the clips. Fill any empty spots on the dome with sample holders. If using the PLANETARY fixture, the PLANETS should be loaded **before** hanging them on the planet pole fixture, and the load should be evenly distributed around the planet (equal spacing and weight distribution of wafers if possible).

c. LOAD SOURCE MATERIAL – POCKETS

1. The CHA has 6 pockets from which crucibles can be placed. The first 3 pockets have been dedicated. **These dedicated pockets should always have the dedicated materials in them.** Verify that those dedicated materials are in the CHA if you are going to use them for your run. If they look low, there should be nickel and aluminum pellets in the cabinet to the left of the bell jar. Place a couple of pellets in the appropriate pocket (do not overfill). Contact a NFC staff member if you need help refilling or replacing any material.
   Pocket 1: Solid Aluminum (no liner)
   Pocket 2: Chromium disks
   Pocket 3: Solid Nickel (no liner)
   Pocket 4-6: Open for use, and can be loaded with any of the allowed materials.
2. When the system is vented, the "gun" or "pocket" position will automatically rotate to pocket 1.
3. **Press F7** to open the shutter.
4. **Press F6** to rotate the "gun" to select a different pocket. A window will pop up with different pocket numbers. Select the pocket number desired, by clicking on the pocket number using the mouse, or by pressing the number of the pocket on the keypad to the right of the Siemens computer screen. The gun will slowly rotate to the pocket you selected. Load the pocket, repeat until all desired pockets are loaded. Left click on **DONE** when finished (or **Press A**).
5. **Press and hold F4** to lower the bell jar down. Keep pressing until the bell jar is all the way down (It will stop automatically).

d. Run Recipe in Automatic

1. **Press F2 PUMPDOWN** to start the pumpdown. The chamber will pump down trying to reach the set point of **2 x 10-6 Torr** – once this pressure is reached, it will continue to pump, but you will now have the option to start your run at this time. When this pressure setpoint has been reach, the following message will appear:

While you are waiting for the pumpdown to complete, you can continue to the next step and program your run.

2. Program recipes in the Inficon computer (**See Section 8 - Appendix**)

3. Zero out the X and Y offsets on the MDC sweep controller for a safe initial beam position. The Program button should already be highlighted '**PRM**' (if not, press PRM). The beam can be adjusted by pressing the corresponding X or Y axis button on the MDC sweep controller. Use the hand controller to adjust the X and Y offsets to 0.0

Wait until you are ready to start the evaporation run, then Go behind the CHA and ***Turn the Cooling water on !***

4. **Press F1 Automatic** to start an automatic process run. If a lower pressure is desired, wait until that pressure has been reached before pressing F1.

5. Select a process recipe. A window comes up asking for which IC5 process to run once the **AUTOMATIC RUN** is started. Click on the **UP** or **DOWN** arrow to select the recipe you want to run. Click **"OK"** (or **Press A**). The process will start automatically. The gun turret will rotate to the correct pocket **Check to confirm that the pocket number is correct by looking at the "hearth controller" which is located to the right of the "sweep controller" and the "source controller"—There should be a red digital number displayed (1 through 6)**.

6. Observe the beam inside the chamber. If it is too bright, use UV protective glasses or a piece of tinted glass. Adjust the beam using the MDC sweep controller. The Program button should already be highlighted '**PRM**' (if not, press PRM). The beam can be adjusted by pressing the corresponding X or Y axis button on the MDC sweep controller. Use the hand controller to adjust the beam by pressing the up or down arrow buttons. Be sure to look inside the chamber at the beam while you are changing the X or Y axis settings to determine where the beam is moving.

7. When the target thickness has been reached, the shutter will close automatically and the beam will shut off. Wait at least 10 minutes for the sources to cool. A message will pop up saying the process is completed, and will give you the option to vent the chamber. **TURN THE COOLING WATER OFF** after you have waited long enough for cooling**,** then vent the chamber by left clicking on YES or by pressing **F9**. Once vented, the system will go into standby. Click **OK** when the "SYSTEM IN STANDBY" message appears. **Press and hold F5** to raise the bell jar, and unload your wafers. At this time you can also remove any sources you loaded in the pockets (refer to the previous instruction section "**LOAD SOURCE MATERIAL – POCKETS"**).

e. Idle State: The CHA is ALWAYS to be left pumped down.

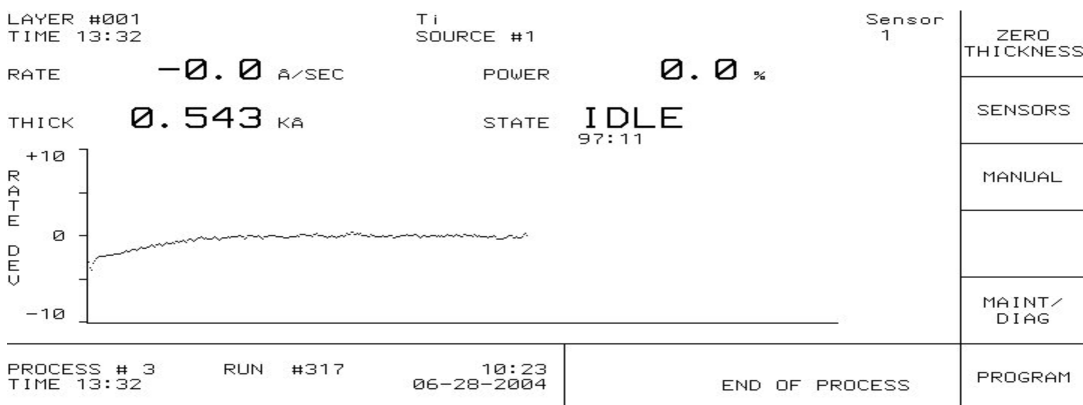
1. Verify that the **cooling water is OFF**. With the bell jar all the way down, left click on the '**PUMPDOWN**' button or press **F2**. The system will do a soft roughing pump for 1-2 minutes. The chamber then slowly pumps. The bell jar image on the screen will gradually change from blue/green to gray indicating that it is pumping.

2. Stay with the system until **"IG2 STEPOINT 1 IS BEING MADE"** is displayed on the screen. This takes about 5 minutes and indicates that the high vacuum valve is open and the system is pumping (If this does not happen within 10 minutes, contact an NFC staff member). Disable the CHA in the Coral system.

8. Appendix: IC5 Recipe Writing

a. WRITING A PROCESS RECIPE (INIFICON COMPUTER)

1. Shown below is the INFICON Main Operating Screen (currently in IDLE mode in this photo). After programming the INFICON, pressing **F6** repeatedly will return the USER to the Main Operating Screen.



b. Defining Materials

1. The IC/5 can store parameters for up to 24 materials at a time. Each layer in a process will reference a specific defined material using a number from 1 – 24 (Current materials that are allowed in the system will be numbered on the CHA Materials Parameter Sheet).

2. **The materials are already defined**. See the CHA Materials Parameter Sheet for specific material information. **DO NOT** change the materials' number of ANY of the defined materials. The specific parameters (i.e. soak times and powers) can be modified if needed. Do not go more than 25% above the recommended powers or times without prior approval (You will not need to change any material parameters, except in the most rare of cases—ask NFC staff for assistance if you have questions).

3. To <u>check or modify the parameters</u>; from the main operator screen (the one with the deposition rate deviation graph); press **PROGRAM - F6** to enter the main program screen. Press **MATERIALS DIRECTORY - F1** to access the materials directory. Move the cursor to a material already assigned if it needs to be edited or checked. Press F5 to enter that material's parameters. **Do not add or delete materials**. NFC staff will do this if needed.

```
MATERIAL DIRECTORY                                         DELETE
                                                           MATERIAL
  1. Cr          7. Pd         13. Ge         19.
  2. Ti          8. Pt         14.            20.
  3. Al          9. Au         15.            21.
  4. Ni         10. Ag         16.            22.
  5. USER       11. Cu         17.            23.
  6. Ti         12. Mo         18.            24.
                                                           MATERIAL

                                     END OF PROCESS        PROGRAM
 0.0A/SEC   0.546KA   0.0%
```

4. **Modify or check the parameters:** Move the cursor to the parameter; enter the value desired then press 'E' to save the number. The values below are the default values for page 1 of all materials. The Density and Z-ratio are the only values that will be different for each material. These are automatically loaded in the IC5. The source is always set to 1. The tooling factor may be adjusted if needed (should be very accurate). Check the materials data sheet for the current value. All of the other entries (on page 1) are set at zero.

```
MATERIAL 6 - Ti                              Page 1 of 3     PAGE
                                                             FORWARD
Density                     4.500   GM/CM^3
Z-Ratio                     0.628

Source                          1   (1-6)

Control Loop                    0   (0=Non-PID, 1=PI, 2=PID)
Process Gain               10.000   A/SEC/%PWR


Master Tooling               26.1   %
Recorder Output                 0   (1-6,0=None)
Recorder Function               0   (0=Rate 100A/S, 1=Rate 1000A/S,
                                     2=Thick 100 A, 3=Thick 1000 A,
                                     4=Rate Dev ±50A/S, 5=Power)     MATERIAL
Crystal Quality                 0   (0-9)                            LIBRARY
Crystal Stability               0   (0-9)
                                                                     MATERIAL
                                          END OF PROCESS             DIRECTORY
 -0.0A/SEC   0.546KA   0.0%
```

Press **PAGE FORWARD – F1** to access page 2. See the Materials data sheet for the parameters for:

Maximum Power, Soak Power 1, Rise Time 1, Soak Time 1, Soak Power 2, Rise Time 2, Soak Time 2

The **Auto-Soak 2** should be set to NO. The **Delay Option** is not used, so it is set to 0. **Feed Power** refers to the power that the CHA will ramp down to after your thickness is reached. Set this to 0. Set the **Feed Ramp Time** to 00:30 seconds and the **Feed Time** to 00:00. This will cause the CHA to ramp the power down to O% over 30 seconds, instead of immediately shutting the power off. It will help the longevity of the liners. **Idle Power** is set to 0.0. **Idle Ramp Time** (See Materials Data Sheet) differs per material, because some materials may take longer to cool then others. This will help prevent the Turret or gun from rotating to the next layer (different pocket) while a source material is still molten.

MATERIAL 6 - Ti — Page 2 of 3

Parameter	Value	Unit
Maximum Power	25.0	%
Soak Power 1	7.0	%
Rise Time 1	1:30	MM:SS
Soak Time 1	1:00	MM:SS
Soak Power 2	9.0	%
Rise Time 2	1:00	MM:SS
Soak Time 2	1:00	MM:SS
Auto-Soak2	NO	YES/NO
Delay Option	0	0=None,1=Shutter,2=Control,3=Both
Feed Power	0.0	%
Feed Ramp Time	0:30	MM:SS
Feed Time	00:00	MM:SS
Idle Power	0.0	%
Idle Ramp Time	5:00	MM:SS

PAGE FORWARD | PAGE BACK | MATERIAL DIRECTORY

0.0 Å/SEC 0.546 KÅ 0.0 % END OF PROCESS

5. Page 3 is not needed. Move the cursor to the parameter; enter the value desired then press ‘E’ to save the number. Press **MATERIAL DIRECTORY – F6** to return to the directory.

c. Defining a Process

1. A process is an ordered set of layers (materials). Each layer consists of a material, chosen by number from a material directory, a deposition rate and a final thickness. Up to 50 different processes can be stored on the IC/5.

2. From the main operator screen (the one with the deposition rate deviation graph); press **PROGRAM - F6** to enter the main program screen. Press **PROCESS DIRECTORY – F2** from the main program screen to access the processes.

PROCESS DIRECTORY

Active Process is 3
Layer to Start is 1

PROCESS 1: Au	PAGE FORWARD
PROCESS 2: Ge,Au,Ni,Ti,Au	
PROCESS 3: Ti	
PROCESS 4: Cr,Ge	
PROCESS 5: Cr,Au	
PROCESS 6: Cu	SELECT ACTIVE PROCESS
PROCESS 7: Cr	
PROCESS 8: Ti,Cu	PROCESS
PROCESS 9: Ge	

-0.0 Å/SEC 0.546 KÅ 0.0% END OF PROCESS PROGRAM

3. Move the cursor to the desired process (that needs editing) or the next empty number to define a new process. Press **PROCESS – F5** to access the recipe. Press F1 or F2 to page "Forward" or "Backward" in the process directory.

PROCESS 4

Page 1 of 2
Layers Defined 2

		Layer 1	Layer 2	Layer 3	Layer 4
Material Index	(1-24)	Cr 1	Au 9		
Rate	Å/SEC	2.0	2.0		
Final Thickness	KÅ	0.050	0.500		
Thickness Limit	KÅ	0.000	0.000		
Time Limit	MM:SS	00:00	00:00		
Co-Deposition	YES/NO	NO	NO		
Ratio Control	%				
Cal Status					
Cross Talk	%				
RateWatch Time	MM:SS	00:00	00:00		
RateWatch Accuracy	%	2	2		
Crucible	(1-64)	1	3		

PAGE FORWARD | LAYER EDITING | PROCESS DIRECTORY

0.0 Å/SEC 0.141 KÅ 0.0% END OF PROCESS

5. Move the cursor to the parameter; enter the value desired then press 'E' to enter/save the number. **Material Index** will be the number that is associated with the material to be deposited from the Materials Directory. It will be a number between 1-24 (each Material Index number can be found on the Materials Parameter Sheet). The **Rate** is the deposition rate in Å/sec. The **Final Thickness** is the film thickness desired in kÅ (So 540 Å = 0**.**540 kÅ). The **Crucible** parameter refers to the pocket number (1-6) which holds the material to be evaporated. Continue with the next layer until complete by using the cursor to move over to the next column.

6. To delete a layer, press **LAYER EDITING – F5** on the process screen. Move the cursor over to the desired layer then Press **TAG / UNTAG – F5** to select the layer. Press **DELETE – F2,** then press **PROCESS – F6** to return to the layer parameters below the layer number.