Diffusion furnace Operating Instructions and Standard procedures
Rev. A

Safety:

1. Heat: Ensure that potentially hot surfaces have cooled before touching or personal injury, damage to equipment, or contamination of samples can occur.

2. Electricity: There is high current, 480V 3 phase power inside the furnace cabinet. Do not open the furnace cabinet for any reason.

3. Chemicals: The furnaces use dangerous chemicals in a gaseous or volatile state such as TCA, Ammonia, Dichlorosilane, and Hydrogen.

4. General Safety Precautions: If the furnace is in an unknown state, contact CSSER staff before using the tool.

General rules:

1. All furnaces shall have a default low temperature setting. The max furnace temperature is 1050 degrees C, unless classified as a non-standard furnace run and requires proper review as stated below.

2. The annealing furnace shall have a default temperature of 450 degrees C. All recipes requiring a higher temperature shall be considered a non-standard run and requires proper review as stated below.

3. There will be a standard recipe for each furnace that will allow only the time of the major step to be changed, within limits. All non-standard furnace runs need to be planned in advance and submitted in writing to Paul Boland, Rick Clift or Mel Pratt. CSSER staff will review the plan and if approved, create the recipe. Only after the recipe has been created can the run be scheduled. We must have sufficient time to review and discuss prior to the run. Our comments/concerns will be submitted to Dr. Stefan Myhajlenko for final approval. Written approval will be given to those changes accepted. Excess recipes will be purged by Paul, Rick or Mel periodically. Paul will be the primary furnace contact, Rick will be the second in line of contact, and Mel will be the third contact.
4. All non-standard furnace runs are to be returned to default conditions after completion of the run by the person running the recipe. If that person is unable to restore the furnace to default conditions due to access privileges, he or she must notify CSSER staff at run completion. Paul, Rick or Mel will return furnace to standard default conditions.

5. All runs need to be scheduled at least 48 hours in advance. Scheduling is done using the appropriate on line calendar:
   http://my.calendars.net/csser_anneal
   http://my.calendars.net/csser_boron_dope
   http://my.calendars.net/csser_dryox
   http://my.calendars.net/csser_ito
   http://my.calendars.net/csser_nitride
   http://my.calendars.net/csser_phos
   http://my.calendars.net/csser_poly
   http://my.calendars.net/csser_wetox

6. All furnace runs are to be logged in the furnace log book and all applicable areas in log book are to be completed before each run by the person running the furnace. The cumulative run # or thickness must be recorded for maintenance and cleanliness purposes. Thickness or resistivity readings must be recorded in the log book after the run, if taken.

7. The recipe operator should review the variable parameter table prior to each run to ensure process variables are set properly.

8. Senior students and others may be granted access to some recipe variables to change the time of the run based upon staff comfort level with the person’s competence and meeting a set of criteria (Phd. Student, top half of cleanroom users for > 6 months, no warnings). Other changes will require staff to create a recipe as outlined above. We can’t have unlimited recipes in the computer.

9. All doping furnace tubes wafer re-activation runs are to be entered in the furnace log book by the person running the re-activation.

10. **The wet oxidation bubbler shall be maintained at specified level of fullness.** The wet oxidation bubbler shall be checked prior to each run by the operator to ensure the bubbler does not run dry during the furnace run.
Oxygen cylinders shall be checked by staff to verify sufficient oxygen for the length of the furnace run.

11. **The TCA bubbler shall be checked by the operator prior to each dry oxidation run to ensure the bubbler does not run dry during the furnace run.**

12. Furnace boats and dummy wafers will be cleaned regularly based upon a cumulative run log. The Phos and Boron solid sources will be reactivated at the same time as boat/wafer cleans for those furnaces. Boat and dummy cleans are to be recorded in the furnace log book. The schedule is as follows:

   - Phosphorous Dope: Every 20 runs.
   - Boron Dope: Every 20 runs.
   - Dry Oxidation: Total 25 µm Cumulative thickness.
   - Wet Oxidation: Total 100 µm Cumulative thickness.
   - Silicon Nitride: Total 25 µm Cumulative thickness.
   - Polysilicon: Total 25 µm Cumulative thickness.
   - Metal Anneal: Every 20 runs.
   - High Temp Anneal: TBD by CSSER staff and LC DG detectors.

13. The doping, anneal, and oxidation quartz furnace boats are to be removed from the furnace and cleaned when required in 10:1 water and HF to prevent buildup on the boats. Boat cleaning is to be entered in the furnace log book. Boats from each furnace are to be cleaned separately in a fresh bath to prevent cross contamination.

14. The doping, anneal, and oxidation furnace dummy wafers are to be cleaned when required in HF, rinsed and spin dried. Fresh HF is to be used for each set of wafers.

15. The poly boat and dummy wafers may be cleaned using HF, nitric acid, and water (1:2:1) rinsed and dried. **NOTE:** The wafers or boat **MUST** be watched and checked frequently to prevent etching the original substrate.

16. The nitride boats and dummy wafers are to be cleaned in hot phosphoric acid, rinsed and spin dried.
**Sample Preparation:**

1. The furnaces are very sensitive to contamination, so care needs to be taken to ensure that only proper samples that have been cleaned correctly go into the furnaces.
2. All samples need to be silicon or quartz substrate.
3. Samples should have no photoresist or other organic contaminants.
4. With the exception of the metal anneal furnace, all samples must have no metallization or metallic contaminants. Selected metals, such as Aluminum and Nickel, are allowed in the metal anneal furnace.
5. Samples must be cleaned prior to introduction into the furnace, again excepting the metal anneal furnace. All samples must be cleaned in Piranha (7:3 sulfuric acid:Hydrogen peroxide) for 10 minutes followed by a BOE dip for 5 minutes. The only samples excluded from this are whole wafers that are removed, in the clean room, from a vendor sealed box immediately before introduction.
6. Samples that do not meet these criteria must be approved by CSSER staff in writing prior to introduction into the furnace.

**Operating Instructions:**

1. Log on to the SEMY Computer system using the screen saver password, which is provided during training.
2. Check the UP/DOWN sign and the log book to ensure that the furnace is working correctly, and that there are no qualification or maintenance processes due.
3. Check the furnace controller to ensure that there is no process currently running.
4. Enter all applicable information in the log book.
5. From the SEMY - Palette, Select “File” and “Log In”. If the Palette is not open, left click the background, and select “Local Palette”.
6. Enter your User ID and Password.
7. See the sections below for instructions for performing each individual task.

**Loading/Unloading the furnace:**

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Pratt, Boland  
3/16/06
1. Verify that the sign on the furnace controller is set to “Furnace Available” instead of “In Process” to ensure that no other users’ samples are still loaded. Change the sign to “In Process”.

2. Press “UNLOAD” on the loader controller for YOUR furnace. Pulling a furnace while it is running can cause damage to you, the furnace, and any loaded samples. **Be sure you are working with the right loader.**

3. Wait 20 minutes for the loader to pull from the tube and cool down.

4. Carefully load your samples and test wafers, with the major flat up. Do not cross slot any wafers as they will break during heating.

5. Press the “LOAD” button on the loader controller.

6. Wait 15-20 minutes for the loader to push into the tube and for the tempeaure to stabilize.

7. When the process is completed, unload the furnace, wait for the loader to cool, and remove your samples. Record measurement results in the log book and note that the run is completed in the the book and by changing the sign to “Furnace Available”.

**Selecting the Active Furnace:**

1. From the main menu, select the “Option” drop down menu.

2. Select “Zone” and then “SEMY1” (Boron, Phos, Anneal, High Temp Anneal) or “SEMY2” (Dry Ox, Wet Ox, Poly, Nitride).

3. Select “Tool” and then the furnace name.

**Changing Recipe Variables:**

1. From the Main Menu, click on the “VarParamEditor” Icon.

2. Select the “File” drop down menu, and then “Open”.

3. Select the Engineering Classification.

4. Pick the desired Variable Parameter Table from the list and select “Open”.

5. All of the recipe variables are displayed in the large White box. Select the one that needs to be changed.

6. Select the white box labeled “Value” in the lower right portion of the screen.
7. Change the variable to the desired value.
8. Press the “Modify” button.
9. Verify that the change appears in the main variable list.
10. Repeat these steps for any other necessary changes.
11. When all changes are complete, select “File” and “Save” from the drop down menu.
12. Select “File” and “Exit”.

**Running the Furnace:**
1. From the Main Menu, select the “Run Tool” Icon.
2. Ensure that the correct recipe is loaded into the furnace controller.
3. Check the level in the Steam bubbler or TCA bubbler if needed. Fill the steam bubbler with DI water if needed. Contact CSSER staff if the TCA bubbler is empty.
4. Press the “Start” button on the controller twice, slowly.
5. Verify that the recipe name is flashing in the display.
6. Press the “Start” button again.
7. Verify that the process has started by watching the controller count down for at least 1 minute.

**Checking the Tool Status:**
1. Click on the “Tool Status” icon on the main menu to show the process state, recipe name, and recipe progress.
2. Click on the Detail button for the furnace to view Temperatures, gas Flows, and more detailed recipe progress.

**Viewing the Data Plot:**
1. Select the “Data Plot” Icon from the main menu.
2. Select “Use Run Number to Set Dates”.
3. Select the desired run. Press “OK”.
4. After verifying that the time is correct, select “OK”.
5. Select “Parameters”, and then “Analog”. Choose the parameters that you wish to see. Press “OK”. Also select the desired parameters from the “Temperature” menu.
6. When viewing the data, use the left mouse to click and drag a box around an area of the plot to zoom in.
7. The center mouse button will give a text display of the data set. Use the “Next” and “Previous” buttons to scroll through the run data.
8. When finished viewing the plot, close the window and select “Don’t Save Changes”.

**FURNACE STANDARD RECIPES:**

**Dry Oxidation**

Minispec name: DRY_OX_C  
Purpose: Grow Oxide film 500-1500Å

**DRY OX C**

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
<th>O2 (slm)</th>
<th>N2/TCA(sccm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2</td>
<td>Ramp up</td>
<td>0:30:00</td>
<td>800</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>800</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Deposition</td>
<td>1:00:00</td>
<td>800</td>
<td>0</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>Ramp Up</td>
<td>1:00:00</td>
<td>1000</td>
<td>0</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>6</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>1000</td>
<td>0</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>7</td>
<td>Deposition</td>
<td>**</td>
<td>1000</td>
<td>0</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>Ramp Down</td>
<td>2:00:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Step time is variable.

Minispec name: DRY_900  
Purpose: Grow Thin Oxide film 100-500Å

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
<th>O2 (slm)</th>
<th>N2/TCA(sccm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Ramp up</td>
<td>1:00:00</td>
<td>900</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>900</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Deposition</td>
<td>**</td>
<td>900</td>
<td>0</td>
<td>6</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>Ramp Down</td>
<td>1:00:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Step time is variable.
## Wet Oxidation

**Minispec name:** WET\_OX\_C  
**Purpose:** Grow Oxide film 1000-5000Å

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
<th>O2 (slm)</th>
<th>N2/H2O(sccm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2</td>
<td>Ramp up</td>
<td>0:30:00</td>
<td>800</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>800</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Deposition 1</td>
<td>1:00:00</td>
<td>800</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Ramp Up</td>
<td>1:30:00</td>
<td>1050</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>1050</td>
<td>0</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Deposition 2</td>
<td>**</td>
<td>1050</td>
<td>0</td>
<td>6</td>
<td>450</td>
</tr>
<tr>
<td>8</td>
<td>Ramp Down</td>
<td>2:00:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

** Step time is variable.

## Polysilicon

**Minispec name:** POLY\_C

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temp</th>
<th>N2 (sccm)</th>
<th>SiH4 (sccm)</th>
<th>Pressure (mT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>650</td>
<td>6000</td>
<td>0</td>
<td>0 atm</td>
</tr>
<tr>
<td>2</td>
<td>Slow Pump</td>
<td>0:20:00</td>
<td>650</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Fast Pump</td>
<td>0:10:00</td>
<td>650</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Leak Check</td>
<td>0:03:00</td>
<td>650</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gas Evac 1</td>
<td>0:03:00</td>
<td>650</td>
<td>0</td>
<td>100***</td>
<td>300</td>
</tr>
<tr>
<td>6</td>
<td>Deposition</td>
<td>**</td>
<td>650</td>
<td>0</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>Gas Evac 2</td>
<td>0:05:00</td>
<td>650</td>
<td>0</td>
<td>100***</td>
<td>300</td>
</tr>
<tr>
<td>8</td>
<td>Backfill</td>
<td>0:20:00</td>
<td>650</td>
<td>6000</td>
<td>0</td>
<td>0 atm</td>
</tr>
<tr>
<td>9</td>
<td>End</td>
<td>0:01:00</td>
<td>650</td>
<td>6000</td>
<td>0</td>
<td>0 atm</td>
</tr>
</tbody>
</table>

** Step time is variable.

*** No gas is flowing. MFC is open to pump down to base vacuum
### Silicon Nitride

**Minispec name:** NITRDE_C

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temp</th>
<th>N2 (sccm)</th>
<th>NH3 (sccm)</th>
<th>SiH2Cl2 (sccm)</th>
<th>Pressure (mT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>0 atm</td>
</tr>
<tr>
<td>2</td>
<td>Slow Pump</td>
<td>0:20:00</td>
<td>800</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Fast Pump</td>
<td>0:10:00</td>
<td>800</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Leak Check</td>
<td>0:03:00</td>
<td>800</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Gas Evac 1</td>
<td>0:03:00</td>
<td>800</td>
<td>0</td>
<td>100***</td>
<td>100***</td>
<td>atm</td>
</tr>
<tr>
<td>6</td>
<td>NH3 Flow</td>
<td>0:01:00</td>
<td>800</td>
<td>0</td>
<td>320</td>
<td>0</td>
<td>750</td>
</tr>
<tr>
<td>7</td>
<td>DCS Flow</td>
<td>0:00:20</td>
<td>800</td>
<td>0</td>
<td>320</td>
<td>75</td>
<td>750</td>
</tr>
<tr>
<td>8</td>
<td>Deposition</td>
<td>**</td>
<td>800</td>
<td>0</td>
<td>320</td>
<td>75</td>
<td>750</td>
</tr>
<tr>
<td>9</td>
<td>Gas Evac 2</td>
<td>0:05:00</td>
<td>800</td>
<td>0</td>
<td>100***</td>
<td>100***</td>
<td>atm</td>
</tr>
<tr>
<td>10</td>
<td>Backfill</td>
<td>0:20:00</td>
<td>700</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>atm</td>
</tr>
<tr>
<td>11</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>atm</td>
</tr>
</tbody>
</table>

** Step time is variable.  
*** No gas is flowing. MFCs are open to pump down to base vacuum

### Boron Doping

**Minispec name:** BORON_C

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Ramp up</td>
<td>1:30:00</td>
<td>1000</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Anneal</td>
<td>**</td>
<td>1000</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Ramp Down</td>
<td>1:30:00</td>
<td>700</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>4</td>
</tr>
</tbody>
</table>

** Step time is variable.  
Recipe Temperature can be variable with CSSER Staff Approval  
O2 can be used on special request with CSSER staff Approval
Phosphorus Doping

Minispec name: PHOS_C

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>700</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Ramp up</td>
<td>1:45:00</td>
<td>975</td>
<td>4</td>
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<tr>
<td>3</td>
<td>Anneal</td>
<td>**</td>
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<td>4</td>
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<tr>
<td>4</td>
<td>Ramp Down</td>
<td>1:45:00</td>
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<tr>
<td>5</td>
<td>End</td>
<td>0:01:00</td>
<td>700</td>
<td>4</td>
</tr>
</tbody>
</table>

** Step time is variable.
Recipe Temperature can be variable with CSSER Staff Approval
O2 can be used on special request with CSSER staff Approval

Anneal

Minispec Name: ANFORM
Purpose: Anneal metal contacts in forming gas

<table>
<thead>
<tr>
<th>Step #</th>
<th>Step Name</th>
<th>Time</th>
<th>Temperature</th>
<th>N2 (slm)</th>
<th>N2/ 5% H2 (slm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stabilization</td>
<td>0:10:00</td>
<td>450</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Anneal</td>
<td>**</td>
<td>450</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>End</td>
<td>0:01:00</td>
<td>450</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

** Step time is variable.
Recipe Temperature can be variable with CSSER Staff Approval

LTO tube (converted to high temperature anneal)

Process parameters have not been defined at this time.