

## Semiconductor Device Processing

### Phosphorous Predeposition

#### Source Treatment in the phosphorous diffusion furnace

You will be using the PDS (planar diffusion source) PH-950 n-type solid sources. The phosphorous diffusion furnace is set at **950 degrees centigrade**. The boat containing the solid sources is stored in the nitrogen dry box. The sources need to be annealed if they are left **unused for 24 hours**. The anneal procedure is as follows

1. Open the N<sub>2</sub> gas valve at the back of the furnace until the flowmeter reads 15. Dry furnace to the operating temperature. Let the furnace purge for 10 minutes. Then turn down the gas to 5 while loading the boat.
2. Place the boat containing the source wafers at the mouth of the furnace, set the N<sub>2</sub> valve to 15, and let wafers anneal for **15 minutes**.
3. Turn gas flow down to 5, wait 2 minutes, and remove the boat.

#### Wafer Cleaning prior to Predeposition

The substrate surface must be properly cleaned and prepared before the predeposition. The following steps may be done while annealing the source wafers. Clean some additional test wafers which have no diffusion mask, (i.e. they have no oxide layer). Use these test wafers for characterizing your process.

1. Piranha Clean: Very slowly add **1 part of H<sub>2</sub>O<sub>2</sub> to 5 parts of H<sub>2</sub>SO<sub>4</sub>**. The mixture is self heating and attains a temperature of 80 degrees centigrade. When cool, the mixture may be re-used by adding 5 ml of fresh H<sub>2</sub>O<sub>2</sub>. **Handle the mixture with utmost caution as it is extremely corrosive**. Place the wafers to be doped in the solution for **10 minutes**.

2. Rinse the wafers in the DI for **2 minutes**.
3. Dip the wafers in 50:1 DI H<sub>2</sub>O: HF for **1 minute**.
4. Rinse in DI for **2 minutes**.
5. Blow dry with N<sub>2</sub> gas.

### **Pre-deposition**

This step is again carried out in the phosphorous pre-deposition furnace. At the diffusion temperature the active component in the solid source wafers decomposes to form P<sub>2</sub>O<sub>5</sub> vapor. This is carried to the surface of the substrate to be doped by diffusion. The surface concentration of phosphorous is typically the solid solubility limit.

1. Load the wafers on to the boat containing the solid source wafers. The wafers must be placed in the slot closest to the source with the **shiny surface towards the source wafer**. Also the region of interest on the substrate must be kept away from the bottom or edge of the boat as these regions do not get a uniform dose. **Always put in some test wafers along with the actual samples.**
2. Make sure N<sub>2</sub> gas valve at the back of the furnace is set to 5. Remove endcap.
3. Place the boat at the mouth of the furnace for **1 minute**.
4. Slowly push the boat in over a period of **2 minutes** until you reach the center zone. Replace end cap and turn N<sub>2</sub> valve to 15.
5. Allow **2 minutes** for the wafers to heat up to the furnace temperature. Nitrogen flow should be 15 for the duration of soak time.
6. Leave the wafers in the furnace for the **desired pre-deposition time**.
7. Turn N<sub>2</sub> valve to 5 and remove endcap. Slowly pull the wafers out of the furnace over a span of **2 minutes**.
8. Let the boat sit at the mouth of the furnace for **1 minute**.
9. Remove the boat from the furnace and replace endcap. Let samples cool for 10 minutes, then remove your samples from the boat. Let the boat cool for at least **20 minutes** before replacing it in the dry box.

### **Phosphorous glass removal**

A phosphorous glass layer is formed on the surface of the substrate during the diffusion process.

This layer must be removed before any further processing can be done.

1. Dip your test wafer in 50:1 DI H<sub>2</sub>O : HF for **5 minutes**. Remove, and make sure water beads on surface. If water does not bead, continue etching until water beads. Record time required for water to bead.
2. Dip the wafer in 50:1 DI H<sub>2</sub>O : HF for **5 minutes** or the time determined in previous step for water to bead (whichever is longer).
3. Rinse in DI H<sub>2</sub>O for **2 minutes**.
4. Blow dry with N<sub>2</sub> gas.
5. Measure the sheet resistance on the test wafers and record your data.