

ECE 220A/MAT 215A Lab Procedures for Diffusion Doping

Phosphorous Predeposition

Source Treatment in the phosphorous diffusion furnace

You will be using the PDS (planar diffusion source) n-type solid sources. The sources may be used at a variety of furnace temperatures (refer to the *Carborundum* Data Sheets for PH-950, PH-1000, and PH-1025 planar diffusion sources. The sources are the same: the different curves will give the differing values of sheet resistivity and junction depths for the full range of temperatures). 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 N₂ gas valve at the back of the furnace till the flowmeter reads 15. Let the furnace purge for 10 minutes.
2. Place the boat containing the source wafers at the mouth of the furnace for 5 minutes.
3. Slowly push the source wafers into the flat temperature zone of the furnace over a period of 3 minutes. Let the source wafers remain at this temperature for about one hour.
4. Slowly pullout the source wafers from the furnace over a period of 3 minutes.
5. Let the boat sit at the mouth of the furnace for 5 minutes before taking it out of the furnace.
6. You may load the silicon wafers to be doped at this stage. In case you plan to do the diffusion later, let the boat cool for 20 minutes before you replace the sources in the dry box.

Pre diffusion wafer cleaning

The substrate surface needs to be prepared before the diffusion. The following steps may be done while annealing the source wafers. Clean some additional test wafers which have no diffusion mask. Use these test wafers for characterizing your process.

1. Piranha Clean: Very slowly add 1 part of H₂O₂ to 5 parts of H₂SO₄. 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 H₂O₂. 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 (deionized water) cascade for 2 minutes in each stage.
3. Dip the wafers in 10:1 DI H₂O: HF for 20 seconds.
4. Rinse in DI cascade for 2 minutes in each stage.
5. 5. Blow-dry with N₂ 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 P₂O₅ 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. Open the N₂ valve at the back of the furnace till the flow meter reads 15. Let the furnace purge for 10 minutes.
2. 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. 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.
3. Place the boat at the mouth of the furnace for 5 minutes.
4. Slowly push the boat in over a period of 3 minutes till you reach the flat zone.
5. Allow 5 minutes for the wafers to heat up to the furnace temperature.
6. Leave the wafers in the furnace for the desired pre-deposition time.
7. Slowly pull the wafers out of the furnace over a span of 3 minutes.

8. Let the boat sit at the mouth of the furnace for 5 minutes.
9. Remove the boat from the furnace. Gently 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 the wafer in 10:1 DI H₂O:HF for 2 minutes. Your test wafers should bead up (why?) in about 1 minute and 45 seconds.
2. Rinse in DI H₂O for 2 minutes in each stage.
3. Blow dry with N₂ gas.