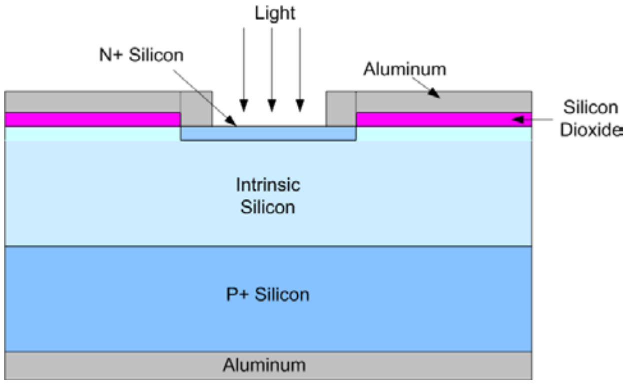
ECEn 555 – Optoelectronics Devices Lab

Week 2

"Photodiode Doping"

The first of the four optoelectronic devices that you will build and measure will be a silicon photodiode. A simple diagram of the photodiode structure you will build is shown below:



You will begin with an epitaxial silicon wafer – a wafer that started as a thick heavily doped p-type substrate, and then had a low-doped (intrinsic) layer grown on it. This intrinsic layer will become the active part of your detector where light is absorbed and converted to electrons and holes.

The main task for this first lab will be to dope a thin layer on the top of a silicon wafer to form your P-I-N (P-type – intrinsic – N-type) diode structure. This will involve the growth of a masking oxide, lithography and etching, and then the application of a dopant in spin-on-glass form.

Major Objectives

1. Determining growth conditions. Using the cleanroom website, or any other resources available, determine proper growth conditions for 5000 Angstroms of thermal oxide. Some suggestions: Oxide growth can take a while and 5000 Angstroms is a relatively thick layer. Choose growth conditions that are relatively fast (under an hour) that do not strain the furnaces (keep temperatures under 1100C). It's probably also a very good idea to use wet oxide growth. (Hint: If you decide to use 1100C and your projected growth time is longer than an hour, you have calculated wrong.)

2. Oxide Growth. Use four epitaxial wafers per group – two with a thinner higher doped layer, and two with a thicker lower doped layer. Dip the wafers in BHF to remove any native oxide. Rinse and dry the wafers well. Place two epitaxial wafers per group in the furnace for the 5000 Angstrom oxide growth.

3. Lithography preparation. While oxide is growing on your wafers, you have time to prepare for lithography. In this lab you will be using the Canon Aligner for your exposures and the Laurell Spinner to apply photoresist. Instructions for both the Aligner and Spinner are available on the cleanroom website. Using some scrap wafers, determine an optimal exposure and development time for AZ3030 resist. Be sure to use HMDS as an adhesion promoter when using AZ3030. For a lithography mask, use Mask#1 for photodetectors that you will be given at the beginning of class.

4. Etching Holes in Silicon. When the oxide growth is complete on your epitaxial wafers, spin photoresist on them and develop the Photoresist#1 pattern. Inspect your wafers under the microscope to make sure the pattern is fully developed. Use Buffered HF solution to now etch through the oxide and down to the silicon surface. Buffered HF etches at a rate of 1000 Angstroms per minute. Remember to be very careful whenever you use HF.

5. Photoresist Stripping. Remove the photoresist from your wafers using Acetone and Isopropanol. Dehydrate the surface at 120C for 10 minutes.

6. Dopant Application (SOG). After windows are etched into your oxide mask, you are ready for the application of your dopant source. Doping will be done using a solid source first applied as a spun on liquid. Specifically you will use spin-on-glass doped heavily with Phosphorous as your source. This liquid is applied like photoresist using the spinner, except you will spin for 10 seconds at 2000 rpm. Try it on a dummy wafer first to make sure you are applying the correct amount of liquid before spinning. Afterward, coat all four of your “processing wafers” with the spin-on-glass.

7. Spin-on-Glass Curing. The spin-on-glass applied in Objective 6 must now be cured in a vacuum oven to drive out solvents and provide some solidification. Place your wafers in the vacuum oven at 140C for 60 minutes to complete the solidification.

After the spin-on-glass cure, the wafers are ready for the predeposition and drive in diffusion steps. Because these steps are very long, all the wafers from the groups will be done together by the lab supervisors. The first step, the predep will be done at 1000C for 90 minutes. The spin-on-glass will then be etched off the wafer and a drive-in-diffusion done. The drive in will be done at 1050C for several hours in a dry oxygen environment.