

ECEn 452 – Semiconductor Devices Lab
Week 6: “Oxide Growth”
Objectives

Introduction

You have now worked with semiconductors and metals and are now ready to investigate the third very important element of semiconductor devices: dielectrics – and specifically silicon dioxide. Growing a high quality oxide will be very critical for the operation of the MOSFET circuit you will soon construct. In this lab you will grow and characterize the first oxide layer for your MOSFET. You will also grow an oxide layer that you will use as the foundation for the dielectric picture you will make in the next laboratory session.

Prelab Questions

1. What purpose(s) does an oxide layer serve when used in a MOSFET?
2. Oxide growth will consist of two steps, first growing a thin oxide layer using dry oxidation, and growing a second, thicker layer using wet oxidation. Using your textbook or other resources and using an oven temperature of 1100 °C, determine the time required for an oxide growth of 5200 Angstroms. Assume as well that you'll have 10 min of dry oxide growth before wet oxide growth.
 - How much oxide will grow during 30 min of dry oxidation?
 - How long will the wet oxidation process take to complete the 5200 Angstroms (recall that wet oxidation takes longer with an oxide already formed by the dry oxidation)?
 - What are the benefits of using both wet and dry oxidation as opposed to growing the entire oxide with only one or the other procedures?
3. Repeat your growth time calculations for 1000 Angstroms of oxide.

Objectives

1. Thin Oxide Growth:

Using a spare silicon wafer (one that will not be used for MOSFET fabrication but has the same crystal orientation) grow a 1000 Angstrom oxide using conditions calculated previously. (Before growing your oxide, strip any native oxide from your wafers by dipping them briefly in Buffered HF.)

Measure the thickness using the ellipsometer, nanospec, and color charts. How well does the thickness match your predictions? Note your measurements and adjust your targeted growth times for future thin oxide growths. (Note calculations may be very low depending upon gas flow in the oven. Adjust time calculation to compensate for potential errors here.)

2. Thick Oxide Growth:

Using 4 (100) wafers that you will use for MOSFET fabrication and 2 (111) wafers that you will use for color picture fabrication, grow a 5200 Angstrom oxide using conditions calculated previously. (Before growing your oxide, strip any native oxide from your wafers by dipping them briefly in Buffered HF.)

It is very important that the wafers used for color pictures have a very uniform oxide layer across their surface. To ensure this place these wafers at the very front of the oxidation tube (nearest the oxygen gas source.) These wafers should come out looking green if the oxide is really 5200 Angstroms thick. It is better to have the layer be a little thicker than this if you have to later correct this thickness.

Measure the thickness using the ellipsometer, nanospec, and color charts. How well does the thickness match your predictions? Note your measurements and adjust your targeted growth times for future thick oxide growths. (Note calculations may be very low depending upon gas flow in the oven. Adjust time calculation to compensate for potential errors here.)

3. Oxide for dielectric pictures:

If your 2 (111) wafers that you will be using for dielectric pictures in next week's lab are more than 5200 Angstroms thick (non green), etch them using Buffered HF until they are the green color you are looking for – assuming of course the oxide starts thicker than 5200 Angstroms. If your oxide is thinner than 5200 Angstroms, you have a bigger problem and will have to grow more oxide on the surface.

4. Oxide Thickness Measurements:

There are three standard procedures to determine oxide thickness in our cleanroom. The first, visually match the wafer's color to a chart located in the lab. This method is quick but less accurate. You'll notice that the colors on the chart are cyclic (i.e. blue repeats at 0.12, 0.31, and 0.49 microns) due to the periodic nature of light waves.

The second method is to use the ellipsometer. The ellipsometer uses light from a laser and interference from reflection at a surface, and by measuring the change in polarization of the reflected laser light very precisely measures the thickness of a transparent film. It is very precise, but has the same cyclic drawback enumerated above, thus it is imperative that an approximate oxide thickness is known before ellipsometer measurements are taken. The lab supervisor will instruct you on proper operation. The use of the ellipsometer is also outlined on the cleanroom website.

The third method is the nanospec. The nanospec measures the reflected spectrum from the oxide's surface by illuminating it with a range of wavelengths. This can be a very accurate method for measuring thin films if you know the refractive index of the film beforehand (which we do in the case of oxide). Have the lab supervisor show you how to use the nanospec – also outlined on the cleanroom website.

While you grow your oxide layers, practice measuring the thickness of several known oxide layers using all three measurement methods.

5. Measure the thickness of your oxide:

Use both the color chart and ellipsometer to determine the thicknesses of your grown oxide layers. Comment on how well the color chart, ellipsometer, and nanospec match up for both oxide thicknesses? If there are discrepancies, which do you think is the most accurate?