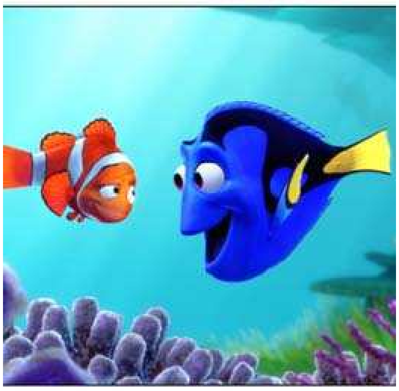
ECEn 452 – Semiconductor Devices Lab

Week 7: "Learning Photolithography Using Full Color Dielectric Pictures"

Objectives

Introduction

In Week 3 you learned about basic lithography and in Week 4 you used it to etch metal features onto a wafer. These activities used only a single lithography mask and required no alignment between one mask layer and another. Most real semiconductor devices require multiple lithography masks and accurate alignment for each one – including the MOSFET you will begin building in the next lab. In order to give you some practice doing alignments as well as to provide a fun laboratory experience, you will be fabricating a full color picture using a silicon dioxide layer. As you know, different thicknesses of silicon dioxide reflect different colors of light from a silicon surface. We will use this principle to form the basis colors for representing our picture. You may choose to make either the scene below from "Finding Nemo" or the Little Engine picture.



Both of these pictures require the use of three lithography masks – that translates to two alignments. The principle behind how the color is produced is explained in the background reading. Accurate alignment of the lithography plates to your substrate will be critical if you are to accurately represent a three color picture because the production of these colors depends on accurate light mixing at the pixel level.

Prelab Questions

1. When doing alignment between a lithography mask and a substrate, why is it important to first get the two aligned in rotation angle, θ, before trying to align in the x and y directions?
2. Why do the reflected colors from a silicon dioxide film make an imperfect basis set for the RGB color system?
3. What would a pixel look like (using the RGB dielectric film system) that was designed to appear very bright yellow?
4. What would your dielectric picture look like if your third lithography mask were misaligned by 20 microns compared to the first two layers?

Objectives

1. Green Silicon Dioxide Film:

In week 6 you should have produced a silicon dioxide film that looks green on two silicon substrates (5200 Angstroms on (111) oriented wafers). If your film is thicker than 5200 Angstroms, use a quick etch in Buffered HF to bring the film thickness down to the green color.

2. Lithography - Green Mask:

Apply AZ3330 photoresist to your wafers. Be sure to use HMDS as an adhesion promoter when using AZ3330 and to dehydrate bake your wafers! Expose the first lithography mask on the wafers – the “green mask”. Develop the pattern and inspect under the microscope to ensure that the resist is completely developed.

3. Etching Down to Blue:

Place the patterned wafers in BHF until the exposed oxide has been etched down to a deep blue color. Consult the color charts for the best blue. Remember that BHF etches at about 1000 Angstroms per second. Check the color in white light to make sure you have an accurate blue.

4. Lithography - Blue Mask:

Strip the resist from the previous mask using acetone followed by an isopropanol rinse. Place in the dehydration oven at 120C for 10 minutes to drive off any water on the surface of the wafer (very important). Apply AZ3330 photoresist to your wafers. Be sure to use HMDS as an adhesion promoter when using AZ3030. Now use the second lithography mask on the wafers – the “blue mask”. You will be required to align the alignment marks on the mask to the alignment marks on the wafer. The lab supervisor should be able to help in the setup of the microscopes on the aligner for doing this. After exposing, develop the pattern and inspect under the microscope to ensure that the resist is completely developed.

5. Etching Down to Red:

Place the patterned wafers in BHF until the exposed oxide has been etched down to a red color. Consult the color charts for the best red. Remember that BHF etches at about 1000 Angstroms per second. Check the color in white light to make sure you have an accurate blue.

6. Lithography - Red Mask:

Strip the resist from the previous mask using acetone followed by an isopropanol rinse. Place in the dehydration oven at 110C for 10 minutes to drive off any water on the surface of the wafer (very important). Apply **AZ2020** photoresist to your wafers. AZ2020 is a negative resist meaning the part of resist exposed to light will actually stick around after developing. This mask will expose the necessary red parts of your picture and the remaining resist will be carbonized to provide the black color we need for the picture. Look for processing information on AZ2020 on the cleanroom website to get the correct exposure and development times. Use the third lithography mask on the wafers – the "Red mask". You will be required to align the alignment marks on the mask to the alignment marks on the wafer. The lab supervisor should be able to help in the setup of the microscopes on the aligner for doing this. After exposing, develop the pattern and inspect under the microscope to ensure that the resist is completely developed.

7. Blackening the Resist:

Once the final resist pattern is complete you will blacken it on a hot plate at 400C. Be very careful when the hotplate is this hot. The resist should start turning black very quickly and after five minutes should be a very dark color. Carefully remove the wafer from the plate. The process is complete, and if all went correctly you should see a very satisfying color picture.

The following pages provide guidance on the alignment marks you will be using for the three masks: