ECEn 555 – Optoelectronics Devices Lab

Week 11

"Laser Diodes – Metal Contacts, Etching, Thinning"

In this lab you will begin the construction of laser diodes in earnest. This will consist of first depositing gold contact stripes on your laser and etching semiconductor layers to provide current confinement. You will then thin down the material to a thickness that can be cleaved effectively to produce laser diodes. You will be given a piece of real laser material along with a "dummy" InP piece that you will use in conjunction to practice your fabrication.

The laser material you are using consists of the following epitaxial layers grown on an InP substrate. The material was grown specifically for us using an MOCVD machine and donated by Luminent a company based in Chatsworth, CA. Here are the specific layers and their thicknesses:

Number	Layer	Thickness	Doping
1	InGaAs	~0.1um	p++
2	InP	~2.2um	p-type(1E18)
3	MQW-InGaAsP(1.3um)		
4	InP		n-type
5	InP n-type substrate		

Layer 1 is grown specifically to make a good metal to semiconductor contact because of its high dopant concentration. Layer 2 is grown for optical confinement. Layer 3 consists of several quantum wells that provide the actual laser emission. Layer 4 is for optical confinement and the epitaxial structure is grown on an n-type substrate.

Major Objectives

1. Patterning Contact Stripes. Mount your laser and InP pieces to a single silicon wafer using the procedures you have learned in previous labs. Spin AZ3330 photoresist onto your pieces and prepare them for lithography. Use the glass laser stripe mask and simply place it on top of the wafer pieces. Align the mask so that the stripes are parallel to the long side of your pieces, then expose them to UV light. This can be done in the Canon aligner by simply putting your silicon wafer and stripe mask on top of a blank mask inside the aligner. Develop the stripe pattern and inspect in a microscope to make sure development is complete.

2. Au/Zn Metallization. Descum your pieces in the LFE using oxygen plasma for 20 seconds. Do a short dip in Buffered HF and then load your wafer into the thermal evaporator. Place a small amount of Au/Zn alloy into an evaporator boat along with a chrome coated tungsten rod. Pump down and evaporate first 15nm of chrome and then as much gold as you can on the sample.

3. Lift-off and anneal. Soak your sample in Acetone to remove the photoresist and lift-off the unwanted Au/Zn. Also remove your laser and InP pieces from the silicon wafer. Use a hotplate at 350C to anneal the samples for 5 minutes.

4. Etching for Electrical Confinement. Remount your samples using photoresist to a piece of silicon approximately 1 inch by 1 inch square. This will be used simply for handling when you place your samples in etching solution later in this step.
   (a) In this step, you will remove the top InGaAs layer of the laser structure not covered in gold. In a glass beaker mix up the following solution: (H_3PO_4:H_2O_2:H_2O 3:1:50). To remind any engineers who have forgotten their chemistry, this means 3 parts Phosphoric Acid, 1 Part Hydrogen Peroxide, and 50 parts water. A reasonable combination might be 9 mL of Phosphouric, 3 mL of Hydrogen Peroxide, and 150 mL of water. Mix the solution very well. Place your samples in the solution for 90 seconds stirring continuously. Remove and rinse in D.I. Water.
   (b) In this step, you will remove the InP layer under the InGaAs layer that was not covered in gold. In a glass beaker mix up the following solution: (HCl:H_2O 3:1). To remind any engineers who have forgotten their chemistry, this means 3 parts Hydrochloric Acid, 1 part water. A reasonable combination might be 150 mL of Hydrochloric and 50 mL of water. Mix the solution very well. Place your samples in the solution for 10 seconds stirring continuously. On your real laser sample, you should see bubbles produced on its surface. This is a sign that you have removed the InP layer you are intending to remove. Remove and rinse in D.I. Water.

   If you did not see bubbles during step (b) on your laser sample, this is a sign that you didn't remove all of the InGaAs during step (a). Go back and reattempt etching the InGaAs and then the InP. Once you are satisfied you etched through the correct layers, remove your chips from their silicon mounting pieces using acetone.

5. Wafer Thinning – Mounting chip. Last week in practicing for this lab, you mounted your InP samples directly to the stainless steel lapping fixture using crystal wax. For your laser sample and InP this week, first mount them to a 1 inch x 1 inch square piece of silicon with crystal wax, then mount the silicon piece with crystal wax to the lapping fixture.

6. Wafer Thinning – Lapping. Use the lapping paper and micrometer that you used last week to thin down the laser and InP pieces to 150 microns.

7. Wafer Thinning – Removal. Once the InP chip is at the target thickness you now have to remove it from the lapping fixture. Again heat up the top part of the fixture until the wax melts. Push the silicon piece off the stainless steel fixture, but leave the laser and InP samples attached to the silicon – you will finish the processing of your lasers and begin testing next week.