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ELEC 4705 - Quiz 4

Thurs. Nov. 30th 2017

Name:

Student Number:

1. Figure 1 shows a device covered in photoresist is being exposed to UV radiation beneath a mask for the purpose of forming channels for electrical contacts.

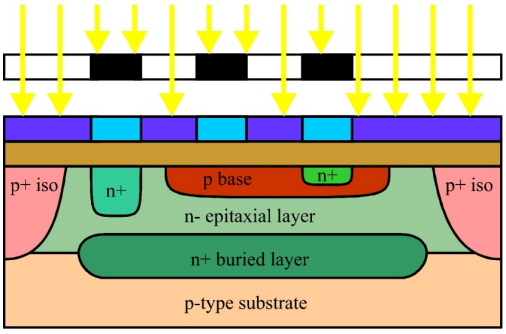

Figure 1: Mid-Device Fabrication (Note: The arrows represent UV light)

(a) (1 point) What device is being made?
The device being made is a BJT.

(b) (3 points) Why would photoresist be used at this stage? What type of photoresist must be used for this example and why?
The photoresist is used to create a sacrificial layer that will be washed away easily after the etching or doping stage. This must be negative photoresist because the negative photoresist will stay after being exposed to the UV light.

(c) (4 points) Describe the different techniques that could be used to form the channels.

The options for forming the channels are either dry etching where an ion beam of a chemically inert material is used to eject atoms from the surface, or wet etching, where a chemical is used to react and remove the atoms at the surface

(d) (3 points) If instead, the structure seen in figure 2 was to be made, how would this be accomplished? Describe the mechanism that allows for this.

Figure 2: Metallic diving board structure

This would be done using anisotropic etching. Anisotropic etching is unique because the etchant doesn't etch at equal rates in all directions, and etches some directions of the crystal structure faster than others and so for example to create this an anisotropic etchant that etched faster sideways than down would be used to create the channel underneath.

2. Lasers

   (a) (4 points) What are the crucial components to achieve lasing with gain? How is this accomplished differently in a solid state lasers as opposed to a gas laser?

   The crucial components of a laser are the gain medium and the optical feedback which is typically achieved with mirrors, ideally one being 100% reflective and the other being 95% reflective. In a gas laser, the gain medium is the gas itself with significant population inversion achieved either with electrical pumping or optical pumping. In a solid state laser, this is instead accomplished with heterojunctions where the difference in index of refraction causes reflection about the gain medium that has population inversion achieved electrically.

   (b) (3 points) What three effects are typically examined when constructing more advanced laser models?

   Modes of the cavities, electron transport and photon generation, or thermal effects

3. Nanotechnology

   (a) (3 points) What is unique about a quantum dot that allows for its very narrow luminescence spectrum? How can this be achieved and tuned?

   The density of states of a quantum dot are extremely narrow and thus allow for nearly discrete photon emission. This can be achieved with nanocrystals and they can be tuned by controlling their size.

(b) Select two of the following three devices: AFM, SEM, and STM.

i. (4 points) What do the two acronyms stand for, what classical device are they replacing, and why were they needed?

All - Used as nanomicroscopes. They are necessary because optical microscopes cannot achieve the resolutions they do.

AFM - Atomic force microscopy

SEM - Scanning Electron Microscope

STM - Scanning Tunnelling Microscope

ii. (3 points) Describe the operation of only one of the two named in the previous question.

AFM - A nano-cantilever is "dragged" across a surface while moving up and down at a set frequency. a laser reflects off the cantilever and onto a photodetector, which records the position of the cantilever, the surface affects the frequency and this effect on the frequency is read as a measure of the surface height.

SEM - An electron beam is fired at a metallized surface and the electrons ejected, reflect and photons created from this provide information on the composition and surface being analyzed.

STM - A nanotip with a voltage applied between it and the surface being analyzed is moved across a surface. the current flow (due to tunneling from the tip into the surface) is affected by the distance to the surface (as well as material etc.) and this current flow is read to

create a depth map of the surface.

(c) (2 points) Give an example of a use for a carbon nanotube discussed in the lectures.
A FET, Field emission source, nanotube gear