Examination Feedback for EEE337 – Semiconductor Electronics
Spring Semester 2013-14

Feedback for EEE337 Session: 2013-2014

Feedback: Please write simple statements about how well students addressed the exam paper in general and each individual question in particular including common problems/mistakes and areas of concern in the boxes provided below. Increase row height if necessary.

General Comments:

The performance is generally poor. The attendance in lecture is not great while most students have not made use of the tutorial sessions to try to understand the lecture and tutorial materials provided. This appears to correlate to the poor performance.
The most common mistakes tend to be related to inconsistent units in calculations and very brief answers that are ambiguous.

Question 1:

In part (a) you should know that light intensity decays exponentially with distance. To absorb 90%, the remaining intensity must be 10%. Some of you have made an error here. Nearly all of you are able to provide the reasons why Si is used as solar cell.
Part (b) specifically asks about the effects of doping in each layer of a Si pin. You should therefore discussed that high doping is required in p and n to ensure low series resistance but the high doping also reduces the minority carrier lifetime. The doping in the i-layer should be low so that a thick i-layer can be inserted to ensure high quantum efficiency. Only a few of you managed to discuss these points.
Most of you did well in part (c).
In part (d) a number of students have not described the role of the tunnel junctions to ensure current flows through the solar cell. A number of students have also included wrong combinations of material chosen for the triple junction.

Question 2:

Nearly all students who attempted this question manage to calculate the gain in part (a)(i). Since an optimized AR coating is included the reflection can be assumed zero.
$I_{ph} = \frac{\eta \lambda P_{opt}}{1.24} = \frac{0.9 \times 0.85 \times 5 \times 10^{-9}}{1.24} = 3.1 \times 10^{-9} A$. Note that the unit for λ in this formulae is in μm. A number of students made an error in calculating this photocurrent.
Most students answered part (b) correctly.
In part (c), you identified that the gain-bandwidth product is too small in current commercial APDs. However your answers are typically short without discussing why thinner APDs are difficult to manufacture. For 100Gb/s very high bandwidth is needed, so I was surprised that only few students have discussed the need to use devices with small transit time and very low RC time constant. The waveguide PIN is the choice and InGaAs is the preferred material as it has high absorption efficiency and high saturation velocity.

Question 3:

In part(a), you should have discussed the fact that a homojunction has poor carrier confinement, high threshold current and poor optical confinement. Most of you only mention high threshold current as the reason. The use of heterojunction clearly improves the carrier confinement, provide lower threshold and much better optical confinement too.
Part(b): In a quantum well laser, clearly at a given energy, the carrier concentration is much higher than bulk laser. Population inversion can be easily achieved with low injection current. In addition the active region is very thin. These produce very low threshold current. To achieve multi-wavelength, the quantum well material and quantum well width can easily be modified. It is also possible to use high injection to achieve lasing from higher energy levels. So when combined with appropriate cavity a wider range of emission wavelengths can be achieved.

In part (c) the question clearly states that InSb is a narrow bandgap material. You should therefore note that the main issue is related to bandgap and temperature. Most of you have identified Auger recombination as the reason that InSb laser is not an efficient infrared laser. However you have note discussed the fact that there is no lattice match wide bandgap material available to InSb laser.
Most students were able to describe quantum cascade lasers as the choice for 3-5μm wavelengths.

Question 4:

Most of you did well in part (a).
Part (b), some of you have errors in your calculations.
For part (c) only some of you managed to provide satisfactory discussion of the limitation of IMPATT. You should note that the thickness required for THz is very thin. Therefore the manufacturing is difficult and band to band tunneling current is a major issue.
Most of you did well in part(d).