Feedback for EEE348 Session: 2013-2014

Question 1:

This question was generally well-attempted. In part a some people did not identify where the substrate would be connected (or showed it connected to ground). In part b, a number of people ended up with a non-inverting expression (correct in other respects)! In part c there were two possible answers: M1=4, M2=4, M3=2, M4=2, M5=2 OR M1=3, M2=3, M3=1.5, M4=3, M5=3. Nobody who chose the 2nd answer (the majority) got the right width for M3. If M4 or M5 is on, each contributes 1/3 and so M3 must contribute 2/3 so the path = 1. Hence the width of M3 = 1.5. In part d, I was looking for some clear points: you might want to connect the substrate to the source, the formation of wells forces transistors to share substrate connections, the substrate must be at least as negative as the most negative source (to avoid the source/body junction forward biasing). For a digital circuit this is going to be ground. In part e) some people did not read the question properly and removed transistors M4 and M5 rather than, as the question said, 'The wire connecting the drains of M4 and M5 is removed'.

Question 2:

This question was less well-answered. People seemed unable to give a reasoned list for part a.ii). The descriptions for what and why RTL is, b.i), were generally poor. RTL is where date is transferred from register to register with intervening logic 'processing' the information. Data clocked into a register will be data clocked into other registers on the previous clock edge, which has had one whole clock cycle to pass through the intervening logic. This ties in with the clock tree, which is designed to ensure that each FF is clocked at the same instant. By doing it this way, you minimize the risk of race hazards (which may be temp/voltage/process) dependent from disrupting the behavior of the design.

Question 3:

Reasonably well-answered. In part a(i), several students confused V_{GS} and V_{DS} so that they computed an incorrect value for the overdrive voltage. Most students had a good stab at the small-signal diagram in part a(ii), but in part b marks were lost for not showing the inversion of the output waveform with respect to the input. Part c(i) was answered less well, and the importance of maximizing a current mirror's output resistance was not generally well explained in part c(ii). The crucial point was that the current mirror sinks an almost-constant current over a large range of output voltages provided its output impedance is high.

Question 4:

Parts a and b were comfortable ground for most students. Identifying the virtual ground node (at the source of M3/4) and the Q-point voltage at this node confused students: because the input was balanced the Q-point at the virtual ground was simply $V_{GS} = V_{OV}+V_{TO}$.

Part d was a struggle in general, and indeed this was the most difficult question in the analogue part of the exam. The answer required deriving an expression for the Miller capacitance, then substituting this into the expression for the cutoff frequency and rearranging.

Question 5:

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 6:

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 7:

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 8:

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).