

2014 Final Exam

1. An Si n-channel MESFET has a gate length of $1.0\ \mu\text{m}$, a total channel height of $0.3\ \mu\text{m}$, a channel width of $100\ \mu\text{m}$, and a channel n-type doping of $1 \times 10^{17}\ \text{cm}^{-3}$.
 - (a) Name a chemical element that could be used for the n-type dopant. Explain your choice.
 - (b) The metal gate of the MESFET forms a barrier height of $1.0\ \text{eV}$ at the metal-semiconductor boundary. What is the pinch-off voltage of the MESFET?
 - (c) Assume that the MESFET is operated in the linear regime (also called ohmic regime). What is the resistance of the channel at zero gate voltage?
 - (d) The gate voltage of now increased to $-10\ \text{V}$ (reverse direction). What is the resistance of the channel at this gate voltage?

2. A GaN light-emitting diode (LED) has an optical output power of $100\ \text{mW}$ when injected with an electrical current of $100\ \text{mA}$.
 - (a) What is the emission wavelength of the LED?
 - (b) What is the number of photons emitted by the LED per second (i.e. the photon flux)?
 - (c) What is the number of electrons injected into the LED per second (i.e. the electron flux)?
 - (d) What is the LED's quantum efficiency?
 - (e) Explain two ways to improve the power efficiency of an LED.

3. A Si pnp bipolar junction transistor has a current amplification of 50 in the common-emitter configuration. The transistor has a base width of $1.5\ \mu\text{m}$ and a base doping of $5 \times 10^{17}\ \text{cm}^{-3}$.
 - (a) What is the current amplification in the common-base configuration?
 - (b) What is the base transport factor of the transistor? (Hint: Note that $L_p = (D_p \tau)^{1/2}$)
 - (c) What is the emitter efficiency of the transistor?
 - (d) Determine the emitter doping of the transistor. (Hint: Note that $L_n = (D_n \tau)^{1/2}$)

4. Consider an n-channel Si MOSFET that uses SiO_2 for the gate oxide layer.
 - (a) Write down the formula for the transconductance (i.e. amplification) of the MOSFET operating in the saturation regime.
 - (b) What is the numerical value of the transconductance when V_{GS} is equal to the threshold voltage V_{th} ?
 - (c) List 3 quantities that can be modified (e.g. increased or decreased) in order to increase the transconductance.
 - (d) Describe the method or means by which each one of these 3 quantities can be modified.