OPEN UNIVERSITY OF TANZANIA
FACULTY OF SCIENCE, TECHNOLOGY AND ENVIRONMENTAL STUDIES

OPH 443: MICROELECTRONICS

INTRUCTIONS:

- Write your **full name**, postal address and **registration number**
- Remember to submit Assignment 1 before **12th December 2008** and Assignment 2 before**27th March 2009**.

ASSIGNMENT I – 2009

Caution: Define all symbols used.

1. (a) What is dry etching?
   (b) The following circuit is to be integrated.

Assuming an n-substrate base, draw a cross-section of the IC for the monolithic diode.

2. It is required to design an integrated resistor starting with a p-substrate.
   (a) Sketch a well labeled cross section structure.
   (b) What are the parameters to be considered in defining the magnitude of the resistor?

3. (a) What is sheet resistance?
   (b) A base diffused integrated resistor with sheet resistance of 200Ω/ has the dimensions of 25μm wide and 250μm long. Assuming no empirical corrections, what is the resistance represented.

4. It is required to design a MOS capacitor starting with a p-substrate.
   (a) Sketch the cross section structure.
   (c) A thin film capacitor has a capacitance of 0.5 $pF/(\mu m)^2$. The thickness of silicon dioxide is 800Angstrom. Calculate the relative dielectric constant of the SiO_2 layer.

5. A bar of N type silicon, 2 cm long, cross sectional area 1 cm^2 and donor concentration 10^{15} cm^{-3} has ohmic contacts at the ends. If the resistance is 10 Ω, find the electron mobility.

6. Given the carrier mobility μ = 2000 $cm^2V^{-1}s^{-1}$ at 0°C, calculate the carrier diffusion constant at the same temperature.

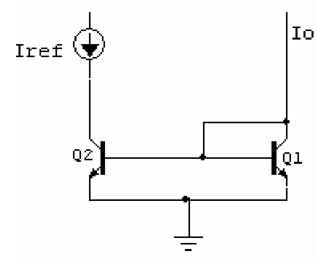
7.(a) Excess carriers are injected on one surface of a thin slice of N-Type Si with length W and are extracted at the opposite surface where $p_n(W) = p_{n0}$. There is no electric field in the region $0 < x < W$. Derive the expression for the current densities at the two surfaces.

(b) If the carrier lifetime is 50 μs and W = 0.1 mm, calculate the portion of the injected current which reaches the opposite surface by diffusion, given the diffusion constant D = 50 cm^2s^{-1}.

8. A rectangular block of homogeneously doped N –type Si, Nd = 10^{15} cm^{-3}, Na = 0, is 2.0 cm long and has a cross sectional area 0.2 cm^2. A voltage is applied across the faces and a current of 400 mA flows. Calculate the electron and hole mobilities.

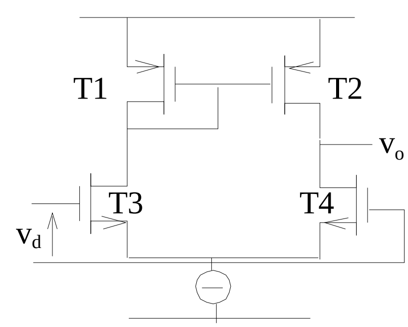
ASSIGNMENT II – 2009

1. The circuit shown below is designed to generate current sinks I_o. If both transistors are identical:
   - (a) Derive function I_o in terms of I_{ref}.
   - (b) Transistor Q1 behaves as a diode. Why is a transistor used instead of a diode?
   - (c) What qualitative improvement will one achieve if FET transistors were used instead? Why?



2. Consider the properties of a standard operational amplifier, say IC Operational Amplifier 741. Using simple circuit diagrams show how:
   - (a) Level shifting is used.
   - (b) Current sources are used.
   - (c) High input resistance is raised.

3. (a) Active loads are widely used in integrated circuit amplifiers. Why?
   (b) A differential amplifier circuit shown below is used as an input circuit of a multistage amplifier. If the transconductances, r_o and the drain resistances, g_m are identical for all transistors, show that the differential gain A_d=$g_m r_o/2$



4. A simple output stage of an amplifier uses a single transistor emitter follower stage.
   - (a) What is the basic advantage of this configuration to the other types (i.e.CB, CE)?
   - (b) Calculate the power output efficiency of this amplifier.
   - (c) To get higher efficiencies what circuit arrangement can you use and why?

5. An ideal pn junction has $N_D = 10^{18}$ cm^{-3}, $N_A = 10^{16}$ cm^{-3}, $\tau_p = \tau_n = 10^{-6}$ s and a device area of 1.2×10^{-5} cm^2. (a) Calculate the theoretical saturation current at 300 K, and (b) Calculate the forward and reverse currents at ± 0.7 V.

6. A varactor diode has a capacitance of 5 pF when the reverse bias voltage applied across it is 4 V. Determine the diode capacitance if the bias voltage is increased to 6 V.

7. An n-channel JFET has the following parameters: $N_A = 10^{17}$ cm^{-3}, $N_D = 10^{14}$ cm^{-3}, a = 1.0 μm, L = 20 μm, h = 100 μm and μ_n = 1000 cm^2/(V.s). Calculate V_p, V_{diff}, G_0, g_{m0} and $g_{m(sat)}$ for this device. For g_{m0} use the values $V_G = V_{p/2}$ and $V_D = -V_{p/4}$. For $g_{m(sat)}$, use the same value for V_G.

8. For an n-channel silicon JFET with $N_A = 10^{19}$ cm^{-3}, $N_D = 10^{16}$ cm^{-3}, a = 1.0 μm, L = 20 μm, Z = 100 μm and μ_n = 1350 cm^2/(V.s), find the pinch-off voltage, the corresponding current at pinch off with V_G = 0, and the cut – off frequency. Take ε = 16 for Si.

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