編號： 205 **國立成功大學 107 學年度碩士班招生考試試題**

系　　所：電機資訊學院-微電、奈米聯招

考試科目：固態電子元件　　考試日期：0205，節次：2

※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. An n-type semiconductor is under thermal equilibrium and has an electron distribution of $n(x) = n_0 \exp(-x/L_n)$, where L is its length, n_0 and L_n are constant, and $0 \le x \le L$.
   (a) Derive and sketch its potential distribution $V(x)$ with the potential of Fermi level at $x = 0$ as the voltage reference. (10%)
   (b) Find the ratio of drift currents at $x = 0$ and $x = L$. (5%)

2. Draw the possible energy band diagram of a Si pn junction under light irradiation ($hv > E_g$) in open-circuit condition. What could be the maximum value of the open-circuit voltage? Why? (15%)

3. Explain the "Schottky effect" and "Fermi level pining" which might occur in metal-semiconductor (MS) contacts, respectively. (10%)

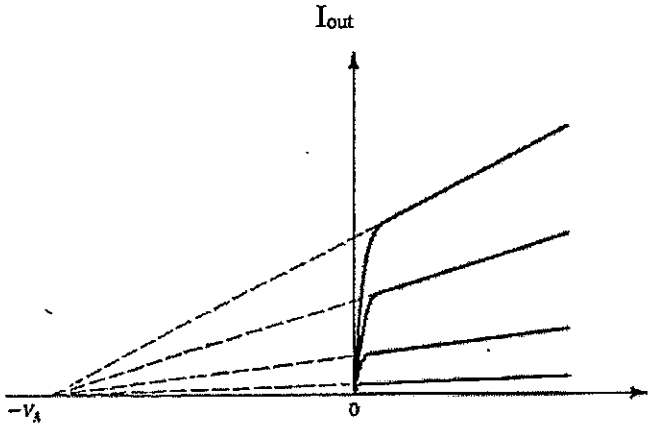
4. Please use energy band diagram to explain why bipolar junction transistors (BJTs) could serve as a current amplifier. (10%)

5. Consider a planar N-channel MOSFET ~~with a metal~~ gate with work function Φ_{metal} =4.61V fabricated on P-type ~~silicon~~ wafer with uniform doping ~~concentration~~ $N_A=10^{17}cm^{-3}$. The SiO_2 gate dielectric thickness (T_{ox}) is 1.5nm. The MOS transistor is ~~10μm wide~~ (W) and 100nm long (L). The threshold voltage (V_t) at room temperature is 0.4V.
   (a) How would V_t change if Φ_{metal} is increased to 4.81V (5%)?
      A. Increases to 0.6V
      B. Does not change
      C. Decreases to 0.2V
      D. Decreases by an amount that is smaller than 0.2V
   (b) Which of the following statements is TRUE if T_{ox} is doubled (3.0nm) (5%)?
      A. The body effect factor γ decreases
      B. V_t increases
      C. The gate capacitance C_{ox} increases
      D. The flatband voltage V_{fb} decreases
   (c) Which of the following statements is TRUE if we increase the doping concentration N_A to $10^{18}cm^{-3}$ (5%)?
      A. V_t decreases
      B. Punch-through will be larger (more severe)
      C. Body effect factor γ decreases
      D. Mobility μ will be smaller (degraded)

(d) Which of the following statements is TRUE if we replace the gate dielectric with HfON with relative dielectric constant ε_r=16 with twice the thickness of the original SiO_2 (5%)?

A. Punch-through will be larger (more severe)
B. The gate leakage current will be larger
C. The gate capacitance C_{ox} increases
D. Mobility μ will be larger (better)

6. Consider the following transistor output characteristics



(a) If this set of curves were MOSFET drain current (i_D) versus drain voltage (v_{DS}) characteristics for different gate biases (v_{GS}), what is the ***name*** of the physical phenomenon responsible for the non-zero slope at high v_{DS} (5%)?
(b) Following (a), ***explain*** the physical phenomenon that results in such non-zero slope (5%).
(c) If the above set of curves were BJT collector current (i_C) versus collector voltage (v_{CE}) characteristics for different base current (i_B), what is the ***name*** of the physical phenomenon responsible for the non-zero slope at high V_{ds} (5%)?
(d) Following (c), ***explain*** the physical phenomenon that results in such non-zero slope (5%).
(e) If the curves intersect at a negative voltage $-V_A$, express the output resistance (r_o) as function of V_A. Consider a BJT with collector current i_{C0} near the edge of saturation (5%).

7. List three possible ways to reduce short channel effects (which causes drain-induced barrier lowering, sub-threshold slope degradation, and V_t roll-off) in enhancement-mode MOSFETs (5%).