國立成功大學
110學年度碩士班招生考試試題

編　號：198

系　所：電機資訊學院-微電、奈米聯招

科　目：固態電子元件

日　期：0202

節　次：第 2 節

備　註：可使用計算機

※ 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. (a) Please plot the simplified energy band diagram of a forward-biased p^+n junction. What important information can you get from this diagram? (10%)

   (b) Describe briefly the physical meaning of effective mass of carriers in semiconductors. (5%)

   (c) Explain why the effective mass of electron m_n in conduction band of Silicon is less than m_0 and the hole effective mass m_p is larger than m_n, where m_0 is the mass of free electron. (5%)

2. (a) Sketch and compare the typical C-V characteristics of an pn junction and an MOS structure. Describe briefly their differences in frequency dependence, why? (10%)

   (b) Explain briefly why the subthreshold I-V characteristics of MOSFET follows 60 mV rule at room temperature. (5%)

3. Briefly describe

   (a) What are the purposes of CMOS scaling? (5%)

   (b) What problem(s) might occur with lowering the threshold voltage of MOSFETs? Please briefly describe the possible solutions. (10%)

4. Regarding bulk carrier mobility of in silicon,

   (a) At low temperatures, mobility increases with temperature ($\mu \propto T^{3/2}$) because it is dominated by the ________________ scattering mechanism (5%).

   (b) At high temperatures, mobility decreases with temperature ($\mu \propto T^{-3/2}$) because it is dominated by the ________________ scattering mechanism (5%).

5. Regarding Early Effect in the bipolar junction transistor,

   (a) What is the physical reason/mechanism of Early Effect, which causes finite output resistance (5%)?

   (b) Which of the following measures is often used to mitigate (reduce) Early Effect (single choice, 5%)?

      A. Reduction of base doping concentration

      B. Reduction of collector doping concentration

      C. Reduction of emitter doping concentration

      D. Reduction of base width

      E. Reduction of emitter width

6. For a planar MOSFET with 1 nm SiO_2 as gate dielectric,
   (a) If we replace the 1 nm SiO_2 with 2 nm HfSiOx (dielectric constant k=19.5). How does C_{ox} change? Neglect the impacts of polysilicon gate depletion and quantum-mechanical charge thickness (4%).
      A. Increase by a factor of 2.5
      B. Increase by a factor of 5
      C. Decrease by a factor of 2.5
      D. Decrease by a factor of 5
      E. Does not change
   (b) The presence of quantum mechanical effects causes C_{ox} to _______ (increase / decrease) (4%).
   (c) If we reduce SiO_2 to only 0.5 nm, what adverse (bad) effects will occur to the MOSFET (4%)?

7. Regarding a short channel effects (such as DIBL, SS degradation, V_{th} roll-off) in MOSFET device
   (a) If we increase the body doping concentration, short channel effects _______ (increase/decrease) (3%)
   (b) If we increase the junction depth (X_j), short channel effects _______ (increase/decrease) (3%)
   (c) If we increase the oxide thickness (T_{ox}), short channel effects _______ (increase/decrease) (3%)

   * Note: "increase" means becoming more serious; "decrease" means becoming less significant

8. Velocity saturation occurs in MOSFETs when the gate length is very _________ (short / long) (4%)

9. For a long-channel N-MOSFET device, which of the following change does **NOT** cause V_{th} to increase (single-choice, 5%)?
   A. Increase the gate workfunction
   B. Increase the gate oxide thickness
   C. Increase the body doping concentration
   D. Decrease the gate length
   E. Increase the source-to-body voltage (V_{sb})