

國立成功大學
111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：0219

節 次：第 2 節

備 註：可使用計算機

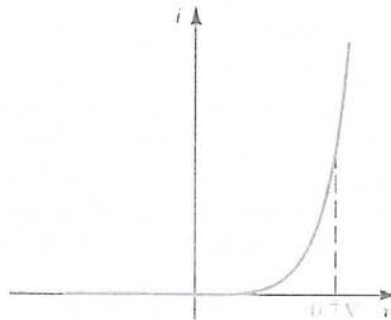
※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. If the doping concentration of the p- and n-type semiconductors of a pn junction are N_A and N_D , respectively, and the dielectric constant of the semiconductor is ϵ_s .
 - (a) Find the built-in voltage V_{bi} of the pn junction. Why there is a V_{bi} ? (5%)
 - (b) Find the relationship between x_n and V_{dn} , where x_n is the width of the depletion region on the n-type semiconductor side, V_{dn} is the voltage drop across it. (5%)
 - (c) If the pn junction is under a forward bias of $1.1V_{bi}$, what could be the voltage drop across the whole depletion region? Briefly describe the reason. (5%)
2. (a) Plot the energy band diagram of an npn bipolar junction transistor operating in the forward active region. (5%)
 - (b) Describe briefly why Fermi level pinning might occur in the MS contacts. (5%)
 - (c) Explain the electric field shielding effect of the MOS structure using the potential distribution of the gate bias. (5%)
3. (a) Briefly describe the effects of CMOS scaling on the threshold voltage and the subthreshold swing of MOSFETs and its causes. (10%)
 - (b) Plot a typical semi-logarithmic transfer curve of MOSFET and mark the subthreshold, linear, and saturation regions. (5%)
 - (c) Explain the role played by the pinch-off region on the output I-V characteristics of MOSFET. (5%)
4. When we apply the following changes to an N-type silicon MOSFET transistor with high-k gate dielectric and a metal gate electrode, what would be the impact on its threshold voltage (V_{th})? (12%)

Applied Change	V_{th} increase (↑) or V_{th} decrease (↓)
Increase the gate metal work function	
Increase the doping concentration in the silicon body	
Increase the gate dielectric thickness	
Use a gate dielectric material with a higher dielectric constant	
Increase the operating (measurement) temperature	
Add negative charge at the silicon/high-K interface	

5. Which of the following is **FALSE** when $V_{sb} > 0$ in a n-channel MOSFET (5%)
 - A. Body effect occurs and the depletion region across the source-to-body junction widens
 - B. The source-to-body junction is reverse-biased
 - C. The threshold voltage of the MOSFET decreases when body effect occurs
 - D. Body effect may occur when the MOSFET source is not tied to ground in a CMOS technology
 - E. Body effect is possible for both n-channel and p-channel MOSFETs

6. Which of the following is NOT a scattering mechanism that reduces the electron mobility in a MOSFET transistor (5%) ?
- A. Surface roughness scattering
 - B. Phonon (lattice) scattering
 - C. Coulombic scattering
 - D. Photon scattering
7. List ONE scattering mechanism in a semiconductor material that causes electron/hole mobility reduction which becomes more prominent (larger) at higher temperature, and occurs in the bulk (not at the surface) of the MOSFET transistor (5%)
8. Regarding the gate-to-source and gate-to-drain overlap regions in a MOSFET transistor,
- (a) What is the advantage of maintaining an overlap? (5%)
 - (b) List one disadvantage when the overlap length is too long. (5%)
9. Following is a typical i - v characteristics of a PN junction diode, measured in a dark environment. If we shine light on the diode ($h\nu > E_g$), it becomes a photodetector or a solar cell. Sketch the new i - v characteristics in the presence of light illumination (5%).



10. Regarding Early Effect in NPN bipolar junction transistors (BJT),
- (a) Please sketch a typical i_C - v_{CE} curve in the presence of Early Effect. (4%)
 - (b) What is the physical cause of Early Effect? (4%)