

國立成功大學

112學年度碩士班招生考試試題

編 號： 200

系 所： 電機資訊學院-微電、奈米聯招

科 目： 固態電子元件

日 期： 0206

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) If the hole concentration distribution $p_n(x)$ of the n-type semiconductor of a pn junction is shown in Fig. 1, find the hole diffusion current $J_p(x)$ and hole transit time, assuming the hole diffusion coefficient is D_p . (10%)
- (b) Why are pn junctions called minority carrier devices? Why does its forward I-V characteristics have the relationship of $I \propto \exp(\frac{qV}{kT})$? (10%)

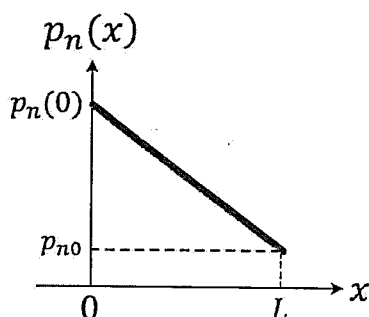


Fig. 1

- 2.(a) Draw the energy band diagram of the MOS structure under strong inversion and use it to briefly describe the necessary conditions for strong inversion of the semiconductor surface. (10%)
- (b) Briefly describe the challenges of scaling the threshold voltage V_{th} and subthreshold swing SS of MOSFETs. (10%)
3. Why is the room temperature subthreshold swing (SS) limited to 60 mV/decade? How does the short channel effect affect SS? Why? (10%)
4. Approximately what is the saturation velocity of electrons in single-crystalline silicon? (5%)
- 10^5 cm/s
 - 10^6 cm/s
 - 10^7 cm/s
 - 10^8 cm/s
 - 10^9 cm/s

5. For silicon PN junction diodes:

(a) Consider a reverse biased PN junction with $N_A=10^{18} \text{ cm}^{-3}$ and $N_D=10^{17} \text{ cm}^{-3}$. How would the depletion region width change (increase (\uparrow), decrease (\downarrow), or no change ($-$)) if we do the following (9%):

Action	Change in depletion region width
Increase the acceptor doping concentration (N_A)	
Increase the donor doping concentration (N_D)	
Increase the reverse bias voltage ($ V_R $)	

(b) Avalanche breakdown in the PN junction diode originates from which of the following phenomenon? (5%)

- A. Band-to-band tunneling
- B. Impact ionization
- C. Thermal runaway
- D. Velocity saturation
- E. Carrier diffusion

6. For MOSFETs:

- (a) What happens to the MOSFET SS at very low temperature, say -196°C or 77K ? (5%)
- (b) When making metal contact to the source and drain, why do we always need to ensure sufficient doping in the semiconductor material (e.g. more than 10^{20} cm^{-3} for silicon) at the contact? (5%)
- (c) List two physical phenomena that reduces the output resistance of MOS transistors when channel length is reduced. (10%)
- (d) Typically, what voltage is the pMOSFET body connected to in a CMOS integrated circuit, and why? (6%)

7. For bipolar junction transistors (BJT's), why is heavy emitter doping preferred? (5%)