RF and Microwave Solid State Devices (CRL722): CARE

Major Test, I-Semester (2008-09)

November 22, 2008

Duration: 2 Hours, Maximum marks: 55

Note: All the questions are compulsory. The values of various constants and some formule are given at the end, and can be used wherever required.

Question No. 1

1. State the conditions under which a MOS transistor is called "ideal". (4)
2. Define the threshold voltage (V_T) of a MOS transistor. **Derive** an expression for V_T for a non-ideal MOS. **State and justify** the assumptions made. (8)
3. Explain the terms: "flat band conditions" and "flat band voltage". (4)

Question No. 2

i. Draw a schematic diagram showing various current components in an n-p-n transistor biased in "normal" mode of operation. (5)

ii. Based on this diagram, **write** expressions for emitter, base and collector currents. (5)

iii. Further, **derive** expressions for common base current gain (α), transport factor (β_T) and injection efficiency (γ) (5)

Question No. 3

Derive an expression for the total current in a forward biased p-n junction. Give **reasoning and justification** for the method used in total current calculation. (10)

Question No. 4

i. Calculate the threshold voltage of an Al-gate NMOSFET having 0.1 μm thick gate oxide made on P-silicon having 10^{17} cm^{-3} uniform doping and fixed charge (Q_f / q) value of 10^{11} cm^{-2}. (8)

ii. In CMOS technology, explain the role of fixed oxide charge (Q_f) and oxide thickness in the field area in parasitic transistor formation. (6)

Formulae: $Q_{SDMax} = -[4 q \varepsilon_{Si} N_A \phi_f]^{1/2}$

Constants:

$q = 1.6 \times 10^{-19}$ C, $\varepsilon_O = 8.854 \times 10^{-14}$ F/cm, kt/q at room tem. = 0.026V

Silicon at Room Tem.: $n_i = 1.5 \times 10^{10}$ cm^{-3}, $E_g = 1.1$ eV,

Relative dielectric constant (ε or k): Si = 11.7, $SiO_2 = 3.8$

Al-SiO_2 energy barrier ($\phi_{M,OX}$) = 3.2 eV; $\phi_{S,OX}$ (also called χ) = 3.25 eV