Department of Electrical and Computer Engineering
UNIVERSITY OF BRITISH COLUMBIA

ELEC 480 SEMICONDUCTOR DEVICES

FINAL EXAM, April 19, 2000

Time: 2.5 hours
Answer any FOUR questions.
All questions carry equal weight.
One sheet of reference material is allowed.
This exam consists of one typed pages.

1. Describe the sequence of processing steps involved in the fabrication of:
EITHER a CMOS inverter,
OR a bipolar RTL inverter.
Comment specifically on photolithography, device isolation, and factors affecting the turn-on voltage, *i.e.,* V_{GS} for a given I_D or V_{BE} for a given I_C.

2. (a) Discuss the steps involved in the formulation of an expression for the maximum frequency of oscillation of a bipolar transistor.
Make sure that all the terms in your expression are clearly defined.
(b) Why are bipolar transistors inherently more suited to high-power applications than MOSFETs are?

3. (a) Sketch the circuit of an inverter which utilizes one enhancement-mode MESFET and one depletion-mode MESFET.
(b) Describe the terms appearing in the expression for the threshold voltage of a MESFET, and comment on the differences in V_T for the two types of MESFET used in the inverter of part (a).
(c) How could the two transistors of the inverter be realized on the same substrate?

4. (a) Explain the term "deep depletion", and discuss the role it plays in the operation of a DRAM.
(b) How does the semiconductor surface potential ψ_S in deep-depletion depend on the gate-body voltage?
(c) Develop equations for the charge on the storage gate under conditions of (*i*) deep depletion and (*ii*) strong inversion.
(d) Indicate how the equations in (c) could be used, together with the thermal generation rate, G $\mathrm{cm}^{-3}\mathrm{s}^{-1}$, of electron-hole pairs, to estimate an upper limit for the allowed time between refreshes of the memory.

5. (a) Describe the influence that V_{DD} has on the switching energy, *i.e.*, the propagation gate delay multiplied by the power dissipation, of a CMOS inverter.
(b) Consider two diodes, each with an n-type region of the same doping density and the same physical dimensions. One diode is a p-n diode and has a moderately doped p-type region; the other diode is a Schottky diode and uses a metal with high work function.
Without resorting to detailed calculations, give reasoned answers to the following questions:
(i) which diode has the higher turn-on voltage?
(ii) which diode has the shorter switch-OFF time?
(iii) which diode has the higher breakdown voltage?