

Department of Electrical and Computer Engineering
UNIVERSITY OF BRITISH COLUMBIA

EECE 480 SEMICONDUCTOR DEVICES

FINAL EXAM, April 18, 2001

Time: 2.5 hours

Answer 4 (FOUR) questions only.

All questions carry equal weight.

No notes, calculators or books allowed.

This exam consists of 2 pages

1. BJT

(a) Sketch the cross-sectional views of two BJTs: the first one is a GA911-style device; the second one is a higher performance transistor and employs trench isolation.

(b) Discuss those features of the second transistor that are intended to make it a faster device than the first one.

(c) GA911 is described as a 300 MHz process. What does this mean? How could this frequency metric be measured?

2. MORE BJT

(a) Consider a 1-D representation of a n - p - n BJT, *i.e.*, $\boxed{E|B|C}$.

Sketch profiles of the electron concentration, the hole concentration and the net doping density ($|N_D - N_A|$) for three different bias conditions in the active mode of operation, *i.e.*:

(i) when emitter-base space-charge-region recombination contributes significantly to the base current;

(ii) when hole injection into the emitter contributes significantly to the base current;

(iii) when high-level injection in the base affects the collector current.

(b) Use a 2-D representation of a n - p - n BJT to help describe the concept of base spreading resistance.

3. HBT

Discuss the features of HBTs that make them superior to homojunction BJTs in terms of high-frequency performance.

4. FET

In deep sub-micron FETs, the following five phenomena may be apparent: channel-length modulation; threshold-voltage dependence on gate dimensions; punch-through; sub-threshold current increase; velocity saturation.

(a) Describe four of these phenomena, and discuss their effect on FET performance.

(b) Consider two of the phenomena and discuss how they are represented in SPICE.

5. MORE FET

As all the EECE480 grads had already obtained good jobs in microelectronics, PMSea Inc. had to hire Lynn, a non-electronics type, to work in their CMOS Fab. Before being fired, Lynn did the following:

(i) made a batch of n-poly-gate/n-substrate FETs instead of n-poly-gate/p-substrate FETs;

(ii) destroyed numerous FETs during testing by not wearing a well-grounded wrist band.

(a) With the aid of energy band diagrams, explain the consequences of the first action, as regards its affect on the threshold voltage.

(b) Regarding the second action, two sets of FETs were involved: set *A* had $L = Z = 0.2\mu\text{m}$ and $TOX = 40\text{ nm}$; and set *B* had $L = Z = 2.0\mu\text{m}$ and $TOX = 4\text{ nm}$. Which set of FETs was destroyed and why?

6. FET and BJT/HBT

Compare and contrast two technologies (CMOS versus either ECL or CML) as regards their high-speed switching capabilities.