

**ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2005**  
**Homework #9 - due Thursday, 12 May 2005, in class**

1. An n-channel JFET is being used as a controlled load by operating the transistor in saturation. The pinch-off voltage of the transistor is 3.5 V; and the built-in voltage of the gate-channel junction is 0.8 V. The gate is grounded. Assume  $G_O = 1.44 \times 10^{-2} \text{ A/V}$  and determine (a) the drain voltage  $V_{D_{\text{sat}}}$ , (b) the value of the load resistor with  $V_D = V_{D_{\text{sat}}}$ , and (c) the  $g_m$  of the JFET transistor in the saturation region. Compare the value of  $g_m$  with that of a bipolar transistor with  $I_C = I_{D_{\text{sat}}}$ .
  
2. Starting from Eq. (4.5.6) and following the procedure described in the text, derive Eq. (4.5.9).
  
3. An n-type silicon sample has a uniform donor concentration  $N_D = 5 \times 10^{15} \text{ cm}^{-3}$ . Calculate the surface potential required (a) to make the surface intrinsic, and (b) to bring strong inversion at the surface.
  
4. An Au gate MOS capacitor is fabricated on an n-silicon substrate with  $N_D = 10^{15} \text{ cm}^{-3}$ . The thickness of the gate oxide is 120 nm, and the charge density at the Si-SiO<sub>2</sub> interface is  $3 \times 10^{11}$  charges  $\text{cm}^{-2}$ . Calculate (a) the flat-band voltage, (b) the threshold voltage, and (c) draw the energy band diagram of the system under thermal equilibrium and at the onset of strong inversion.
  
5. Consider a MOS capacitor of area  $1 \text{ cm}^2$  made on n-silicon with  $N_D = 1.5 \times 10^{14} \text{ cm}^{-3}$  and an Al gate. The SiO<sub>2</sub> layer is 200 nm thick. The Si is 20  $\mu\text{m}$  thick and is epitaxially grown on n<sup>+</sup>-silicon substrate having  $N_D = 10^{19} \text{ cm}^{-3}$ . Neglecting any interface charge between Si and SiO<sub>2</sub>, determine the flat-band capacitance, and  $C_{\text{max}}$  for the structure, and sketch the C-V plot.

Homework assignments will appear on the web at:  
<http://www.ece.udel.edu/~kolodzey/courses/eleg646s05.html>

Note: On each homework and report submission, you must please give your name, the due date, assignment number and the course number.