

ECE 5205 Homework assignment 4 (turn in by 3-6-14) Total points: 20

1. **Substrate bias:** Calculate threshold voltage of the MOSFET with  $n^+$  doped polysilicon gate with p-type doping of  $1 \times 10^{16} \text{ cm}^{-3}$ , oxide thickness of 250 Å for following biases: a)  $V_s = V_d = 0\text{V}$  and  $V_{\text{bulk}} = -2\text{V}$ ; b)  $V_s = V_d = 3\text{V}$  and  $V_{\text{bulk}} = -2\text{V}$  (4 points)
2. **Substrate Bias.** Calculate the maximum depletion width and corresponding depletion charge for problem 1, cases a) and b) (3 points)
3. **Substrate Bias:** Still considering problem 1, what would be the minimum amount of  $V_{\text{sub}}$  at which band-to-band tunneling would be in principle possible. Justify your  $V_{\text{sub}}$ . (3 points)
4. **Substrate Bias:** Assuming p-type doping of  $5 \times 10^{15} \text{ cm}^{-3}$  and oxide thickness of 450 Å what kind of  $V_{\text{sub}}$  would you have to apply to shift the threshold voltage by 0.25 V? (4 points)
5. **Threshold shift:** Consider problem 4 and determine what kind of counter  $\delta$ - doping dose would have to be implanted at the interface to shift the threshold voltage back by 0.25V to its original value but still keeping  $V_{\text{sub}}$  at the value that you have determined in problem 4. (3 points)
6. **Linear MOSFET Current:** Consider current in linear regime of the MOSFET. What happens to the current when: a) the length  $L$  of the transistor is doubled and the thickness of the oxide  $t_{\text{ox}}$  is halved? B) the mobility is increased by 50% and the  $(V_g - V_T)$  voltage difference decreased by 50%? (3 points)