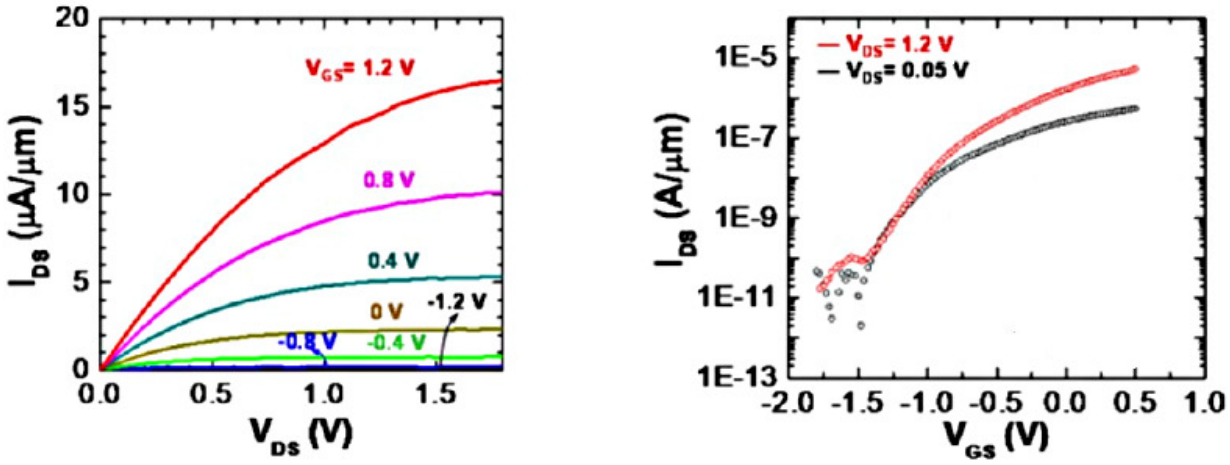
ECE 305 – Spring 2018

Homework 10 – Due Tuesday, April 10, 2018 at 12:00 PM in class (or in EE 326B)

1. The gate electrode of an MOS capacitor (MOS-C) is often in fact heavily doped polycrystalline silicon. These are designed to act almost like metals, with a Fermi level close to the conduction band minimum or valence band maximum. Consider a case where $E_F - E_C = 0.1$ eV for the gate, and $E_F - E_C = -0.4$ eV in the non-degenerately doped crystalline silicon substrate. Assume that the electron affinities of polycrystalline and crystalline silicon are identical.
    a. Please sketch the equilibrium energy band diagram for the polysilicon gate MOS-C.
    b. What is the effective "metal"-semiconductor workfunction for this band diagram, and is this value small enough to be neglected for most calculations? Why?
    c. Will the given MOS-C be in accumulation, flat band, depletion, or inversion for $V_G = 0$? Justify your answer. **Hint:** this may be different from the case where $V_G' = 0$.

2. Consider the input-output relation (left) and transfer characteristics (right) for a field-effect transistor made from a 2D semiconductor material (WSe_2) depicted below. Assume the power supply voltage V_{DD}=1.2 V, oxide capacitance C_{ox}=3 μF/cm^2, channel width W=2 μm, R_s= R_D=5 Ω.



    a. What are the on and off currents for this transistor?
    b. What is the threshold voltage for this transistor? Justify your answer.
    c. What is the average subthreshold swing for V_{DS}=1 V? Explain how you find it.
    d. What is the drain-induced barrier lowering for this transistor? Explain how you find it.
    e. What is the inversion layer charge density for this transistor in the on state (in μC/cm^2)?
    f. What is the channel resistance in the on state when V_{DS}=0.25 V?