DEVICES – Ph.D. Qualifying Exam Spring 2007

1. Suppose you have a silicon sample in the shape of a bar 1cm long, 1mm wide, and 1mm thick. The silicon is doped n type with n = 10^{16} electrons/cm^3, and its mobility is 1300 cm^2/Vsec. Electrical (ohmic) contacts are on the two ends of the sample. A voltage of 10V is applied across the contacts. (charge on an electron = 1.6×10^{-19}C)

(2.5%) a) What is the drift velocity, v_D, of the electrons in the silicon?

(2.5%) b) What is the current density, J, in the silicon?

(2.5%) c) How much power is dissipated in the sample?

(2.5%) d) If the power dissipated is increased enough to heat the sample to, say, 700C, would the resistivity increase or decrease? Explain.

2. A thin layer on type n type silicon, 0.1μm thick, is on a sample of silicon dioxide. The silicon is doped with 10^{16}donors/cm^3, and the Si/SiO_2 interface is ideal, i.e. the electrical properties of the silicon are not affected by the presence of the silicon dioxide. Two ohmic contacts are on either end of the silicon layer as shown (side view and top view). A metal plate labeled P is 10μm above and parallel to the silicon layer.

(6%) a) A small voltage V_{AB} (say 1mV) is applied between contacts A and B which results in a current I_{AB} flowing from A to B. A negative voltage V_{PB} is applied between the metal plate and the contact B. Plot the current I_{AB} as a function of the voltage on the plate V_{PB}. You do not need to dimension the current axis, i.e. you do not need to calculate current values. But you do need to dimension the voltage axis, V_{PB}.

(4%) b) Plot qualitatively the current I_{AB} as a function of V_{PB} if the polarity of V_{PB} is reversed.