KTH Information and Communication Technology

IH1611 spring 2019

Problems to student recitation 4

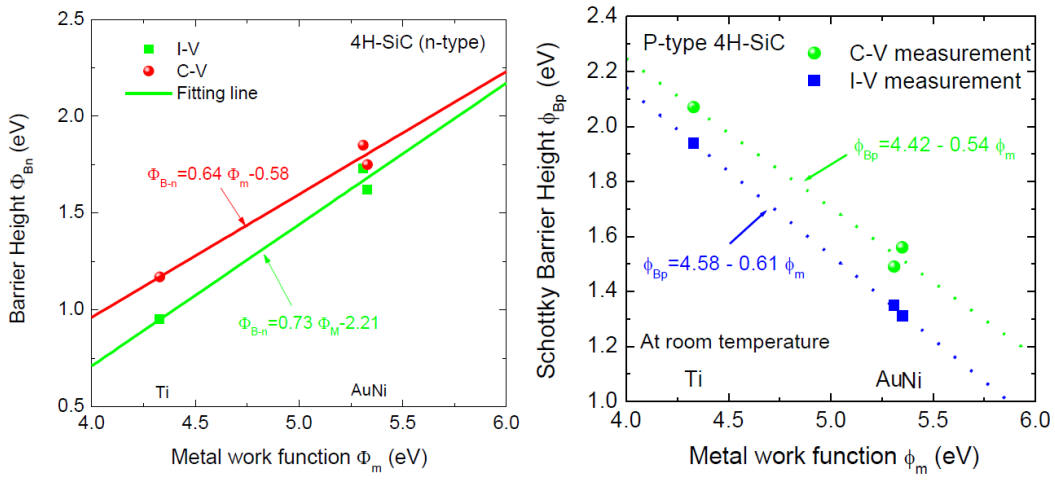
1. An abrupt Si pn-junction with area 10^{-4} cm^2 has the following properties:

p side	n side
$N_A = 10^{17}\,\mathrm{cm}^{-3}$	$N_D = 10^{15}\,\mathrm{cm}^{-3}$
$\tau_n = 0.1\ \mu\mathrm{s}$	$\tau_p = 10\ \mu\mathrm{s}$
$\mu_p = 200\ \mathrm{cm}^2/\mathrm{Vs}$	$\mu_n = 1300\ \mathrm{cm}^2/\mathrm{Vs}$
$\mu_n = 700\ \mathrm{cm}^2/\mathrm{Vs}$	$\mu_p = 450\ \mathrm{cm}^2/\mathrm{Vs}$

   The junction is forward biased by 0.6 V. What is the forward current?
   What is the reverse current at a reverse bias of -0.6 V?

2. Estimate the electron mobility for a sample with 4.5×10^{17} cm^{-3} donors. For what acceptor doping level would one get a hole mobility of the same magnitude?

3. Use the information in the figure to determine the approximate value of the energy bandgap for the material SiC. Which type of Ohmic contact would be easier to form towards SiC, what doping polarity should the semiconductor have?



Source thesis published at KTH.

4. In Metal-Oxide-Semiconductor transistors (MOSFET) it is useful to know the Fermi level for a doped semiconductor with respect to the Fermi level of the semiconductor in the intrinsic (undoped) case. Assume that $N_V=N_C$ for the semiconductor.
   Derive an expression for
   $$\phi_B = \frac{\left|E_i - E_F^{Doped}\right|}{q}$$

5. An nMOSFET has 1 nm SiO_2 as gate oxide and a doping concentration $N_a=10^{17}$ cm^{-3} in the body.
   Calculate the threshold voltage V_t. Use a typical work-function value for the compound TiN, see e.g.
   http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4011932

6. An nMOSFET has a dual layer of 1 nm SiO2 (closest to the silicon surface) and 3 nm HfO_2 (on top) as gate dielectric stack, to prevent severe leakage. Sketch the voltage distribution in this system, for a flatband condition, assume n-type polysilicon gate and p-type substrate. Assume that HfO_2 has a band gap of roughly 6 eV, and electron affinity of 2.14 eV, and $\varepsilon_r/\varepsilon_0=16$