Department of Electrical and Computer Engineering
UNIVERSITY OF BRITISH COLUMBIA
EECE 480 SEMICONDUCTOR DEVICES: PHYSICS, DESIGN and ANALYSIS

MID-TERM EXAM, October 21, 2010

Time: 1.25 hours
Notes, books and simple calculators are allowed.
Data-storage- or telecommunication-devices are not allowed.
This exam consists of **1** page. There is a figure on the back of this sheet.

1. [8 marks]
The hole-energy E-k relationships for the valence bands of two semiconductor materials, A and B, each with spherical constant-energy surfaces, can be expressed as
$E_A - 0.7 = \alpha k^2$ and $E_B - 1.4 = 2\alpha k^2$,
respectively, where α is a constant and the energies are in units of eV.
For both materials, the electron-energy E-k relationship for the conduction band is given by
$E - 0.7 = 2\alpha(k - k')^2$,
where $k' > 0$, α is a constant, as before, and the energies are in units of eV.
(a) Sketch the band structure (E-k) for each material. The scale need not be precise, but any important differences in wavenumber and curvature of the bands for the two materials should be evident.
(b) Each material is made into an n^+p diode. The diodes have identical doping densities.
For each diode, sketch the equilibrium energy band diagram (E_C, E_F, E_V). The scale need not be precise, but any differences in bandgap, in built-in voltage, and in $(E_F - E_V)$ for the two diodes should be evident.

2. [8 marks]
Two n^+p diodes are identical in all respects other than the electron minority carrier diffusion length, which is $100\,\mu$m in diode X and $1\,\mu$m in diode Y. The p-quasineutral region in each diode is of length $10\,\mu$m.
(a) If the base contact were ohmic, which diode would have the higher current magnitude when operating at a given forward bias? Give reasons for your answer.
(b) If the base contact were blocking, and each diode were operated as a solar cell, which one would give the higher base photocurrent magnitude? Give reasons for your answer.

3. [4 marks]
The bandgaps of the compound semiconductors InAs, InP, and GaP are approximately 0.3, 1.3, and 2.3 eV, respectively.
If solar cells were made from these materials, which one would have the highest theoretical photovoltaic conversion efficiency? Give reasons for your answer.

Bonus. [4 marks]
Fig. 1 shows a band diagram from *Bandprof* for a forward-biassed np diode. Recall that *Bandprof* assumes no recombination.
Redraw the band diagram, identifying the electron and hole quasi-Fermi levels, for a case when recombination is allowed. Give reasons for the changes you make.

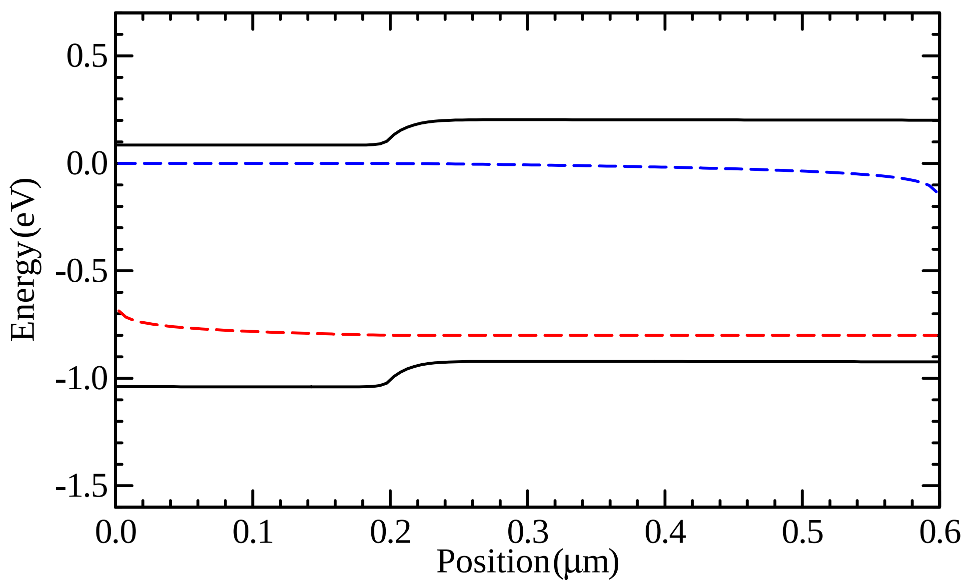

Figure 1: Energy band diagram (E_C, E_V, E_{Fn}, E_{Fp}) for a forward-biassed diode with no recombination.