Examples from Solar Cell Device Physics (Stephen J. Fonash, 2nd Edition)

Chapter 3 – Basic Structures for Photovoltaic Action

Case 1: Photovoltaic action arising from a Built-in Electrostatic Field

<u>Structure:</u> A basic p-type Si layer with bulk defects. Specifically, donor-like gap states are present from E_v to mid gap, and acceptor-like ones fill the rest. All parameters except absorption coefficients can be found on page 76 of the book. The built-in field is created by contact workfunction difference.

<u>Performance:</u> The resulting device has the following performance: J_{sc} = 13.791mA/cm^2, Eff = 2.947%, FF = 0.683, V_{oc} = 0.313V.

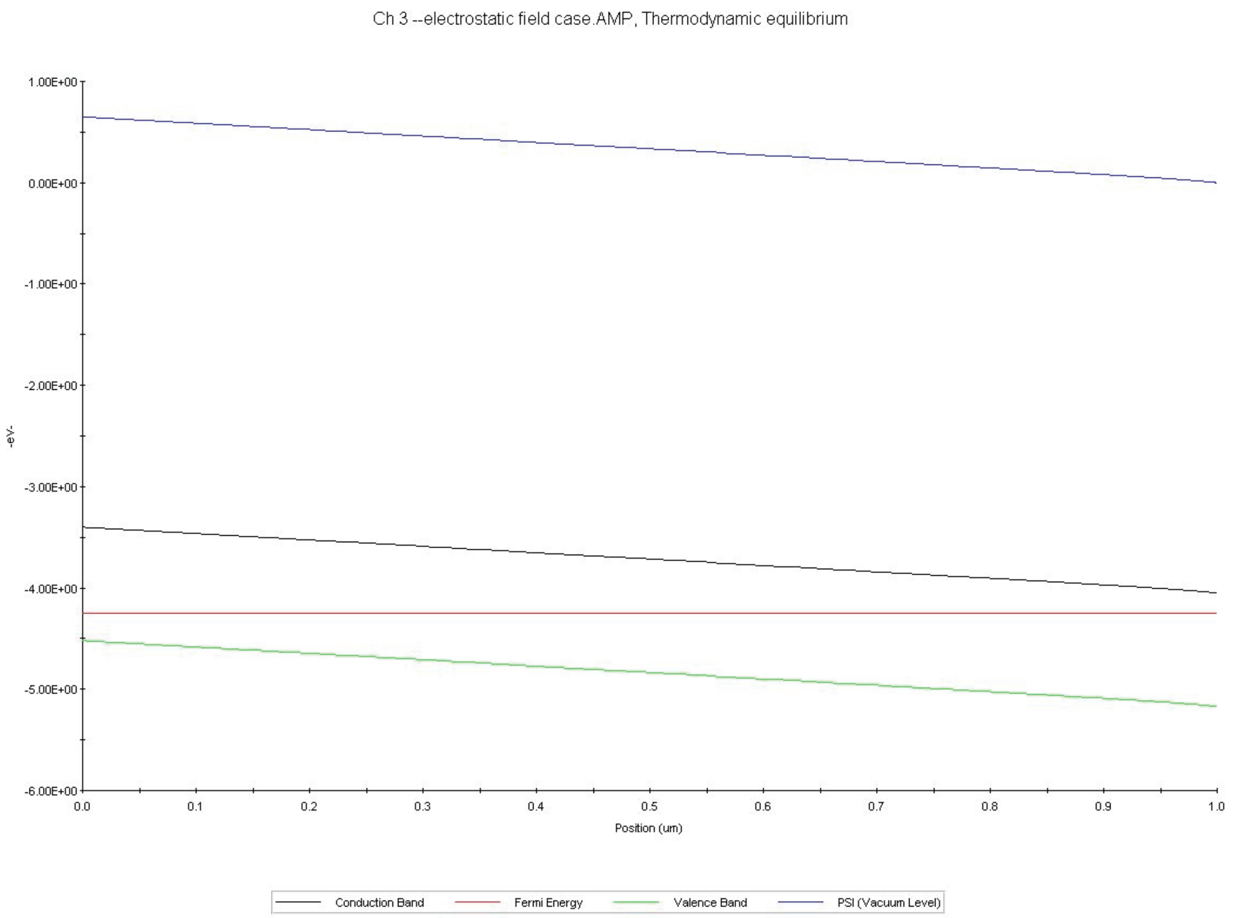

Fig.1. The numerically calculated band diagram in thermal equilibrium for the above structure.

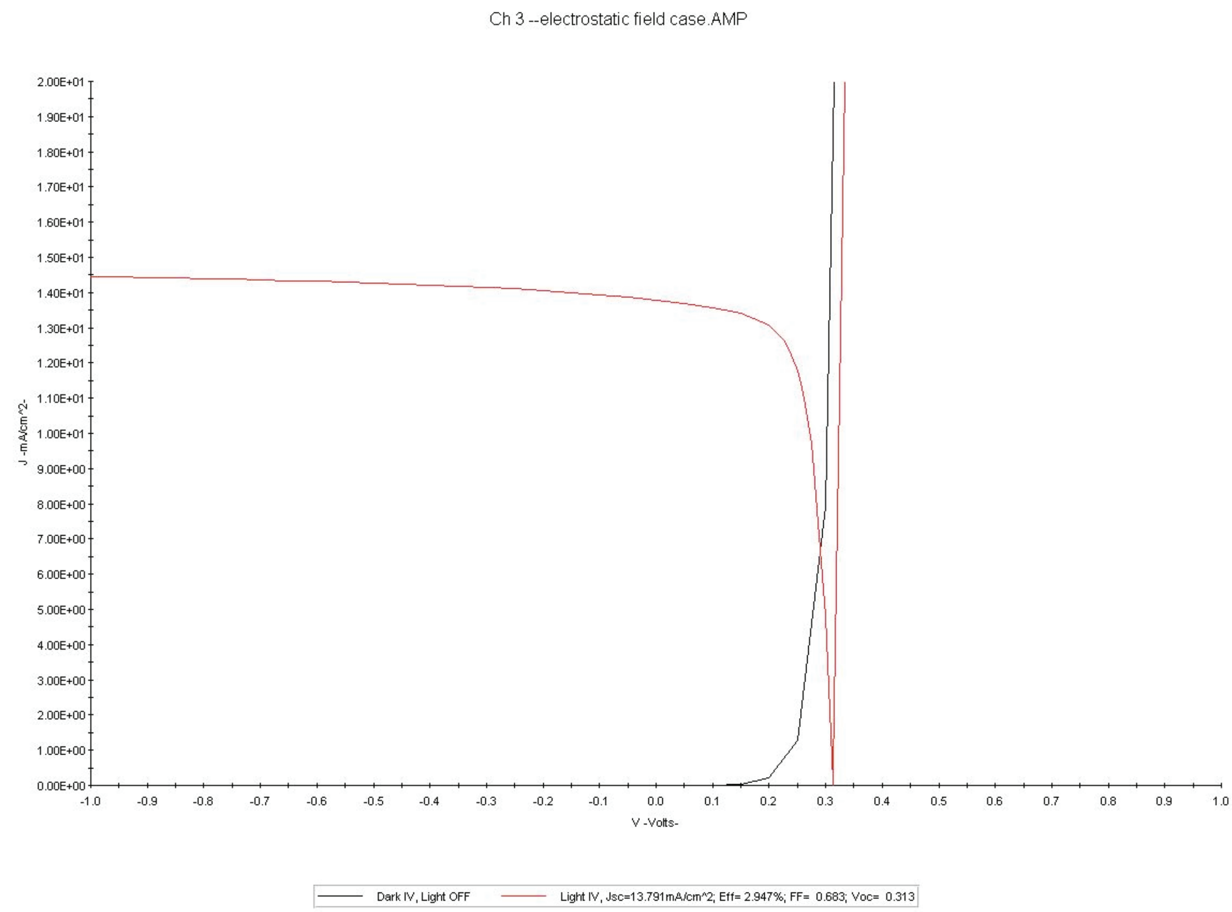

Fig.2. The dark and light J-V characteristics of the above structure.

Case 2: Photovoltaic action arising from Diffusion (the Dember phenomenon)

Structure: The absorber in this case is taken to have the same material properties like the previous one, but the new structure has no built-in electric field and no effective force field (i.e., no electron affinity, no hole affinity, and no density of states changes). Both contact work functions are set to be equal to 4.62eV.

Performance: The resulting band diagram is not shown here because everything is flat. The resulting device has the following performance: J_{sc} = 0.442mA/cm^2, Eff = 0.000%, FF = 0.250, V_{oc} = 0.003V.

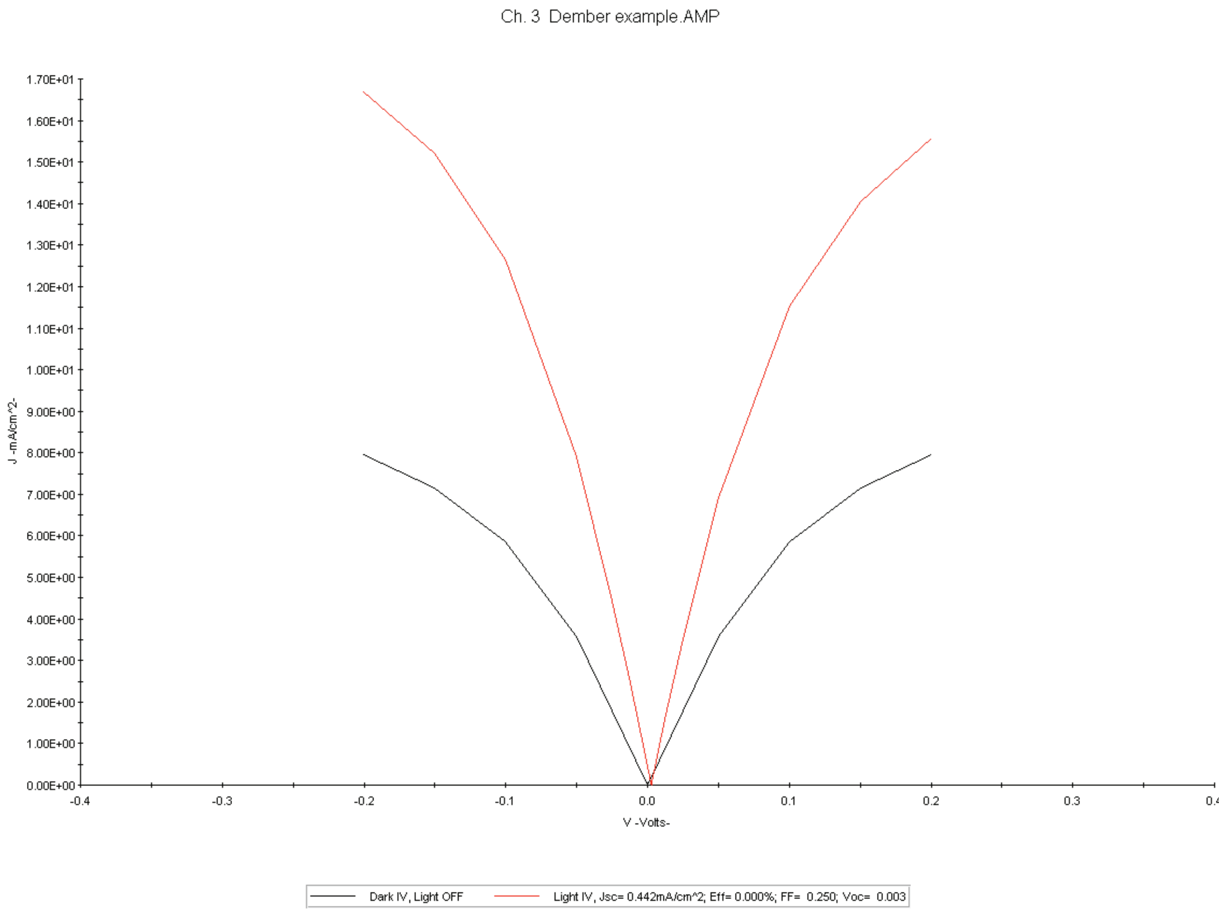

Fig. 3. The dark and light J-V characteristics of the device.

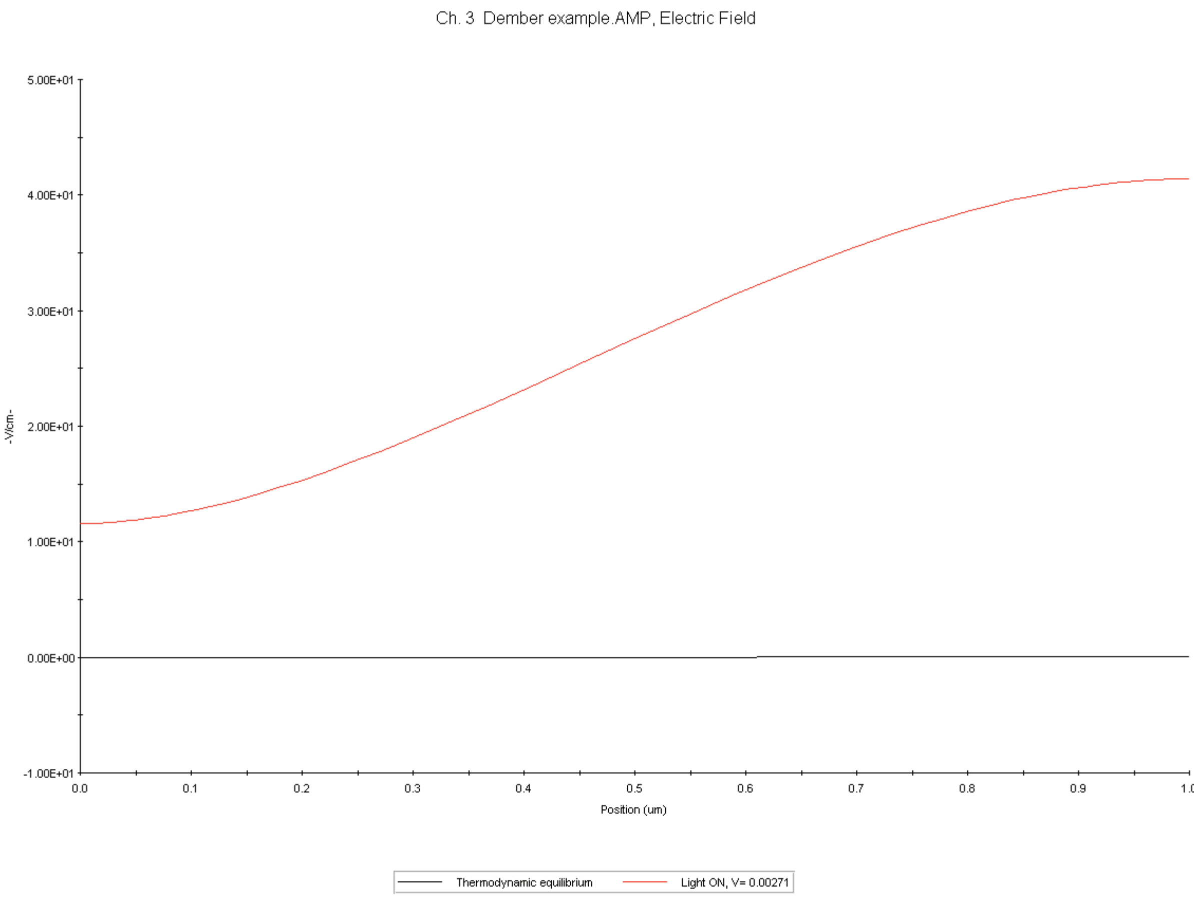

Fig. 4. The electric field at TE and at open circuit under illumination in the structure.

Case 3: Photovoltaic action arising from a Built-in Electron Effective Field

Structure: This structure consists of only an electric force field for electrons. This means it has a graded electron affinity which occurs step-wise over 20nm. There is no band bending throughout the structure (i.e., no built-in electrostatic field) because the work functions of all layers are equal to 4.62eV. All related material parameters can be found on page 87 of the book.

Performance: The resulting device has the following performance: J_{sc} = 3.360mA/cm^2, Eff = 0.049%, FF = 0.239, V_{oc} = 0.061V

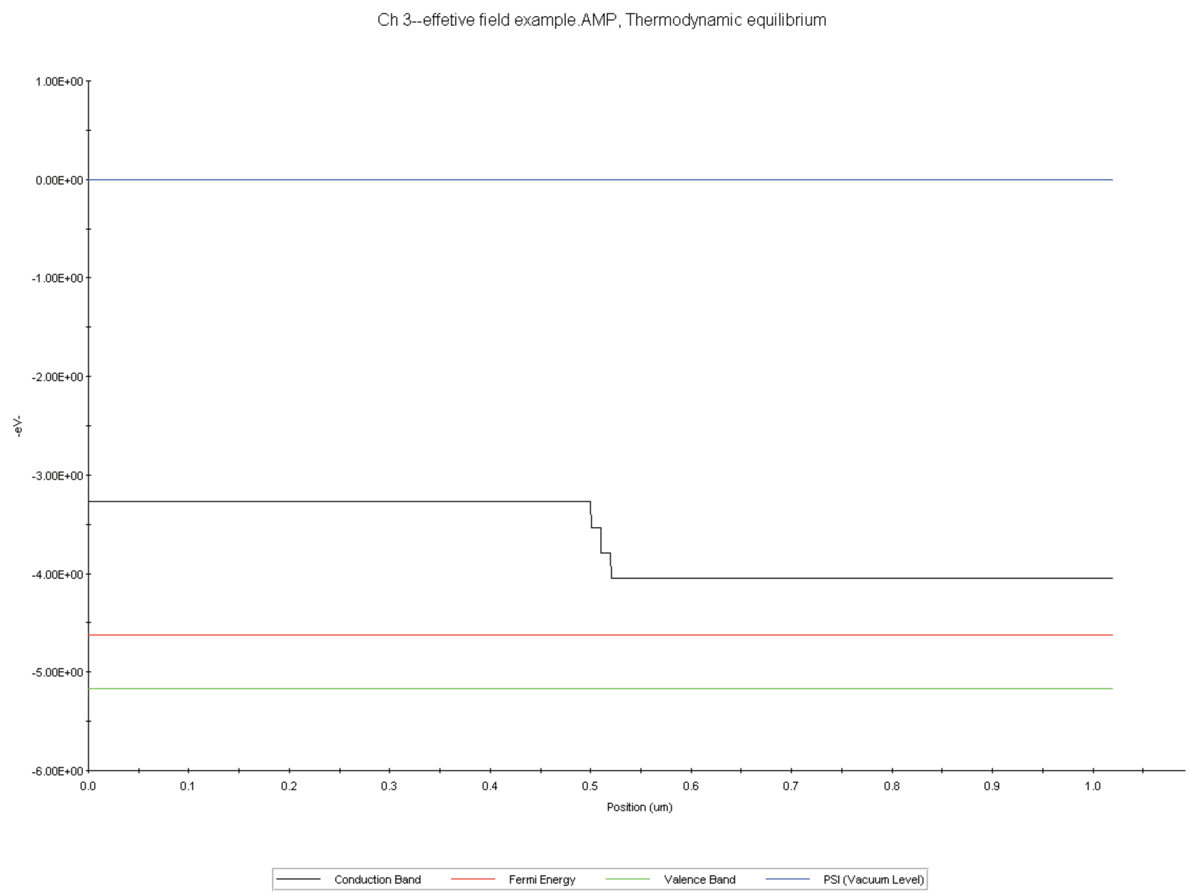

Fig. 5. The numerically calculated band diagram of the structure with only electron effective force field.

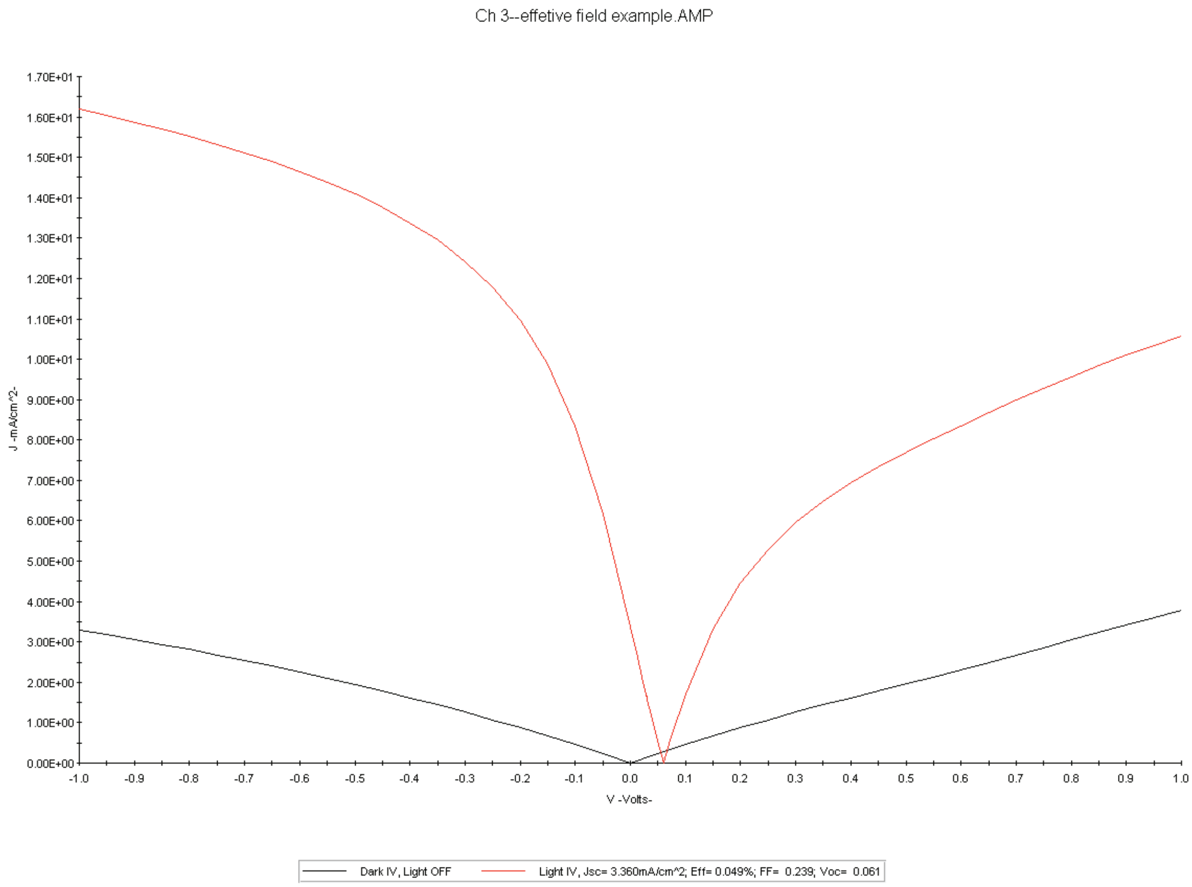

Fig. 6. The dark and light J-V characteristics of the structure.

Case 4: Photovoltaic action arising from a Built-in Electron Effective Field 2

Structure: This structure is the same as case 3 except the bandgap of the final layer. Here it is changed from 1.12eV to 1.30eV. Due to this action, the new structure has an addition of a hole effective force field along with the previous electron one.

Performance: The resulting device has the following performance: J_{sc} = 6.539mA/cm^2, Eff = 0.673%, FF = 0.161, V_{oc} = 0.639V

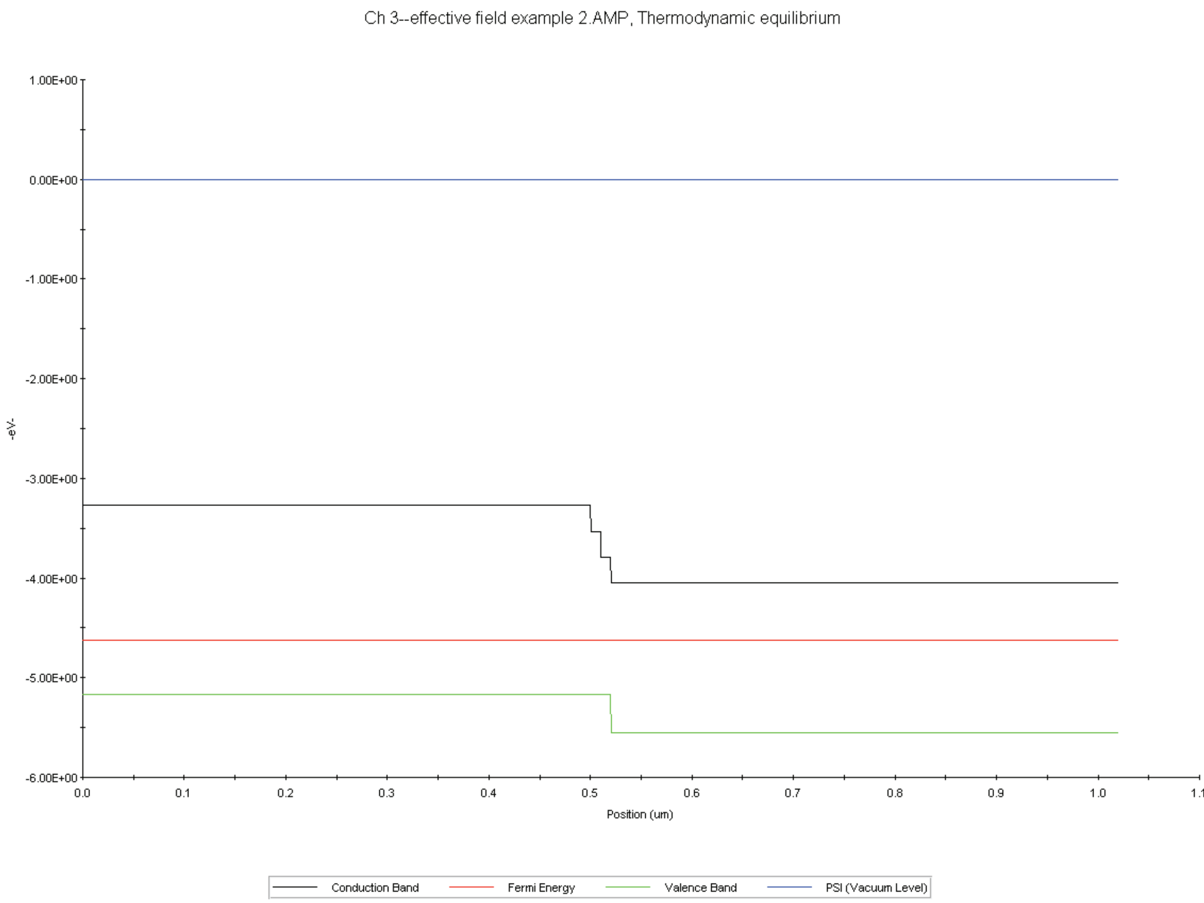

Fig. 7. The numerically calculated band diagram of case 4 structure.

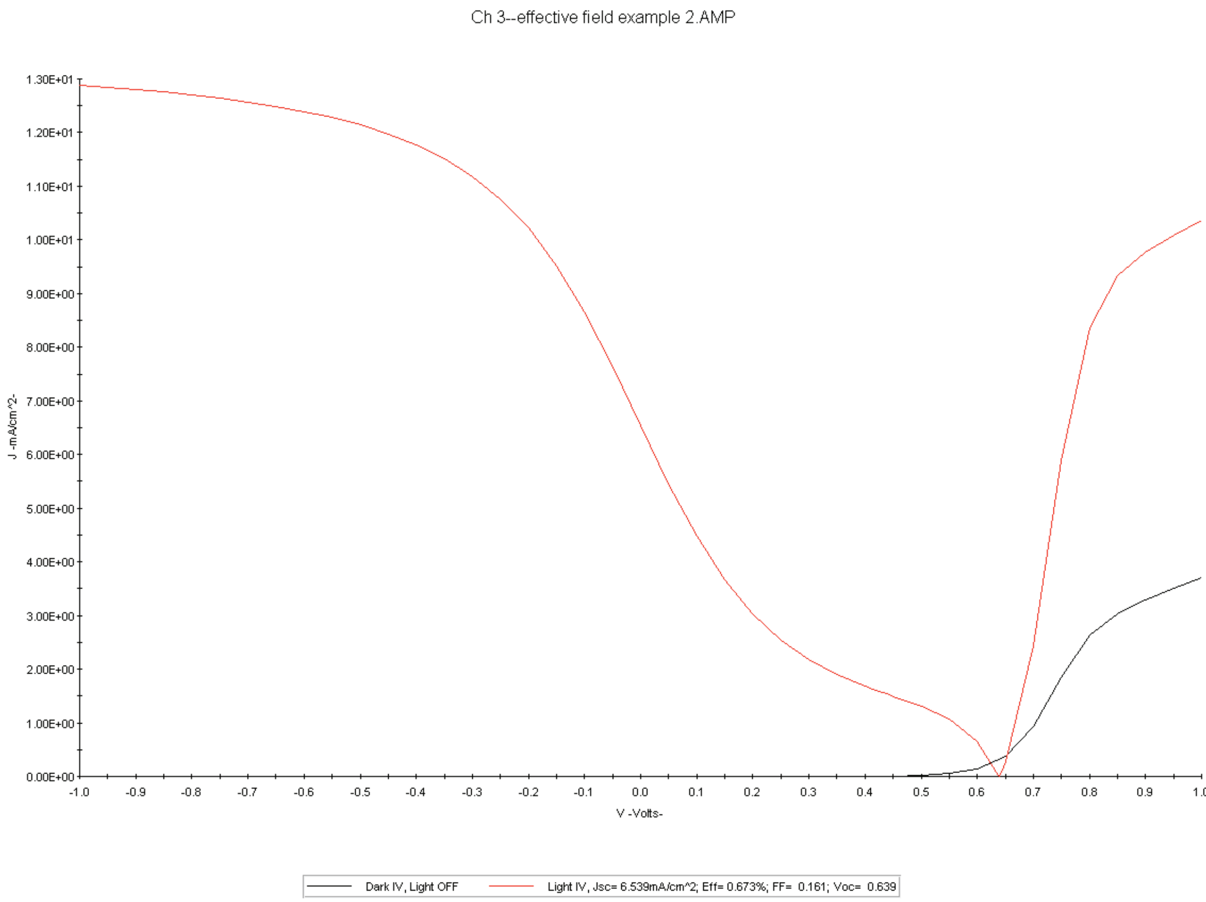

Fig. 8. The dark and light J-V characteristics of the structure.