EEE337/348: Tutorial 5

1) An IMPATT diode consists of semiconductor layers with accurately controlled doping concentrations. A Silicon p^+-i-n^+-i-n^+ diode is designed such that impact ionisation is confined within the injection region of the IMPATT.
   a. Sketch and label the electric field profile of this p^+-i-n^+-i-n^+ diode.
   b. Suggest the operating voltage if the diode has the following parameters,
      i) the thickness of the injection region is 1 μm and its breakdown field is 300 kV/cm,
      ii) the drift region is 4 μm,
      iii) the n+ layer, sandwiched between the two i layers, (also referred to as the field control layer) has a doping concentration of 10^{18} cm^{-3} and thickness of 10 nm

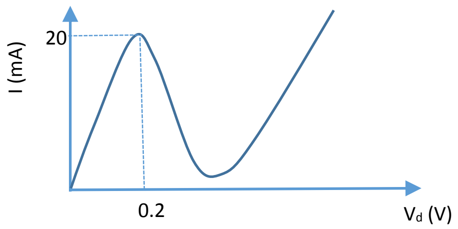
2) For the IMPATT diode in (1), calculate the electric field in the drift region. Is it sufficiently high to maintain velocity saturation of electrons?

3) Assuming that the saturation velocity in Silicon is 10^5 ms^{-1}, calculate the operating frequency of the IMPATT diode in (1).

4) Describe how a pn diode can be modified to work as a tunnel diode. Explain how the negative resistance is achieved in the tunnel diode.

5) Consider a GaAs tunnel diode with the following parameters; a lead inductance of 0.1 nH, a series resistance of 4 Ω, a junction capacitance of 70 fF and a negative resistance of -20 Ω. Calculate the frequency when the real part of the impedance becomes zero.

6) The typical I-V characteristics of a GaAs tunnel diode is shown below.



   The device area is 10^{-7} cm^2, the doping concentration is 10^{20} cm^{-3} on p and n-sides, and the built-in potential is 600 mV. The speed index of a tunnel diode is defined by I_p/C_j, where I_p is the peak current and C_j is the diode capacitance. Calculate the speed index for this tunnel diode.

7) Explain the key features in a semiconductor material that allows a Gunn diode to produce the negative resistance.