8.1 The pn Junction Diode

Device dimensions and physical parameters of a pn junction diode are listed below.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Doping</th>
<th>Diffusion coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_p=0.5µm</td>
<td>N_p=5×10^17 cm^-3</td>
<td>D_n=5 cm^2/s</td>
</tr>
<tr>
<td>W_n=1.0µm</td>
<td>N_d=2×10^17 cm^-3</td>
<td>D_p=5 cm^2/s</td>
</tr>
</tbody>
</table>

The pn junction has an area of A=20µm ×20µm. For a forward bias of 0.7V,

(a) Find the diode saturation current I_o.
(b) Find the diode current I_D.
(c) Find the small-signal resistance r_d.
(d) Find the depletion capacitance C_r.
(e) Find the diffusion capacitance C_d.
(f) Draw the small-signal model.

You can assume x_n<<W_n and x_p<<W_p.

8.2 Diodes in Circuits

Two diodes D_1 and D_2 are connected in parallel with a total of 1mA current. If D_1 has N_p=10^{18} cm^-3, N_d=10^{15} cm^-3 and D_2 has N_p=10^{17} cm^-3, N_d=10^{15} cm^-3, find the current flow through each diode. **Assume that W_p and W_n are 2.0 µm.** (Hint: neglect the electron minority current and compare the built-in voltage.)

8.3 The Bipolar Junction Transistor

Device dimensions and physical parameters of a nnp bipolar transistor are listed below.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Doping</th>
<th>Diffusion coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>W_n=0.5µm</td>
<td>N_a=10^7 cm^-3</td>
<td>D_n=5 cm^2/s</td>
</tr>
<tr>
<td>W_p=1.0µm</td>
<td>N_d=8×10^18 cm^-3</td>
<td>D_p=5 cm^2/s</td>
</tr>
</tbody>
</table>

(a) Sketch the minority carrier distribution under forward-active bias.
(b) Find α_F.
(c) Find forward-active current gain β_F.
8.4 BJT Operating Regions
Identify the operating region (cutoff, forward active, saturation, or reverse active) of the following npn bipolar junction transistors: (npn: $\beta_F=100$)

(a) 0.72V 5V 20kΩ

(b) 5V

(c) 5V 20kΩ

(d) 5V 20kΩ open circuit

(a) 5µA

(b) 100µA

(c) 5µA

(d)