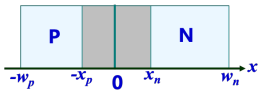
十二：PN结二极管的频率特性

Tuesday, March 24, 2020 1:30 AM

1. 预习作业：
   a. 推导长PN结P侧交流少子电子的连续性方程和电流方程，到处交流少子电子的扩散电流分布；

   解：



PN结一维坐标示意图

PN结在直流偏压V上叠加一个频率为ω，振幅为v_a的交流电压；

总电压：$v = V + v_a e^{j\omega t}$，$v_a \ll V_T$， 小信号条件；

总电流：$i = I + i_a e^{j\omega t}$，(直流成分+交流成分)

非平衡少子浓度：

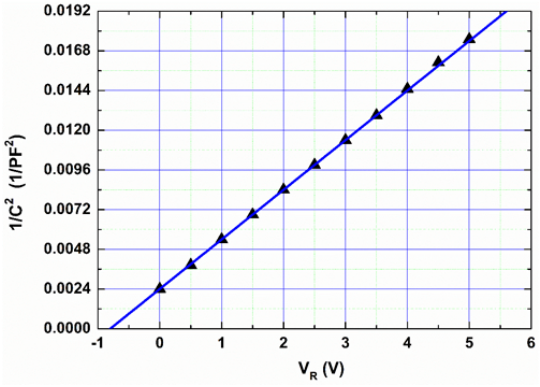
$$p_n(x,t) = p_n(x) + p_a(x)e^{j\omega t}$$
$$n_p(x,t) = n_p(x) + n_a(x)e^{j\omega t}$$

P侧中性区：

少子电子连续性方程：

$$\frac{\partial n_p(x,t)}{\partial t} = D_n \frac{\partial^2 n_p(x,t)}{\partial x^2} - \frac{n_p(x,t) - n_{p0}}{\tau_n}$$
$$\Rightarrow \frac{\partial n_p(x)}{\partial t} = D_n \frac{\partial^2 n_p(x)}{\partial x^2} - \frac{n_p(x) - n_{p0}}{\tau_n} = 0$$
$$\Rightarrow \frac{\partial \left[n_a(x)e^{j\omega t}\right]}{\partial t} = D_n e^{j\omega t} \frac{\partial^2 n_a(x)}{\partial x^2} - \frac{n_a(x)e^{j\omega t}}{\tau_n} = j\omega n_a(x)e^{j\omega t}$$

   b. 已知：Si长P^+N结，$A = 4\times10^{-4}cm^2$，$D_n = 25cm^2/s$，$D_p = 10cm^2/s$，$\tau_n = \tau_p = 0.1\mu s$，$V_T = 25mV$。实验测量其反偏情况下的$C-V$特性曲线如图所示；



   i. $V = 0.6V$时，估算：C_T =? C_D =? r_D =?

   解：

$$N_d = \frac{2}{qk\varepsilon_0 A^2} \cdot \frac{\Delta V}{\Delta \frac{1}{C_2}}$$
$$= \frac{2}{1.6\times10^{-19}C\times9.0\times10^{9}N\cdot m^2/C^2\times8.85\times10^{-12}F/m\times(4\times10^{-4}cm^2)^2} \times \frac{4V}{0.0144pF^{-2} - 0.0024pF^{-2}}$$
$$\approx 3.270\times10^{13}m^{-3} = 3.270\times10^{7}cm^{-3}$$
$$\psi_0 = V_T \ln\frac{N_a N_d}{n_i^2}$$