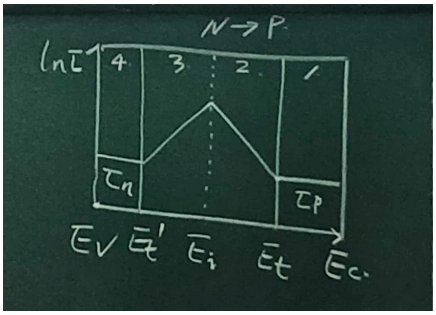
第十八课：肖克莱-瑞德公式

Wednesday, November 20, 2019 5:26 AM

1. 肖克莱-瑞德公式：
   a. $\tau = \tau_p \frac{n_0 + n_1}{n_0 + p_0} + \tau_n \frac{p_0 + p_1}{n_0 + p_0}$；
   b. 一般情况下，复合中心上电子浓度有变化Δn_t，这时电中性条件为：$\Delta p = \Delta n + \Delta n_t$；

      有：$u = \frac{\Delta n}{\tau_n'} = \frac{\Delta p}{\tau_p'}$， 但当复合中心很少时，依然满足$\Delta n = \Delta p$;
2. 载流子寿命τ随着载流子浓度的变化：



   禁带：$E_v < E_t' < E_i < E_t < E_c$，复合中心：$E_t$

   $n = N_c \cdot e^{-\frac{E_c - E_F}{kT}}$， $p = N_V \cdot e^{-\frac{(E_F - E_V)}{kT}}$
   a. 强N型：费米能级E_f满足$E_t < E_f < E_c$；

      $\because E_f > E_t \Rightarrow n_0 \gg n_1 \gg p_1 \gg p_0$

      $\tau = \tau_p$
   b. 弱N型(高阻区)：$E_i < E_f < E_t$;

      $\because n_1 \gg n_0 \gg p_0 \gg p_1$

      $\tau = \frac{n_1}{n_0}\tau_p$
   c. 弱P型：$E_t' < E_f < E_i$;

      $\because n_1 \gg p_0 \gg n_0 \gg p_1$

      $\tau = \frac{n_1}{n_0}\tau_p$
   d. 强P型：$E_v < E_f < E_t'$;

      $\because p_0 \gg n_1 \gg p_1 \gg n_0$

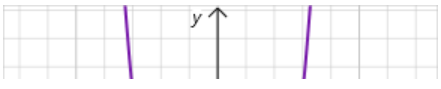
      $\tau = \tau_n$
3. E_t与τ(E_t在什么位置时，复合中心复合是最有效的)：

   $$u = \frac{np - n_i^2}{\tau_p(n + n_1) + \tau_n(p + p_1)}$$

   在复合中心时，因为$E_t \approx E_i$，所以$c_n \approx c_p \Rightarrow \tau_p \approx \tau_n = \tau_0$

   $$u = \frac{np - n_i^2}{\tau_p(n + n_1) + \tau_n(p + p_1)}$$

   $1 \qquad np - n_i^2$

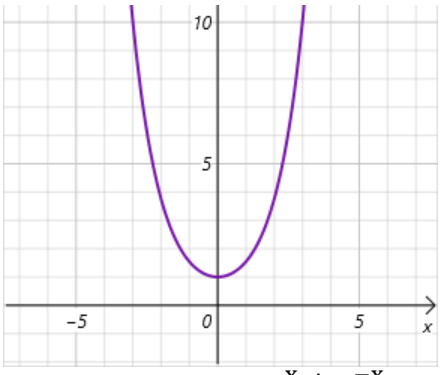


$$= \frac{1}{\tau_0} \cdot \frac{np - n_i^2}{(n+p) + (n_1 + p_1)}$$

$$= \frac{1}{\tau_0} \cdot \frac{np - n_i^2}{(n+p) + 2n_i \cosh \frac{E_t - E_i}{kT}}$$

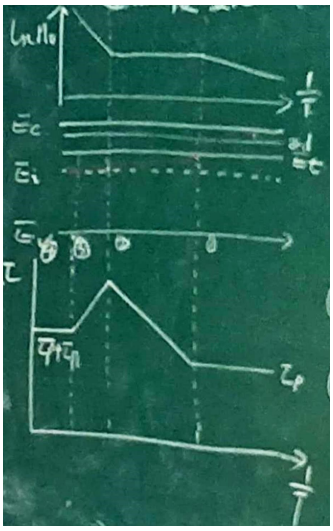
当$E_t = E_i$时，取到u_{max}, τ_{min}

$$u_{max} = \frac{1}{\tau_0} \cdot \frac{np - n_i^2}{(n+p) + 2n_i}$$



$$y = \cosh x = \frac{e^x + e^{-x}}{2}$$

4. τ随温度变化(N型)：



a. $E_f > E_t$

$\tau = \tau_p$

b. $E_t > E_f, n_0$不变

$$\tau = \frac{n_1}{n_0} \tau_p$$

c. $n_0 = p_0 = n_i$

$$\tau = \frac{\tau_p}{2}\left(\frac{n_i + n_1}{n_i}\right) + \frac{\tau_n}{2}\left(\frac{n_i + p_1}{n_i}\right)$$

$$= \frac{\tau_p}{2}\left(1 + e^{\frac{E_t - E_i}{kT}}\right) + \frac{\tau_n}{2}\left(1 + e^{\frac{E_i - E_t}{kT}}\right)$$

i. 温度不太高的本征激发：$E_t - E_i \gg kT$

$$\tau = \frac{\tau_p}{2} e^{\frac{E_t - E_i}{kT}}$$

ii. 温度很高的本征激发：$E_t - E_i \ll kT$

$\tau = \tau_p + \tau_n$