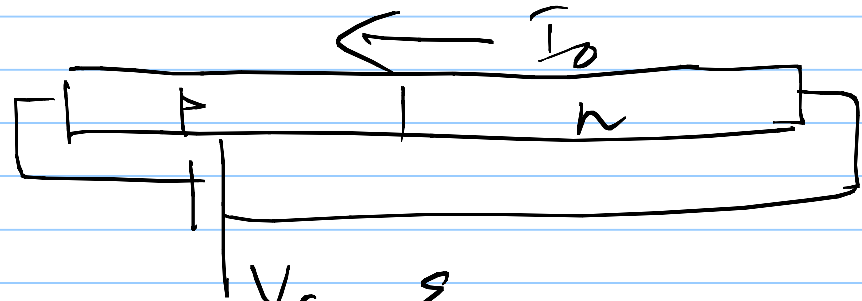
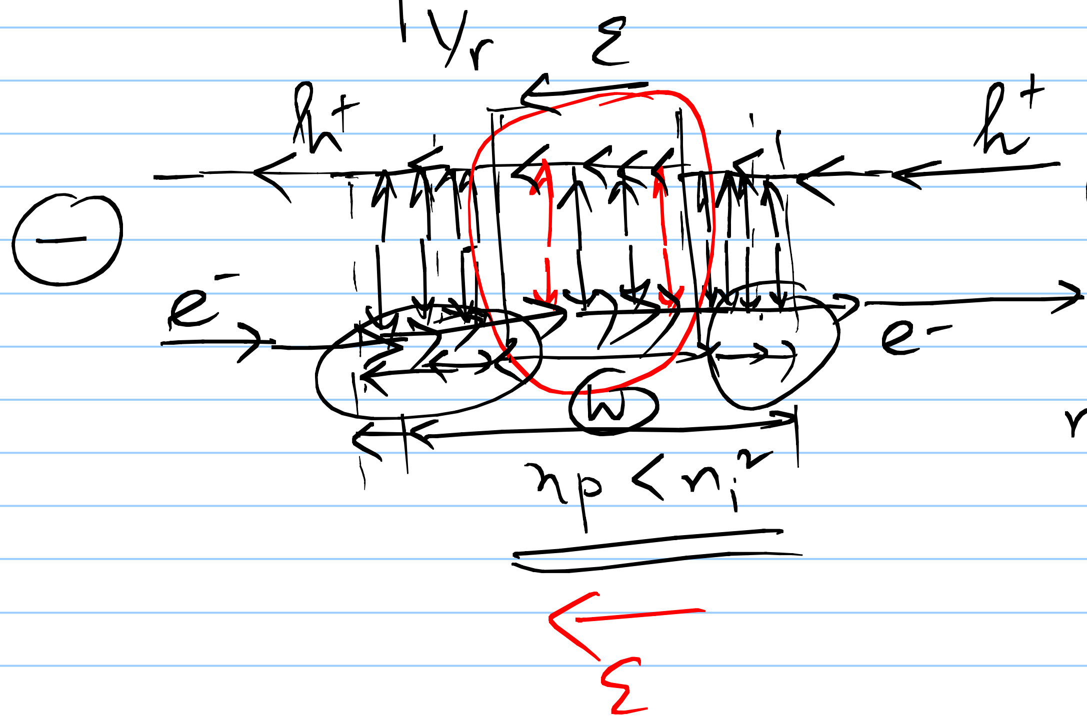
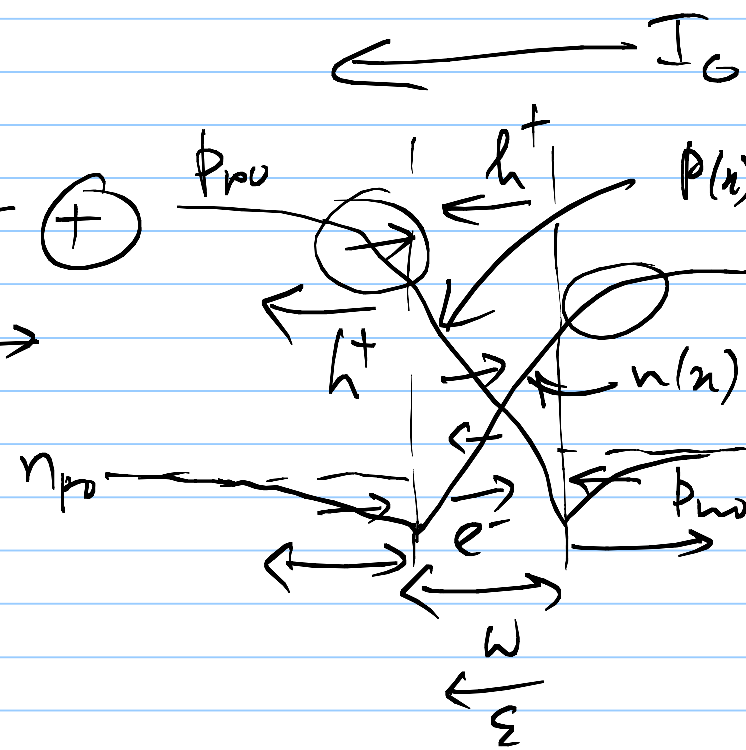
Breakdown in p-n junction

26/9/2014





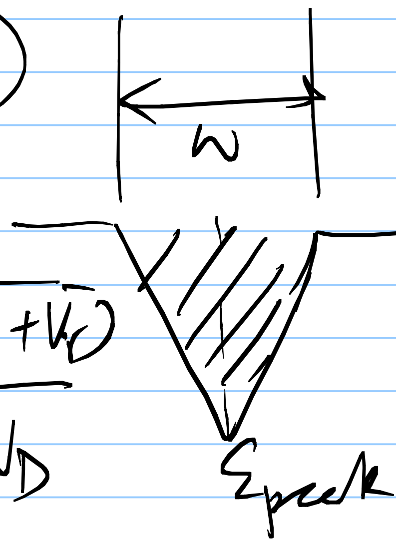


$\mathcal{E} \geq 10^6 \text{ V/cm} \rightarrow$ Si, Ge

→ Generation within SCR is significantly high

→ Breakdown occurs.

$$(V_0 + V_r) = \frac{1}{2} W \mathcal{E}_{peak}$$



$$\mathcal{E}_{peak} = \frac{2(V_0 + V_r)}{W}$$

$$\mathcal{E}_{peak} = \sqrt{\frac{2q(V_0 + V_r)N_D}{\epsilon_{Si}}}$$

$$p^+n \Rightarrow W = \sqrt{\frac{2\epsilon_{Si}(V_0 + V_r)}{q N_D}}$$

$N_A \approx 10^{20}/cm^3$

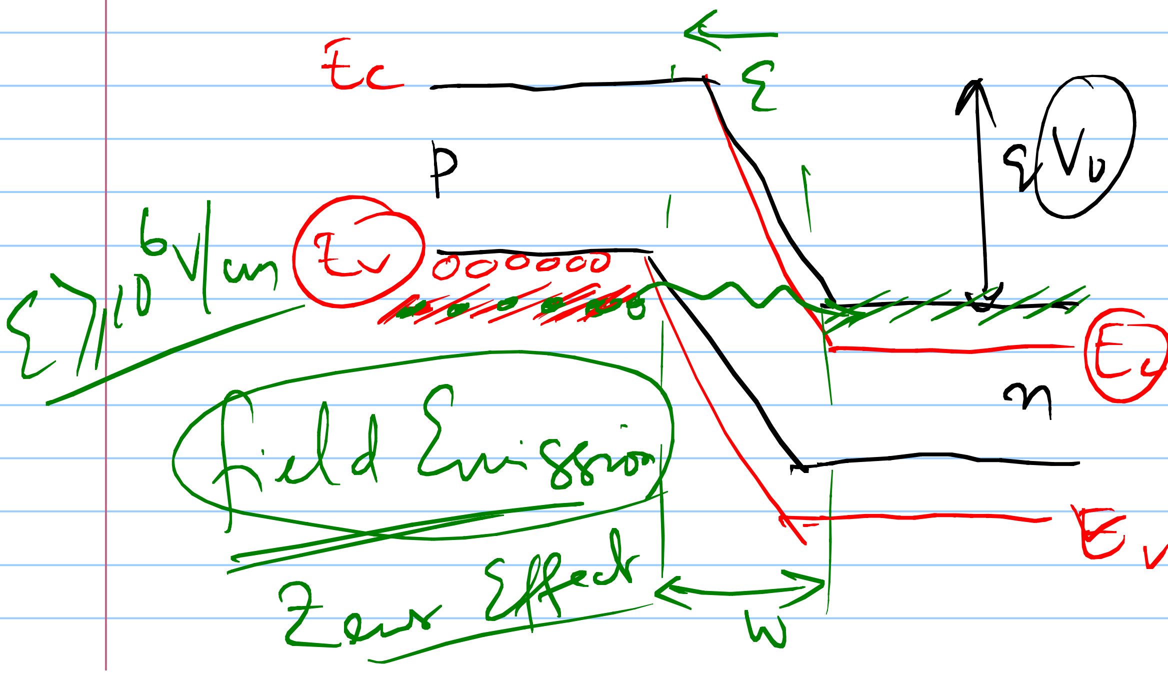
$N_D \approx 10^{18}/cm^3$

Zener Breakdown.

V_r is small, N_D is high for p^+n jn.

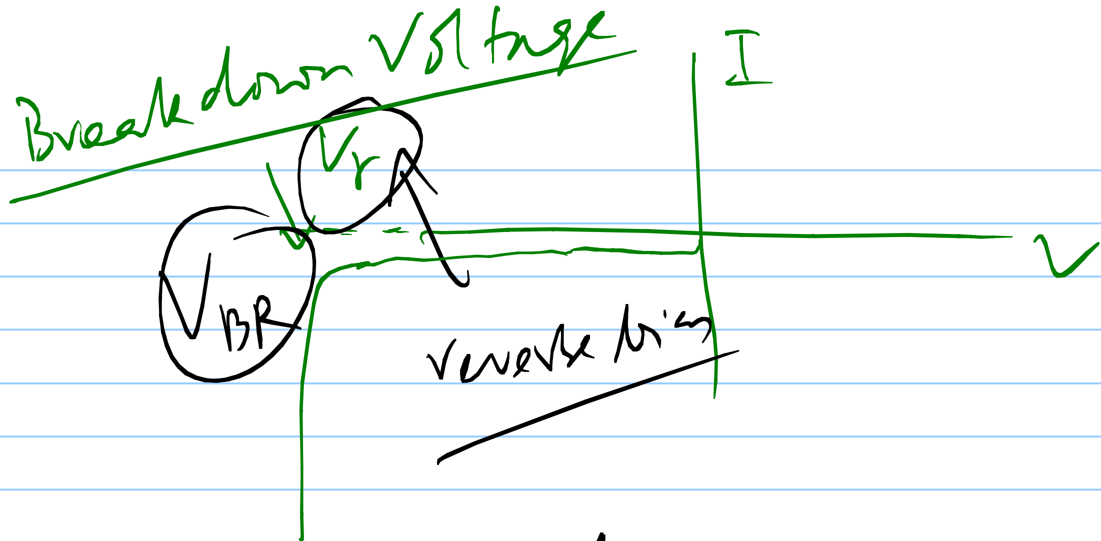
→ W is small

$$V_0 = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$$



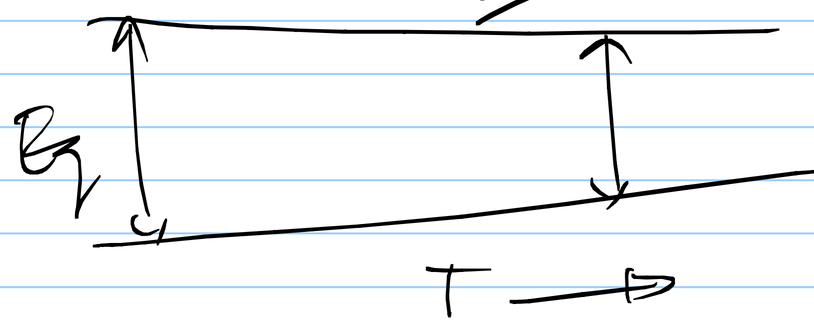
① { $\mathcal{E}_{peak}$ ↑ very high
W significantly small

② { → One side must be occupied by electron
→ Other side must be empty



Zener breakdown depends on E_g.

Temperature ↑ E_g ↓ small reduction of E_g.

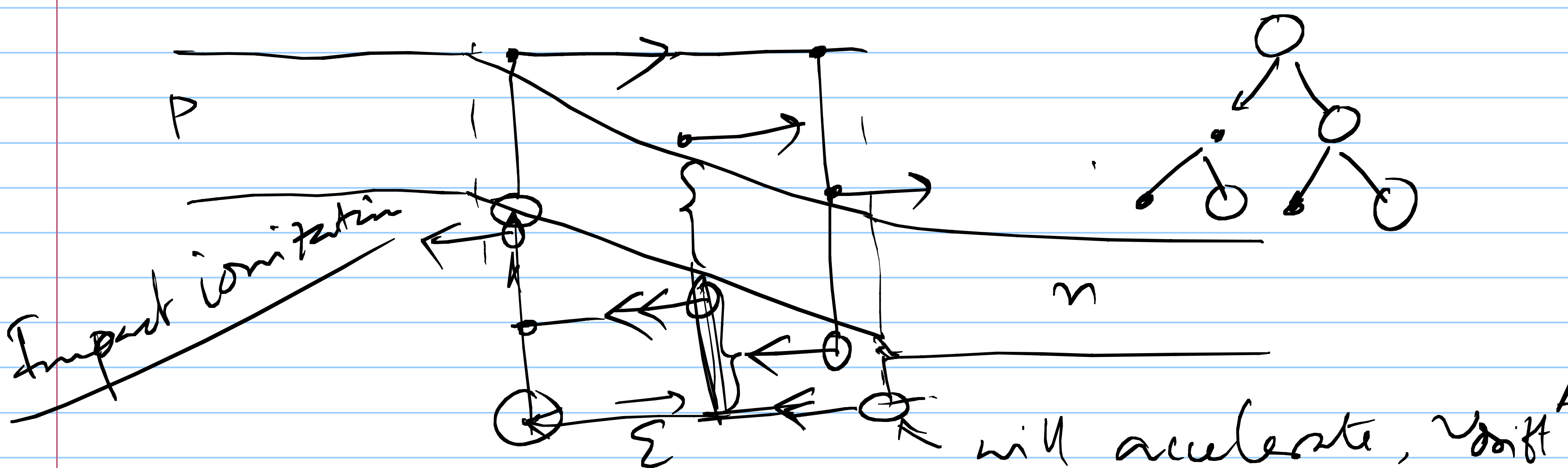


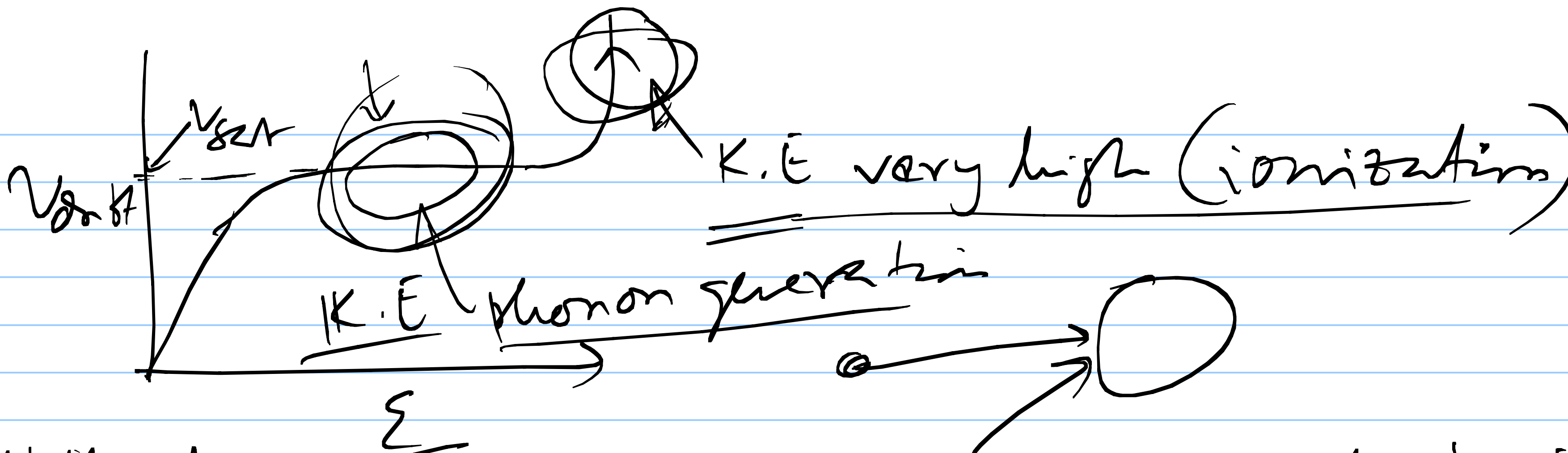
Zener Breakdown voltage will have negative Temp. coeff^n

Avalanche breakdown

$\mathcal{E} \geq 10^6 \, V/cm$ $\qquad$ $\mathcal{E} = \sqrt{\dfrac{2q(V_0+V_r)N_D}{\epsilon_s}}$

if $N_D \downarrow \Rightarrow W \uparrow$ $\mathcal{E}_{peak} \downarrow$





multiplication factor

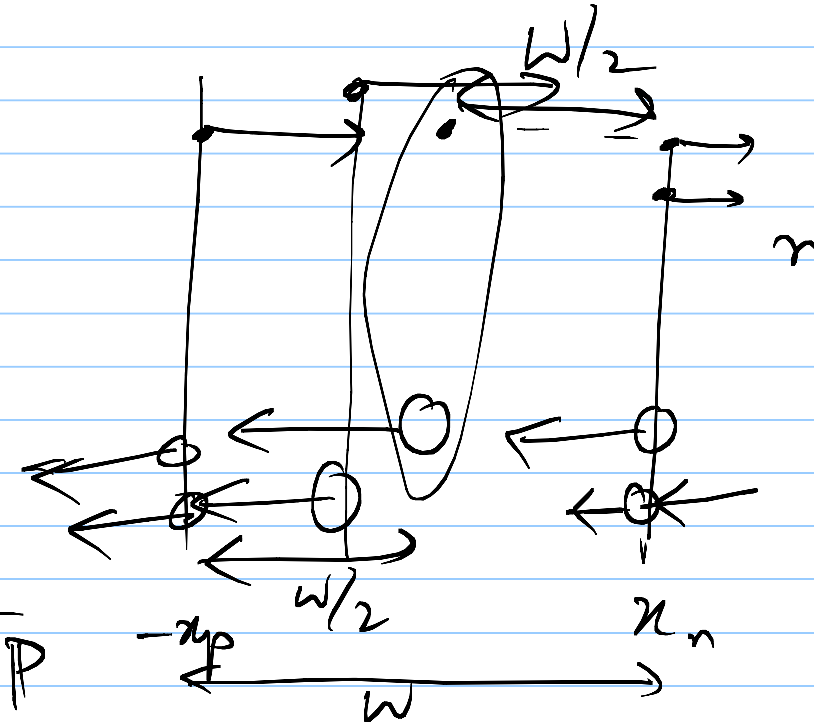
$$MI_0$$

- collision can be ionizing
- collision can be non-ion

P → probability to have an ionizing collision when a carrier is travelling through the SCR width 'W'

p^+n jn.

P_{in} $\quad P P_{in}$



$$P_{out} = P_{in} + P P_{in} + P P P_{in} + \dots$$

$$= P_{in}(1 + P + P^2 + P^3 + \dots)$$

$$P_{out} = \frac{P_{in}}{1-P} \Rightarrow M = \frac{P_{out}}{P_{in}} = \frac{1}{1-P}$$

$$M = \frac{1}{1-P} \Rightarrow P = 1 - \frac{1}{M}$$

$\alpha_n, \alpha_p \Rightarrow \alpha \longrightarrow$ ionization coeff^n.

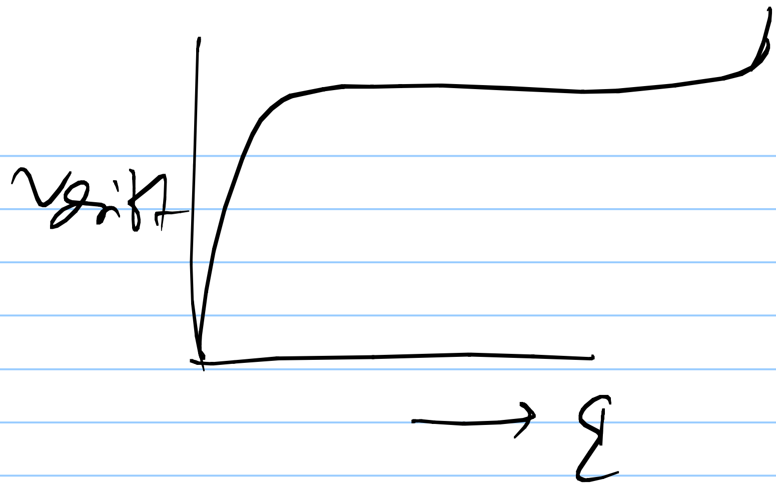
$$\alpha(x) = a_0 \, e^{-b/\mathcal{E}(x)}$$

$$1 - \frac{1}{M} = \int_{-x_p}^{x_n} \alpha(x)\,dx = P = \left(\frac{V_r}{V_{BR}}\right)^n$$

V_{BR} → Breakdown voltage

$a_0 \rightarrow /\text{cm}$

$b \rightarrow \text{V/cm}$

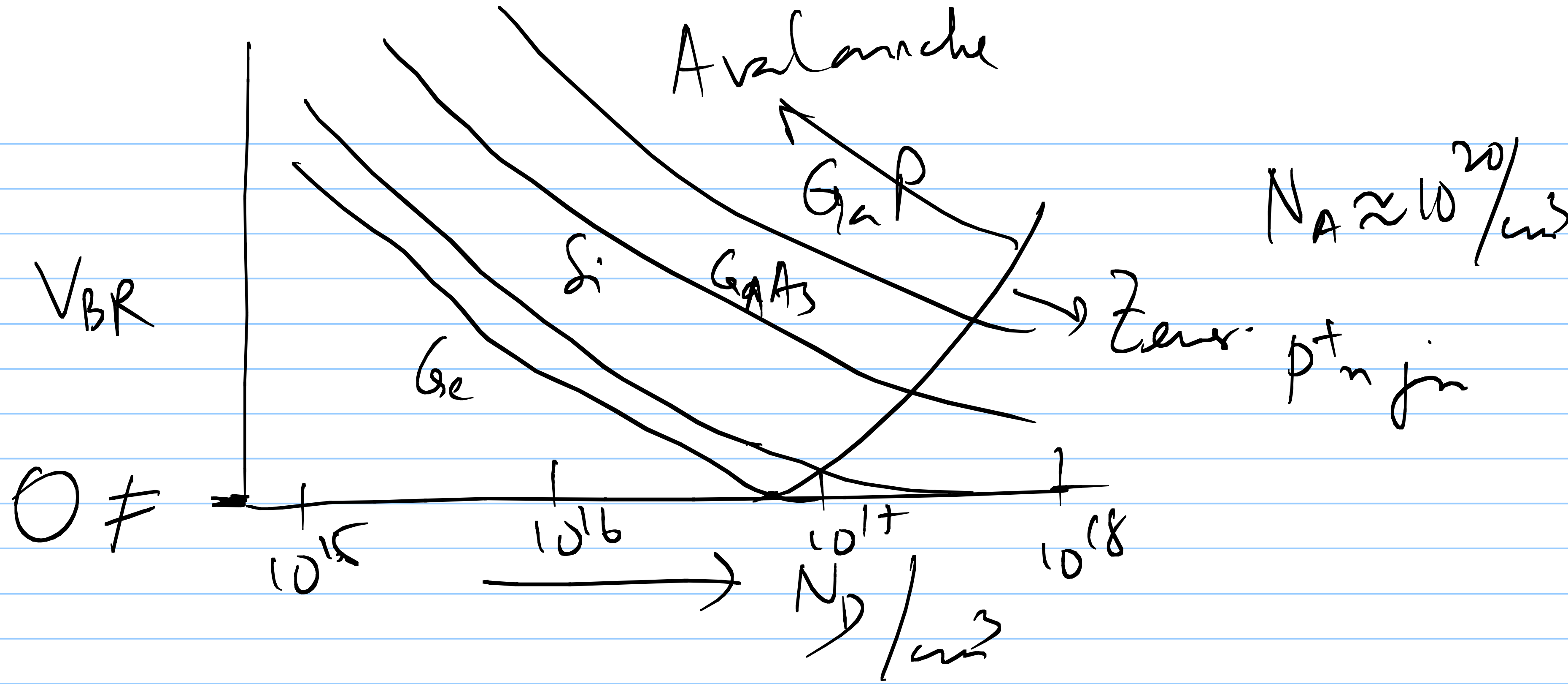


Temp ↑ → optical phonon ↑

Generation rate

P ↓

Avalanche breakdown
will have a +ve Temp. coeffⁿ.


Avalanche
GaP
GaAs
Si
Ge
V_{BR}
0 V
10^{15}
10^{16}
10^{17}
10^{18}
N_D/cm³
Zener
$N_A \approx 10^{20}$/cm³
p^+n jn