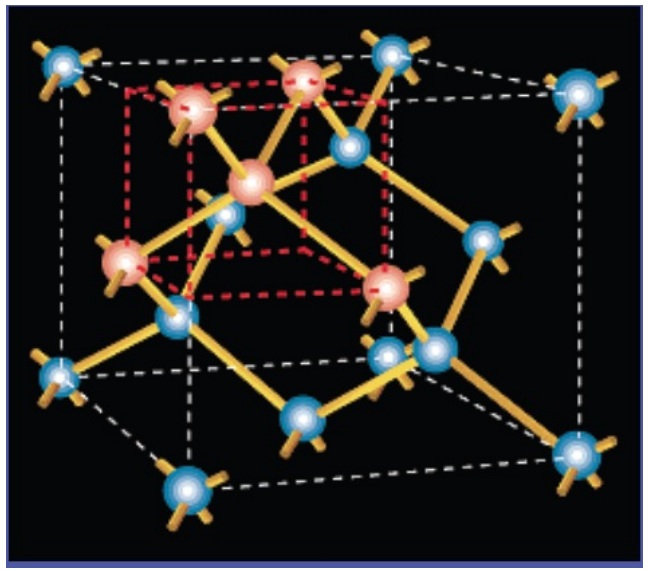
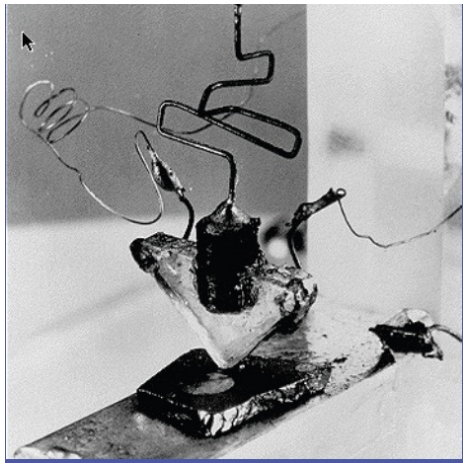
gfiori@mercurio.iet.unipi.it

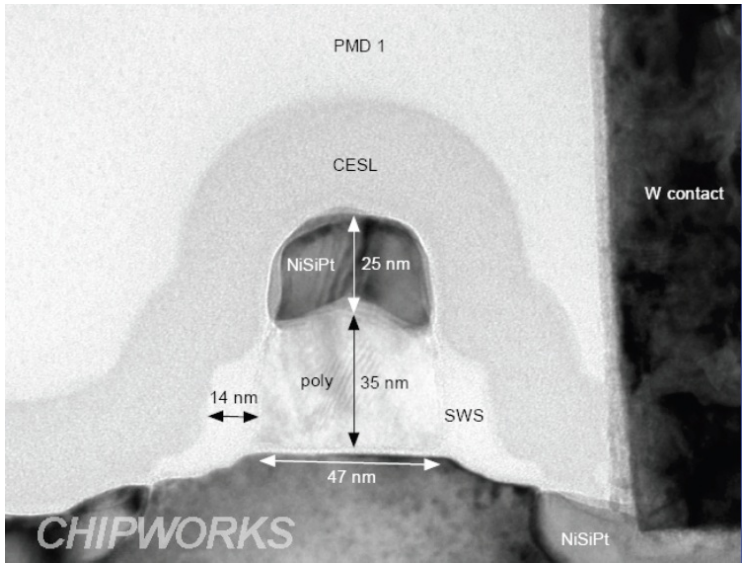
gianlucafiori.org

millmann-grabel-terreni

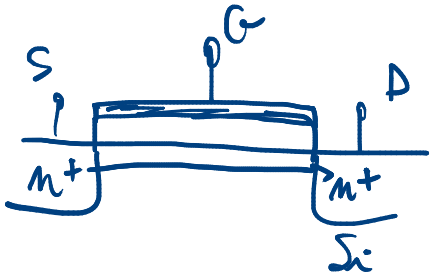
sedra-smith

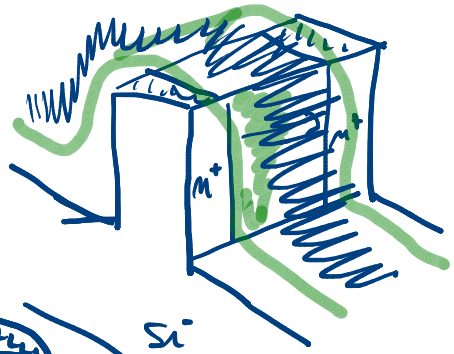


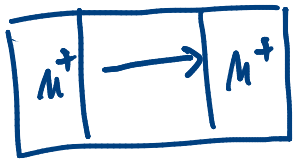


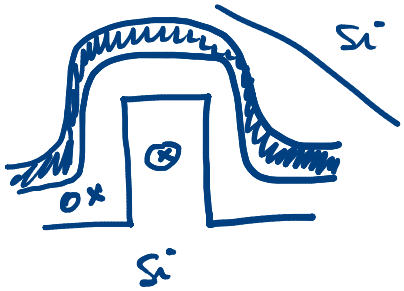


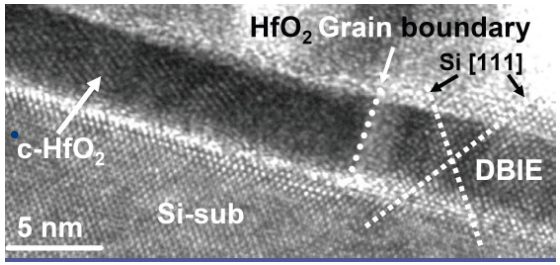
legge di moore

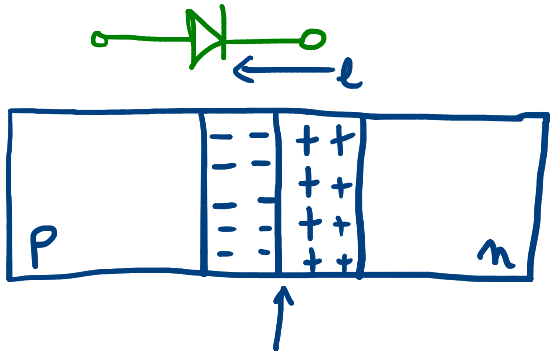




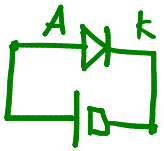


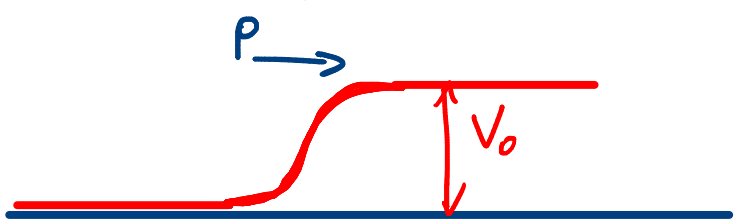




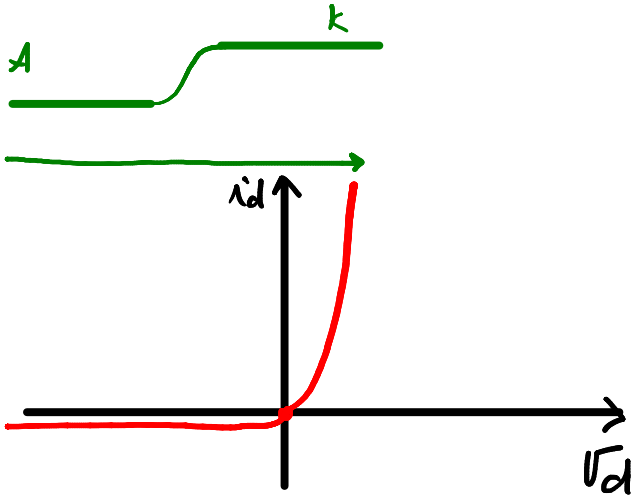


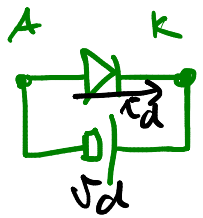
built-in

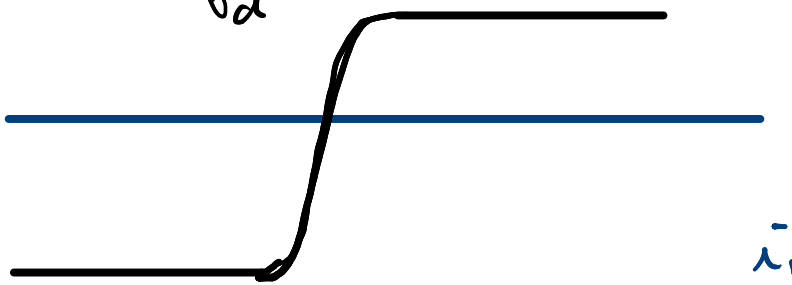




$V_{Ak} > 0$







SCHOCKLEY

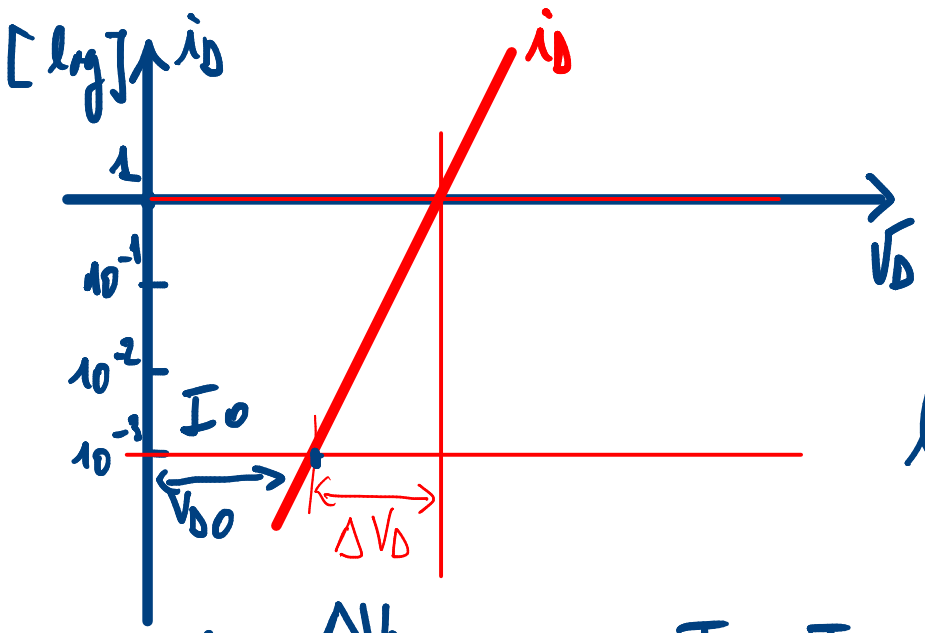
$$i_D = I_S \left(e^{\frac{V_D}{\eta V_T}} - 1 \right)$$

$V_T = \frac{k_B T}{q}$ $\quad k_B = 1{,}38 \cdot 10^{-23}\ J/K$

T = Temperature [K]

$V_T = 26\,mV$ $\quad q = 1{,}6022 \cdot 10^{-19}\ C$

$$i_D = I_S\left(e^{\frac{V_D}{\eta V_T}} - 1\right) \qquad V_D \gg \eta V_T \Rightarrow i_D \simeq I_S\, e^{\frac{V_D}{\eta V_T}}$$



$$\log\left(\frac{i_D}{I_0}\right) = \frac{V_D}{2.3\,\eta V_T} + \log\left(\frac{I_S}{I_0}\right)$$

$$\eta = \frac{\Delta V_D}{3 \cdot 2{,}3 \cdot V_T}$$

$$I_S = I_0 \cdot 10^{-\frac{V_{D0}}{2.3\,\eta V_T}}$$

$$\frac{dI_S(T)}{dT} \cong I_S(T) \cdot \frac{0{,}072}{K}$$

$$I_S(T) = I_S(T_0)\, e^{0{,}072\,(T-T_0)}$$

$$I_S(T_1) = 2I_S(T_0) = I_S(T_0)\, e^{0{,}072\,(T_1-T_0)}$$

$$T_1 = T_0 + \frac{\ln(2)}{0{,}072} = T_0 + 9{,}627\,K$$

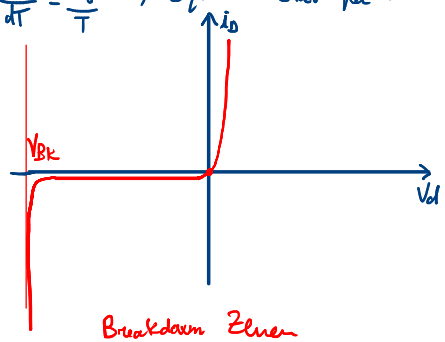
$V_F \qquad I_D = I_S\left(e^{\frac{V_F}{\eta V_T}} - 1\right)$

$$V_F = \eta V_T \ln\left(\frac{I_D + I_S}{I_S}\right) \qquad V_T = \frac{kT}{q}$$

$$\frac{dV_F}{dT} = \frac{V_F}{T} + \eta V_T \underbrace{\frac{I_S}{I_D + I_S}}_{\frac{d\ln}{dT}} \cdot \underbrace{\left(-\frac{I_D}{I_S^2}\right)}_{\frac{d\,\text{inv}}{dT}} \cdot \underbrace{I_S \cdot 0{,}072}_{\frac{dI_S}{dT}}$$

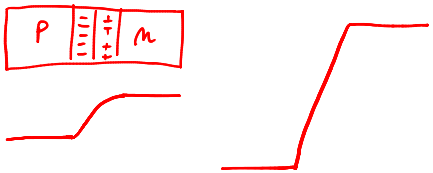
$I_S \ll I_D$

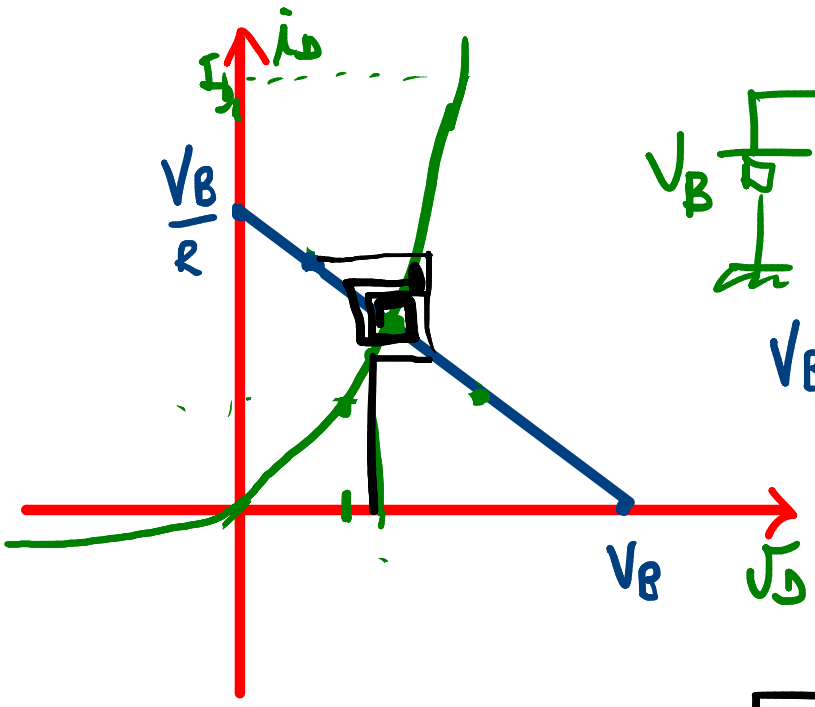
$$\frac{dV_F}{dT} = \frac{V_F}{T} - 0{,}072\,\eta V_T \qquad 2\,mV \text{ per } 1\,K$$

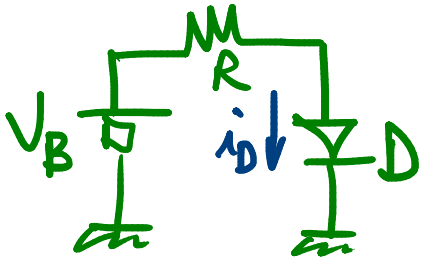


Breakdown Zener

" Valanga



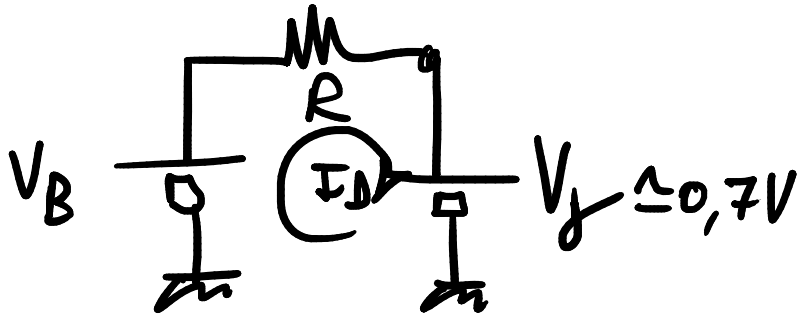




$$V_B = R\,i_D + V_D$$

$$i_D = \frac{V_B - V_D}{R}$$

$$\begin{cases} i_D = f(V_D) \\ i_D = \dfrac{V_B - V_D}{R} \end{cases}$$



$$I_D = \frac{V_B - V_J}{R}$$