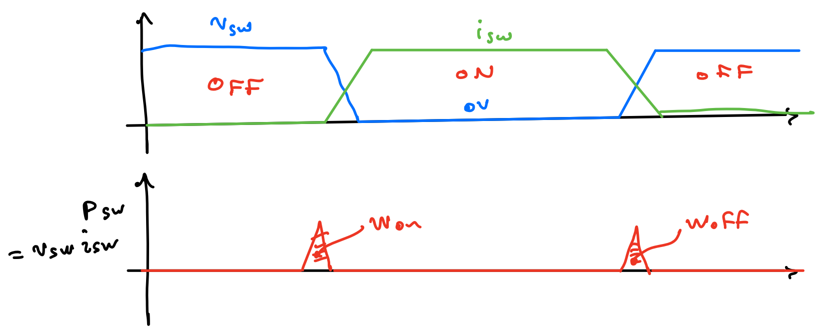
Lecture #12 10/27/21

.... continued.

- The big picture of sw losses.

  2 main types

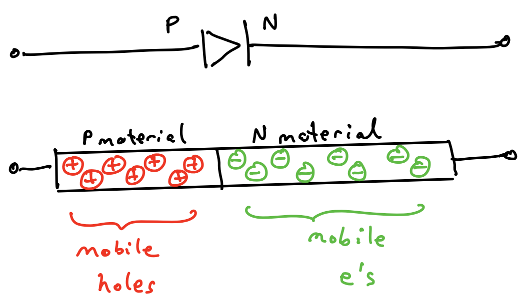
  - Diode "Reverse Recovery Loss" (Today)
  - Transistor finite turn on/off transition time



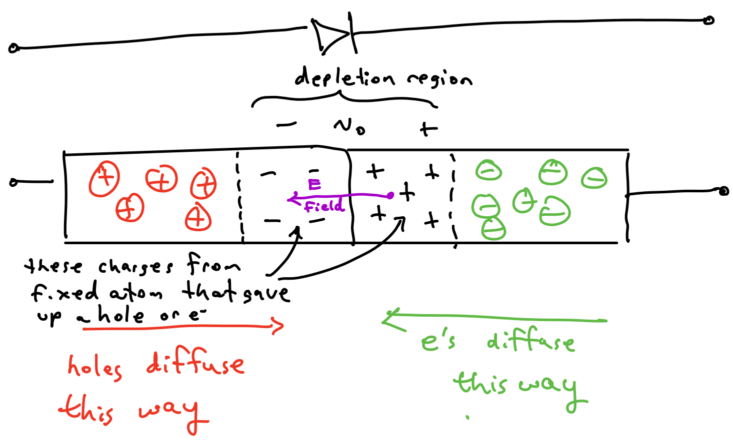
$\hookrightarrow$ $P_{sw} = (W_{on} + W_{off}) f_s$

- Diode semiconductor physics review

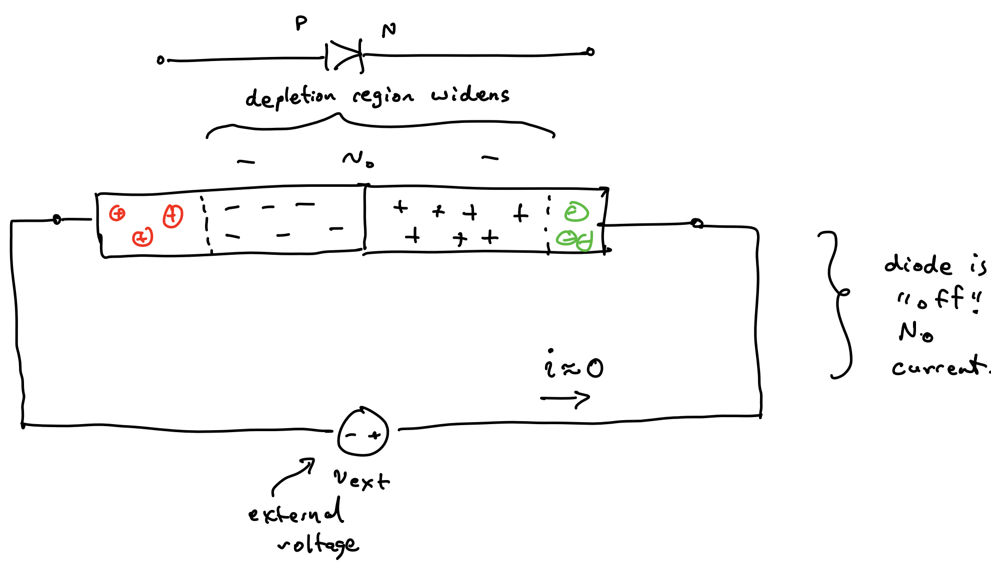
  - The PN Junction



• Diffusion & Reaching Equilibrium

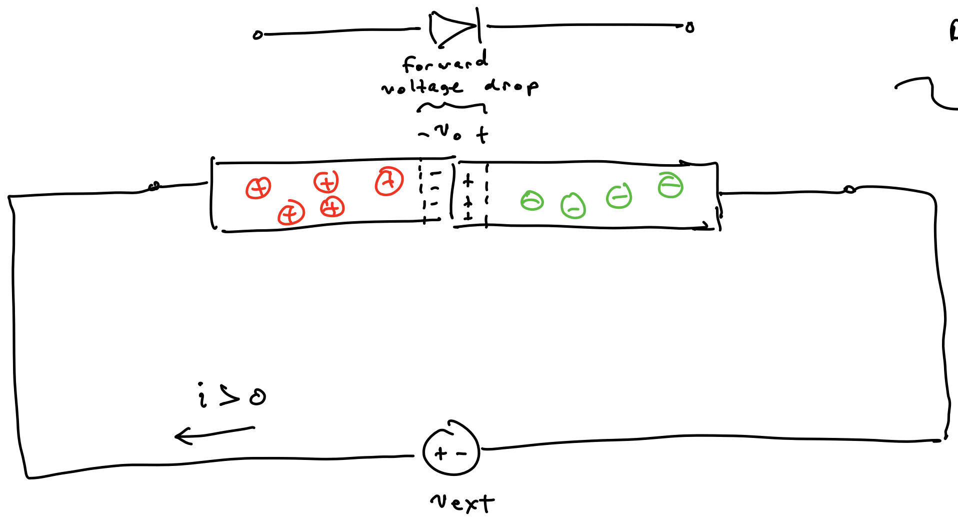


• Device under <u>reverse bias</u>



→ v_{ext} reinforces E field in depletion region & makes this region wider

- Forward biased diode (turned "on")



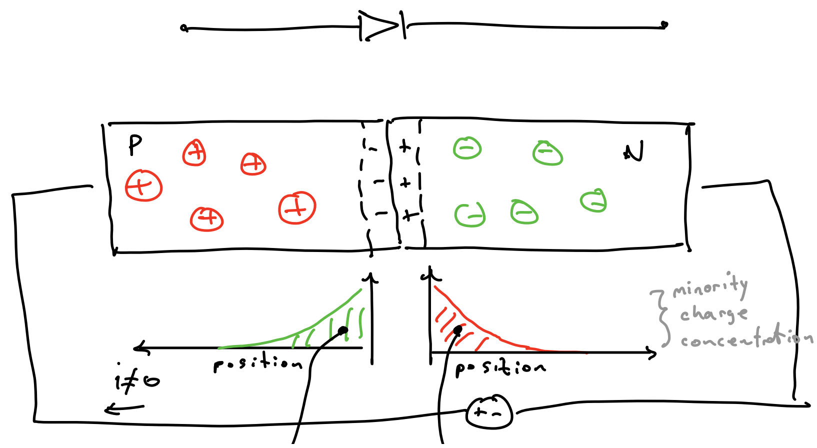
Diode is "on"

- External voltage makes depl. region narrow & cannot prevent diffusion of holes & e's.

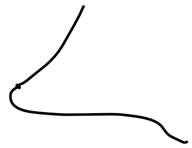
- Holes move across barrier & become "minority carriers" on other side. And vice versa for e's moving to P side.

- Conduction can continue w/ external voltage present.

— Charge Behavior in Diode



ON state



area gives total charge = q

- Forward current is due entirely to recombination
- The diode equation

$$q(t) = Q_0 \left(e^{\lambda V_{ext}(t)} - 1 \right) \quad , \quad \lambda = \frac{1}{26\,mV} \text{ @ } 300K$$

material dependent

take derivative

$$\frac{dq}{dt} = i(t) - \frac{q(t)}{\tau_L} \quad , \quad \tau_L = \text{minority lifetime}$$

In equilibrium, inflow current must equal outflow

$$\Rightarrow \frac{dq}{dt} = 0$$

$$\Rightarrow i(t) = \frac{q(t)}{\tau_L} = \frac{Q_0}{\tau_L} \left(e^{\lambda V_{ext}(t)} - 1 \right)$$

$$= I_0 \left(e^{\lambda V_{ext}(t)} - 1 \right)$$

famous diode eqn. Applies only in S.S.

- Reverse Recovery (happens at diode <u>turn off</u> transition)
  - To turn off, must remove a certain charge amount "Q_R" s.t. depletion region is re-established & device can turn off.

- Governed by instantaneous charge dynamics ... diode voltage & current can deviate from ideal equation.

— Reverse Recovery Circuit Example