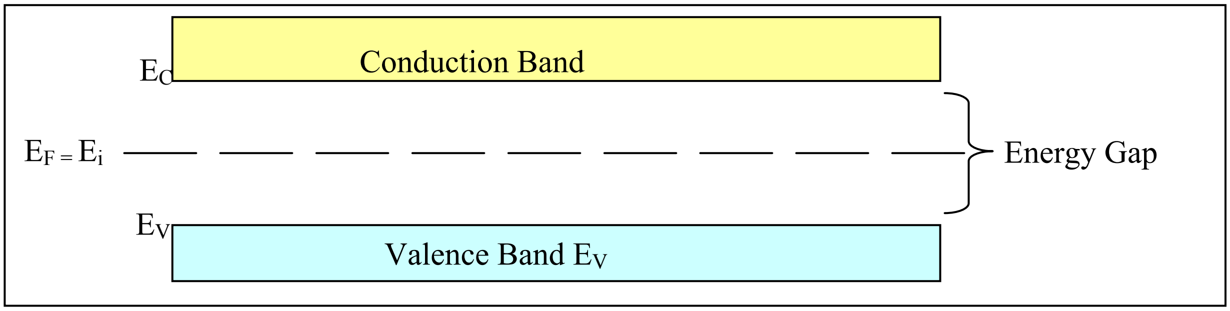
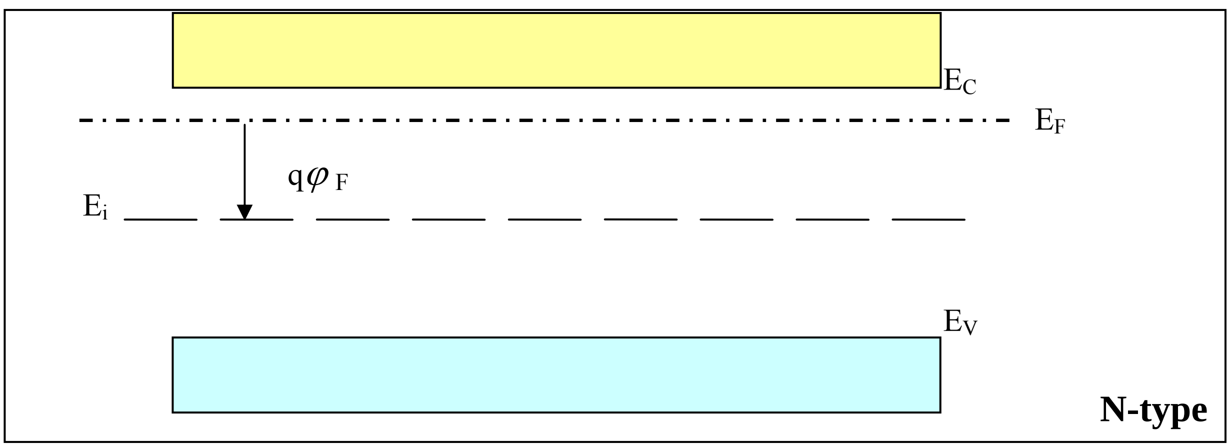
Energy Bands:

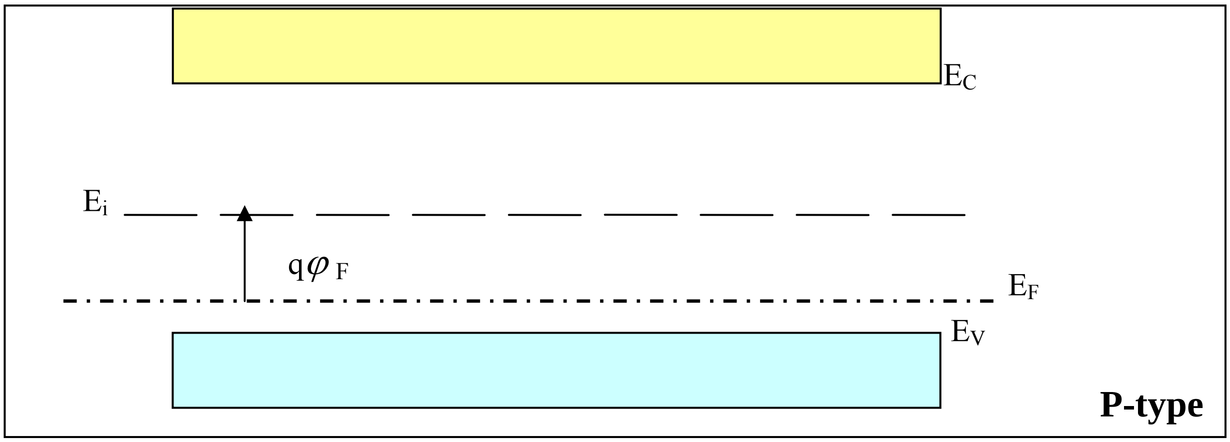
- The Fermi level:
    - This is an energy level in the energy gap that represents the point where the probability of finding an electron is = 0.5 .
    - For intrinsic semiconductors, the Fermi level E_F, is in the middle of the energy gap and it is called intrinsic Fermi-level E_i.



- For N-type semiconductors, E_F is closer to conduction band E_C. As a result, as N_D increases ➔ E_F get closer to E_C or φ_F increases.
  φ_F = Fermi potential = $(E_F - E_i)/q = V_t \ln(N_D/n_i)$ → positive
  $V_t \approx 0.025$ V, Thermal Voltage = constant/T



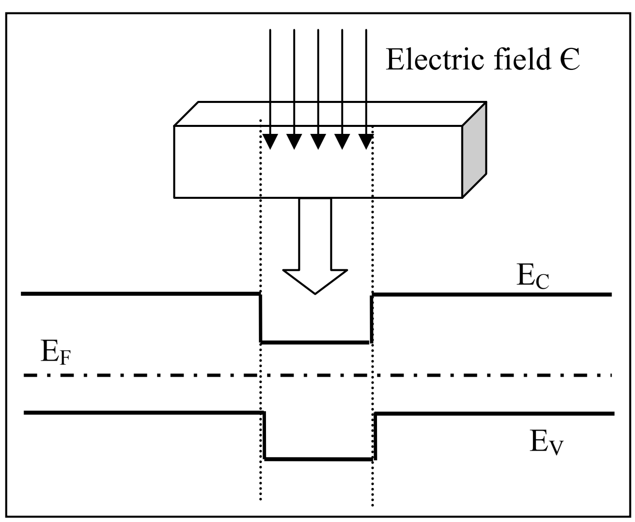
- For P-type semiconductors, E_F is closer to Valence Band E_V. As a result, as N_A increases ➔ E_F get closer to E_v.
  $\varphi_F = (E_F - E_i)/q = -V_t \ln(N_A/n_i)$ → negative



- In the absence of current flaw, the Fermi-level would be continuous and constant.

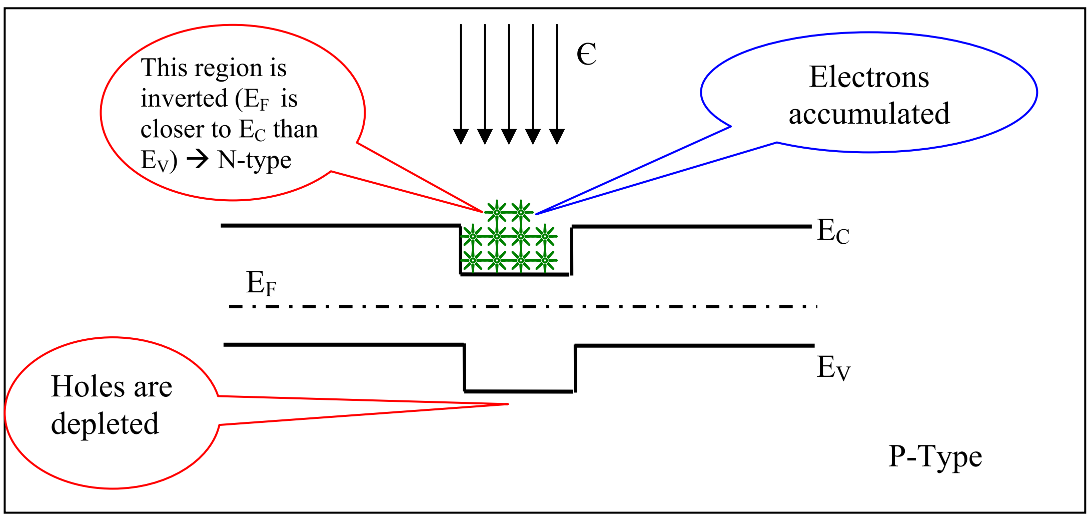
• <u>Energy Bands under Bias</u>:

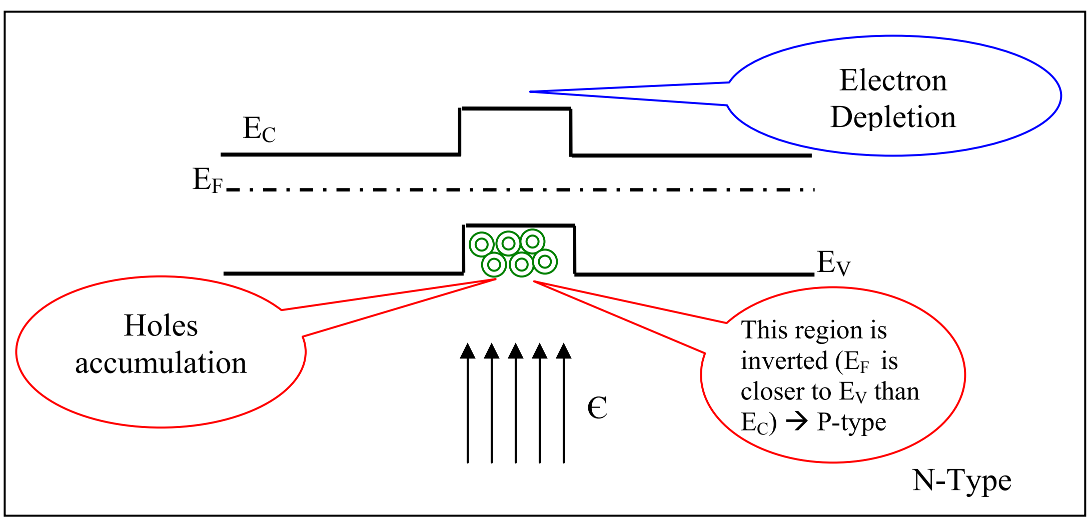
- An applied electric field pushes the bands in its direction, e.g



- Electrons act like liquid ➔ accumulate in lowest region in conduction Band. While holes act like bubbles ➔ accumulate in highest region in Valence Band.

- This effect could be used to invert a certain region in a semiconductor by applying a large enough voltage with the appropriate polarity.





The P-N Junction (Diode):

- The Diode is made by bringing into a contact a p-type semiconductor with an N-type semiconductor.
- Ferric level will align. As a result, the band will bend around the junction by $q(\varphi_{FN} - \varphi_{FP})$. This is called the Build-in potential.

$$V_{bi} = \varphi_{FN} - \varphi_{FP} = V_t \ln[(N_A * N_D)/n_i^2]$$

N_D = net Donor concentration on the N-side
N_A = net acceptor concentration on the P-side
V_{bi} is typically ≈ 0.5 V to 0.8 V