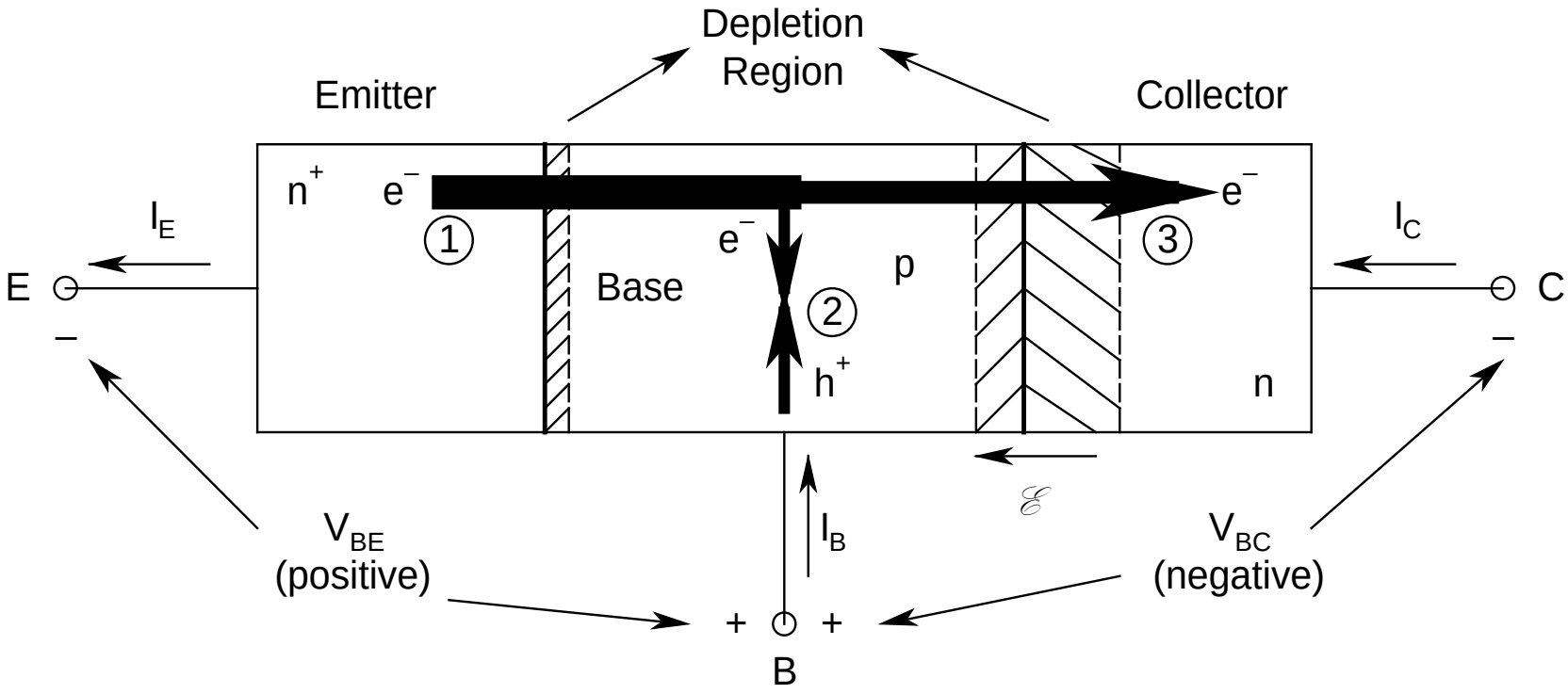
Operation in the Forward Active (FA) Mode



① Injection Component, ② Recombination Component, ③Collection Component

- ***BE junction forward biased*, *BC junction reverse biased***
- ***Emitter injects electrons to base***
  - ***Supplied by the external terminal to maintain charge neutrality in emitter***
    - ***Emitter current (I_E) flows out of the emitter terminal***
- ***Base injects holes to emitter***
  - ***This component is reduced as much as possible by doping emitter very heavily***

- Injected electrons ***diffuse*** through the base due to ***concentration gradient***
  - ➢ At the same time, some of them ***recombine*** with the ***holes*** in the ***base***
  - ➢ Supplied by the ***external terminal*** to maintain ***charge neutrality*** in ***base***
    - ***Base current*** (I_B) ***flows into the base terminal***
- Electrons that ***survived recombination*** will reach the ***base edge*** of the ***BC depletion region***

- Note the ***direction*** of the ***electric field*** (E) present in the ***BC depletion region***
- This ***field*** will ***sweep*** the ***survived electrons*** to the ***collector***
  - ➢ These ***electrons*** will ***flow out*** of the ***collector terminal***
    - ***Collector current*** (I_C) ***flows into the collector terminal***
- ***Base Control***:
  - ➢ A ***small change*** in I_B can cause a ***large change*** in $I_C \Rightarrow$ ***Transistor action***

- For a ***good transistor***, the ***ratio*** I_C/I_B should be ***as large as possible***
- Can be ***achieved*** by ***reducing*** the ***chances of recombination*** in the ***base***
- ***Two ways***:
  - ***Reduce base doping*** $\Rightarrow$ ***Limits supply of holes*** $\Rightarrow$ ***Reduces recombination***
  - ***Reduce base width*** $\Rightarrow$ ***Reduces amount of time electrons spend in base*** $\Rightarrow$ ***Reduces recombination***

Current Gain

- ***Common-Emitter (CE) Current Gain***:
  - $\beta = I_C/I_B$ (***Higher the better***!)
- ***Common-Base (CB) Current Gain***:
  - $\alpha = I_C/I_E$ (≤ 1: ***closer to 1, better it is***!)
- Also, $I_E = I_C + I_B$
  - $\alpha = \beta/(\beta + 1)$ and $\beta = \alpha/(1 - \alpha)$
- ***Note***: As $\alpha \rightarrow 1$, $\beta \rightarrow \infty$
- ***Typical values***: $\beta \sim$ 100-5000, $\alpha \sim$ 0.99-0.9998