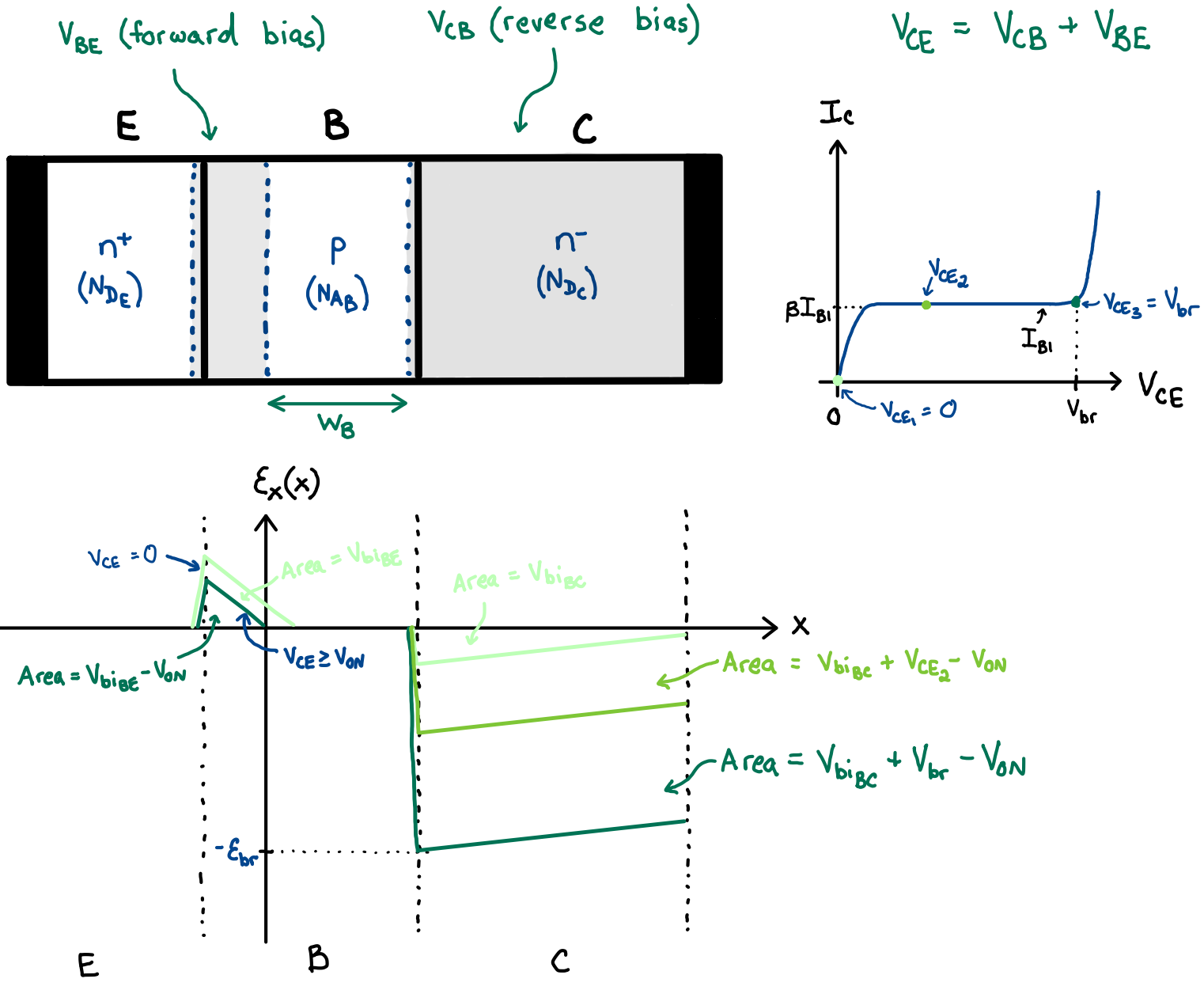
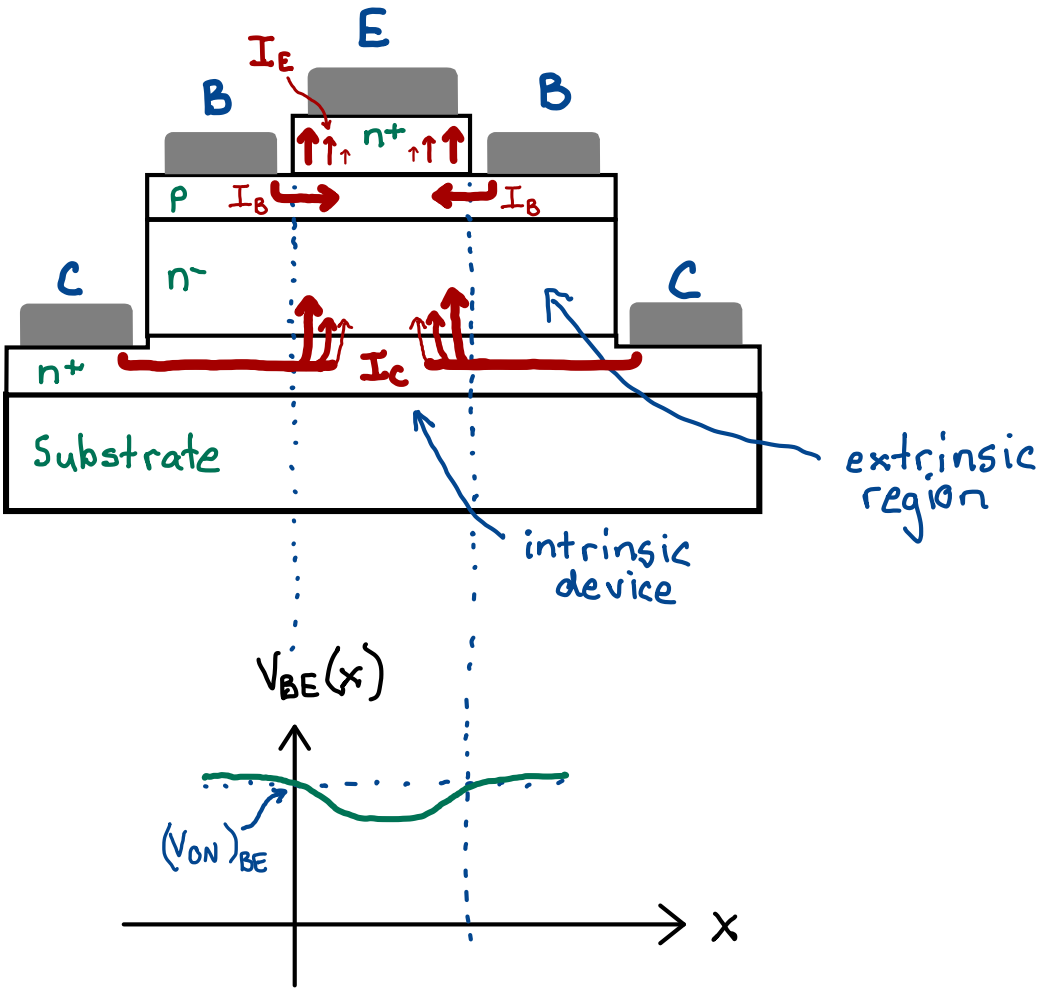
Breakdown in BJTs



Can you draw band diagrams for each of these 3 values of V_{CE}?

Problems Encountered in this Device:



- Base resistance
  - Thin, moderately doped base
  - Separation between base contact and emitter mesa
- Current crowding
  - Thin, moderately doped base

Summary of BJT design parameters:

→ To maximize β:

- make W_B small
- make $N_{A_B} << N_{DE}$

} Leads to large R_{base} and current crowding

→ To mitigate Early effect and increase V_{br}:

- make collector n- and thick

Limited by RF parameters and Kirk Effect (to be discussed)

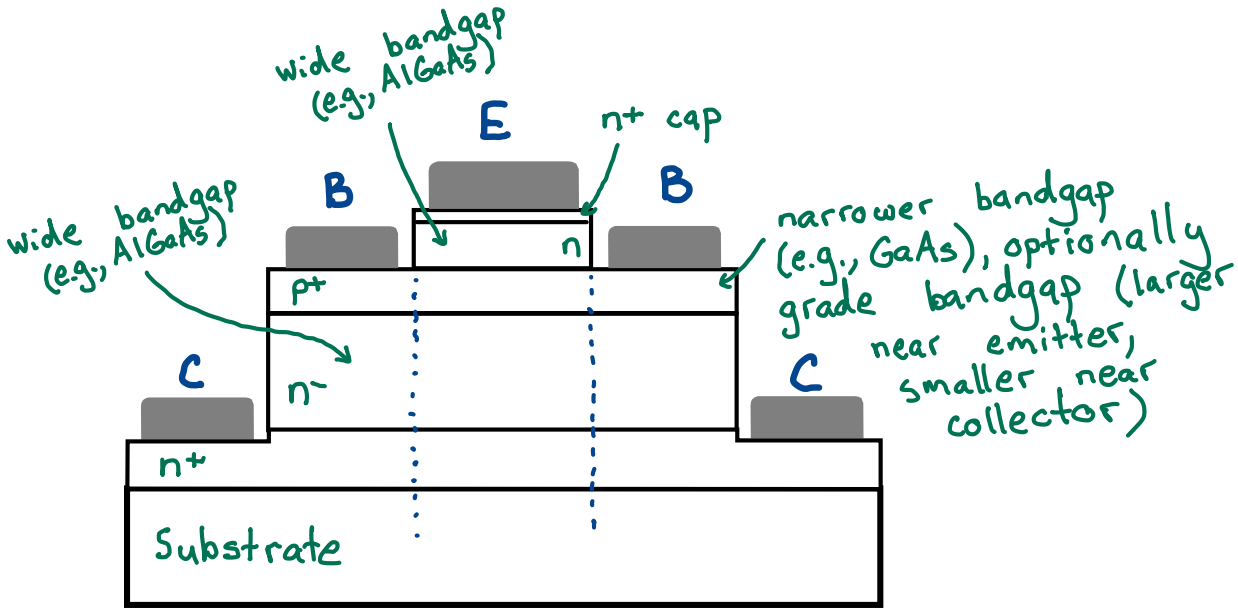
How do we address R_{base} and current crowding issues?

→ Device design

→ Processing techniques

(Different solutions for Si than for III-V semiconductors)

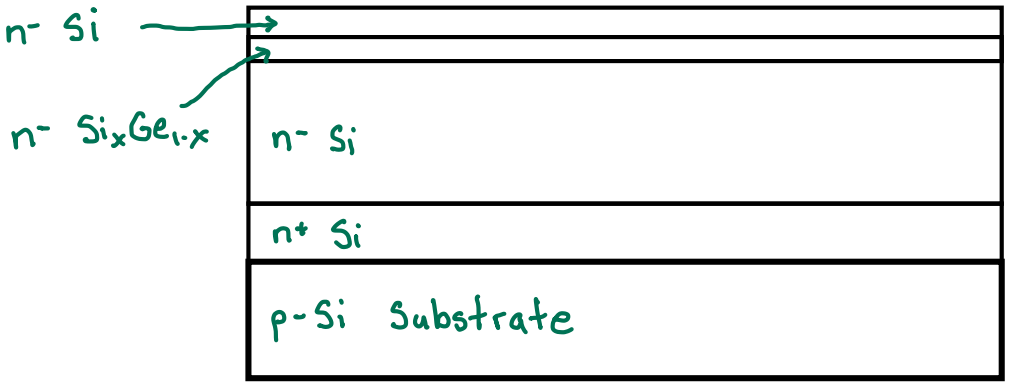
AlGaAs / GaAs DHBT:



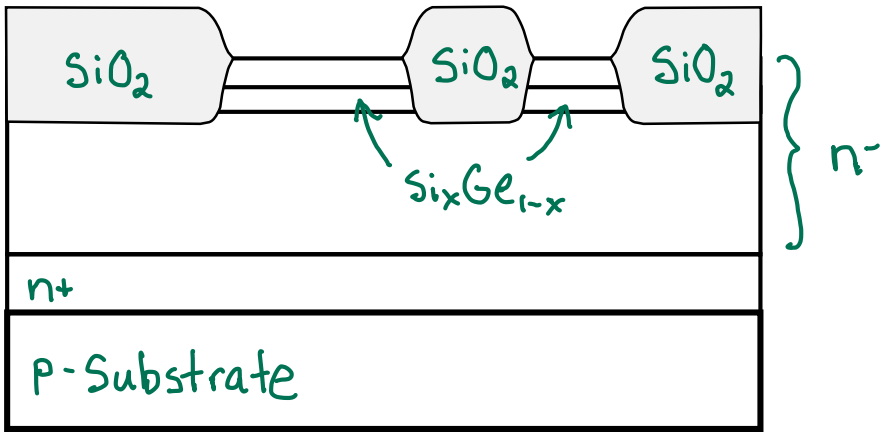
- Wide bandgap emitter allows high base doping (p^+) while maintaining γ close to 1
- p^+ base reduces R_{base} and current crowding
- n^+ emitter cap maintains good emitter contact
- Wide bandgap collector increases breakdown voltage

Si Double Polysilicon HBT w/ self aligned emitter/base:

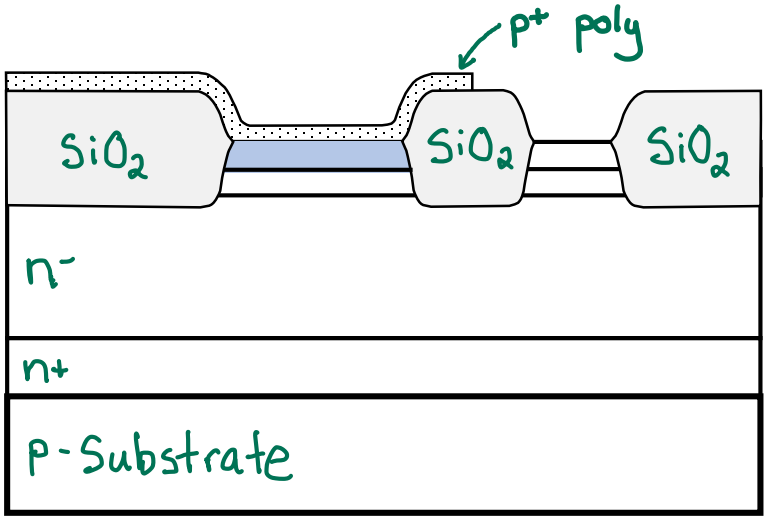
1. Epitaxial growth of material layers



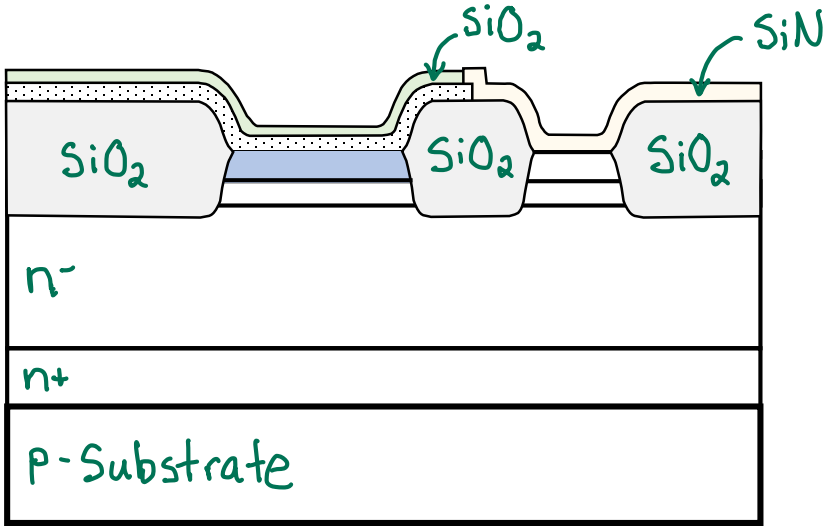
2. Local oxidation (LOCOS) of Si



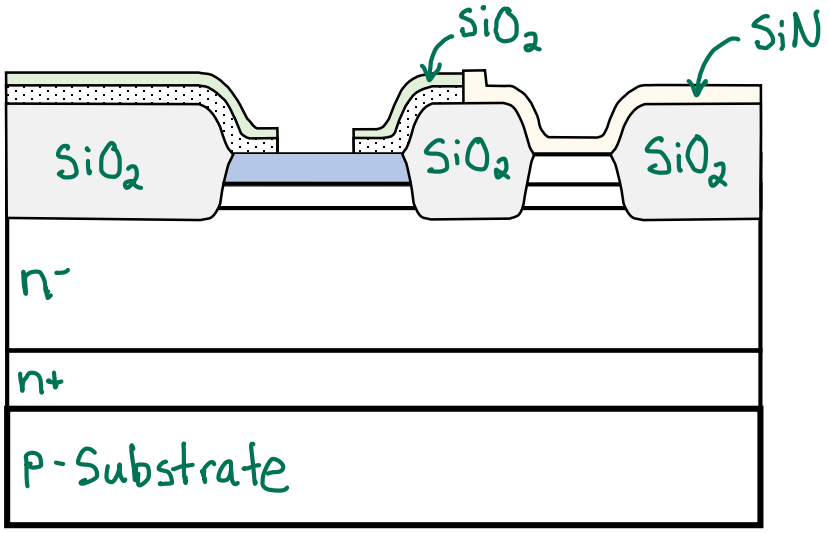
3. p+ polysilicon deposition, p-diffusion (anneal)



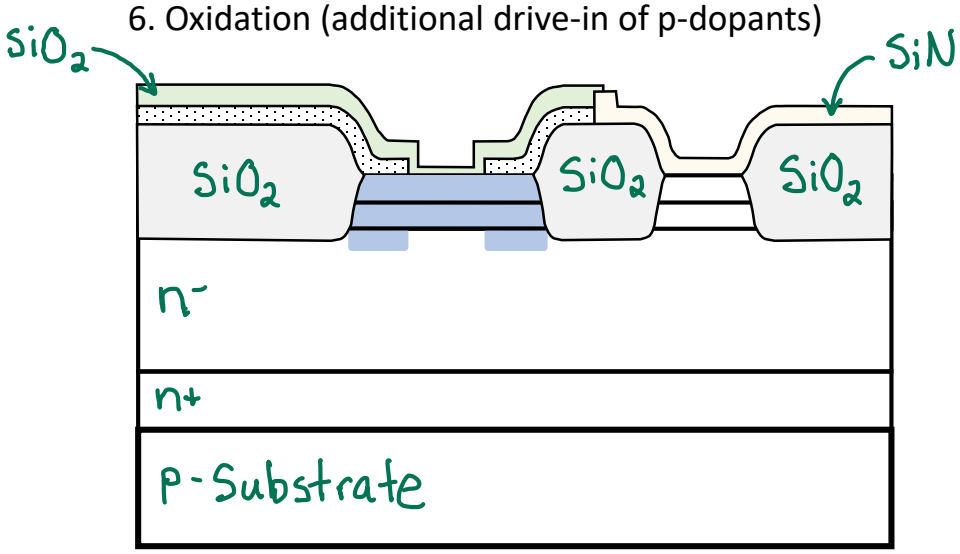
4. SiN mask, oxidation of p+ poly



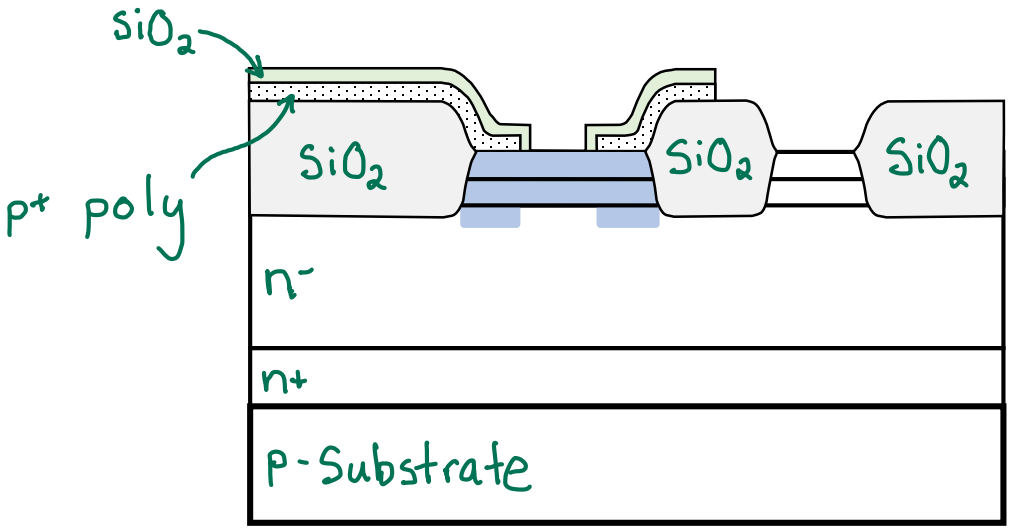
5. Etch p+ polysilicon and SiO_2



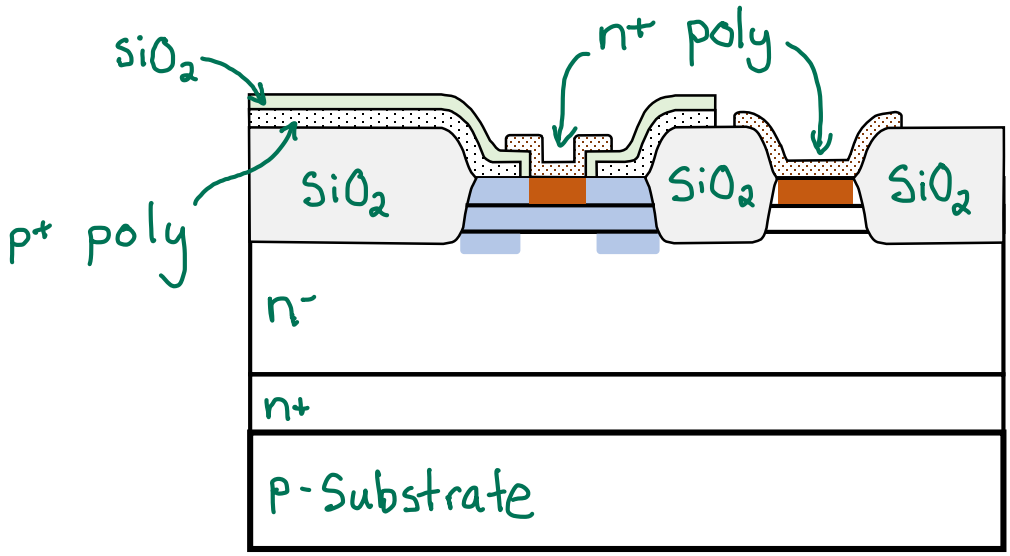
6. Oxidation (additional drive-in of p-dopants)



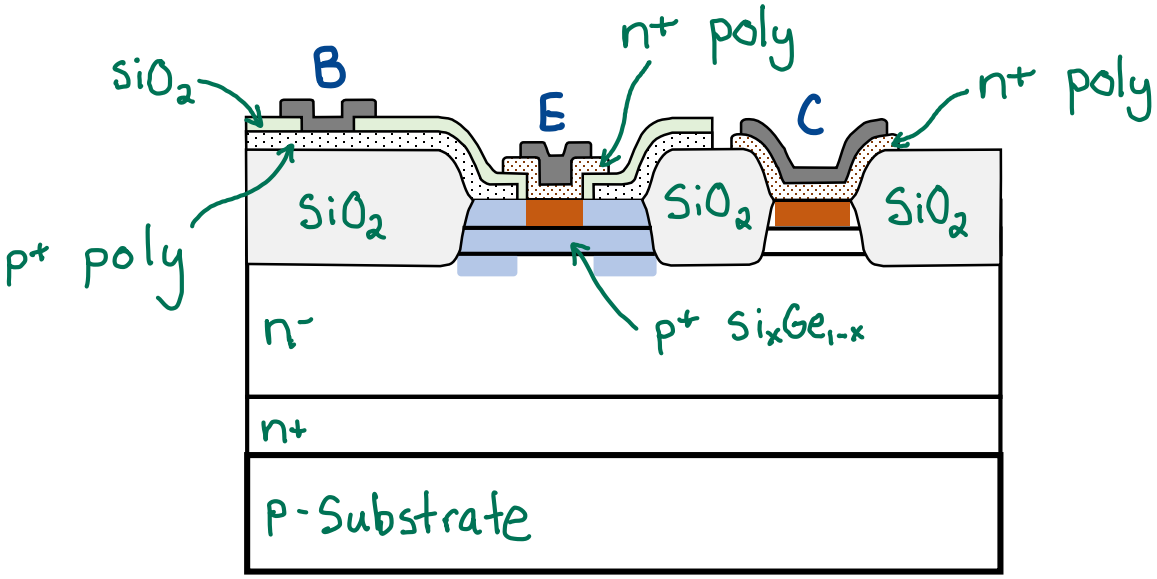
7. Anisotropic etch of SiO_2, remove SiN



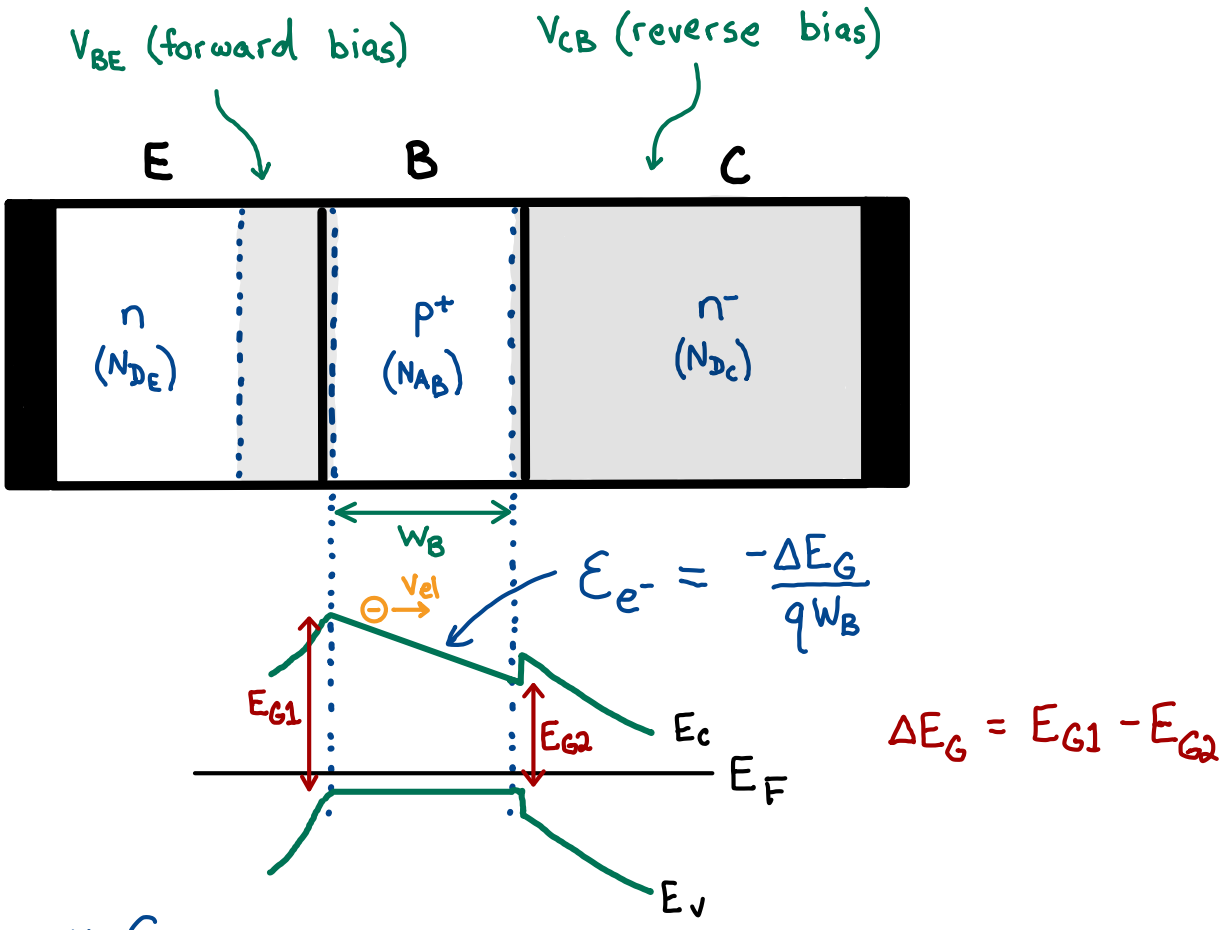
8. n+ polysilicon deposition, n-diffusion (anneal)



9. SiO_2 etch, deposit contacts



Graded Bandgap in the Base



- $v_{el} = -\mu_n \mathcal{E}_{e^-}$
- Quasi $\mathcal{E}$-field in base pulls e^-'s across base at a faster rate than diffusion rate, doesn't impact holes
- For the same value of V_{BE}, this increases J_{nE} by a factor $(\Delta E_G/kT)$, while J_{pE} and J_{rec} remain unchanged (see Muller/Kamins for derivation)
- Linear grade in base increases β by a factor $(\Delta E_G/kT)$