IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Microelectronics: Devices to Circuits

BJT: Second Order Effects

SUDEB DASGUPTA

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



$$I_C = (\alpha_N I_E + I_{CO})M = (\alpha_N I_E + I_{CO})\frac{1}{1 - (V_{BC}/BV_{CBO})^n}$$

Where M is a multiplication factor

Injection level, Thermal Effects:

- Parameters α and β of a practical transistor may vary considerably with injection level, which is determined by magnitude of I_E and I_C.
- For very low injection, the assumption of negligible recombination in the junction depletion region is invalid.

Source: Solid State Electronics Devices, BEN G. STREETMAN & SANJAY KUMAR BANERJEE, SIXTH EDITION

- The base conductivity modulation effects results in a decrease in ϒ(emitter injection efficiency).
- Large value of I_C is responsible for significant power dissipation in the transistor and therefore heating effect of the device.
- Power dissipation due to collision of carriers into the lattice.
- Power dissipation does not exceed the maximum power rating of the device.
- In the devices designed for high power capability, the transistor is mounted on an efficient heat sink, so that thermal energy can be transferred away from the junction.

Source: Solid State Electronics Devices, BEN G. STREETMAN & SANJAY KUMAR BANERJEE, SIXTH EDITION

- If the temperature of the device is allowed to increase due to power dissipation or thermal environment, the transistor parameters changes.
- The most important parameter depend on the temperature are the carrier lifetimes and diffusion coefficients.
- The mobility decreases with increasing temperature in the lattice –scattering range, varying approximately as $T^{\frac{3}{2}}$.
- D_p decreases as the temperature increases, thereby causing a drop in β due to an increasing transit time τ_t.
- β becomes larger as device is heated.

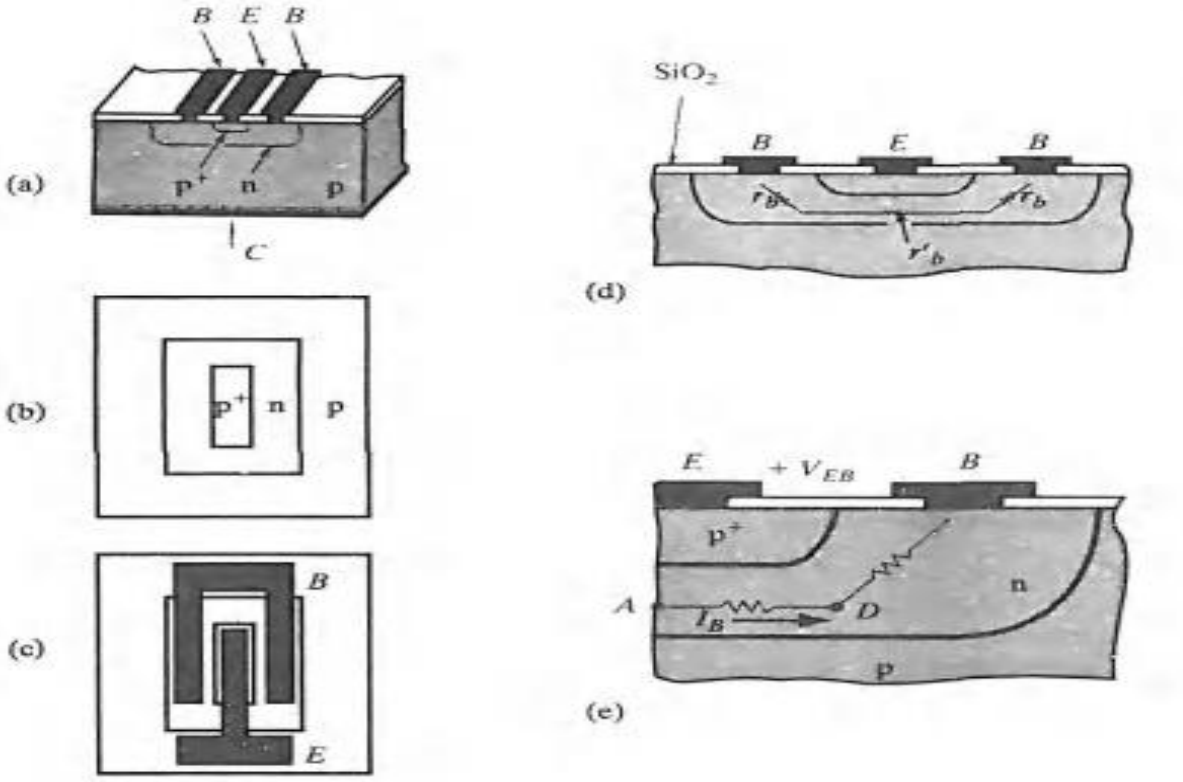
Source: Solid State Electronics Devices, BEN G. STREETMAN & SANJAY KUMAR BANERJEE, SIXTH EDITION

- The thermal runaway can occur if the circuit is not designed to prevent it.
- Runway of the collector current can result in overheating and destruction of the device.

Base resistance and emitter crowding:

- Large area bipolar transistor can have non-uniform current distribution due to the resistance of the base layer.

Source: Solid State Electronics Devices, BEN G. STREETMAN & SANJAY KUMAR BANERJEE, SIXTH EDITION



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Recapitulation

- BJT can be used as a inverter on in saturation region and off in cutoff.
- Second order effects affect the performance of the BJT devices.
- Base region is lightly doped in BJT devices.
- Carrier mobility decreases with increases in temperature.
- To avoid the thermal runaway designer used the heat sink.
- Structural effects are important in determining the operation of the transistor.

Thank You