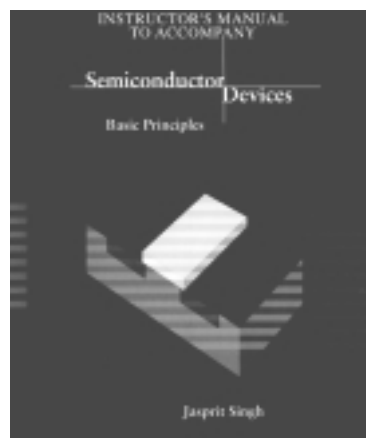

Chapter

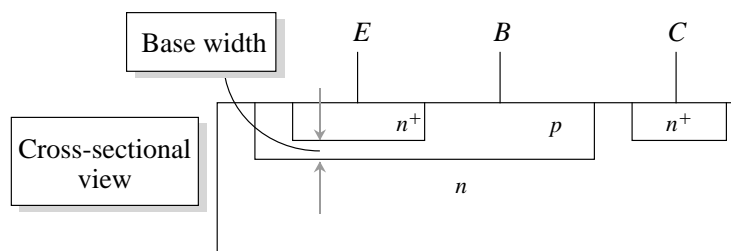
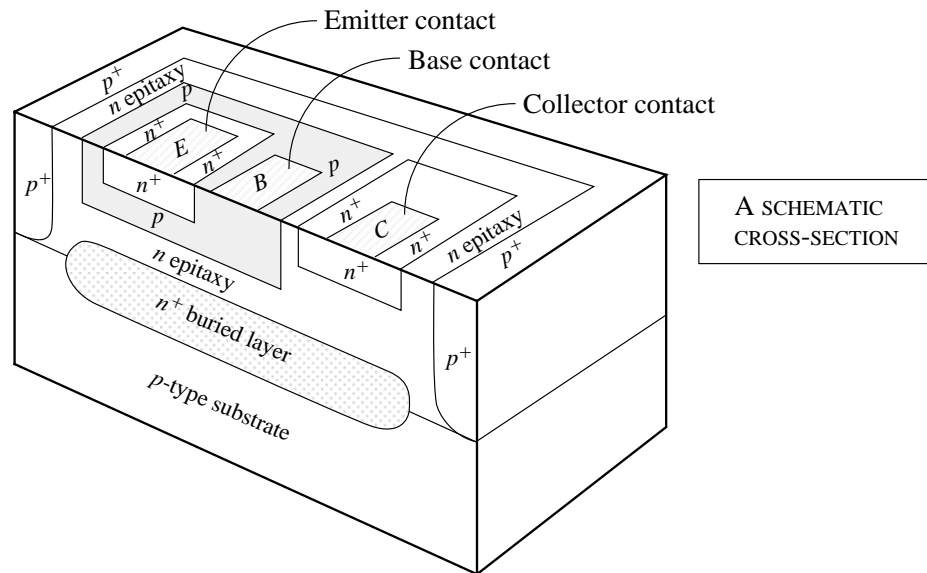
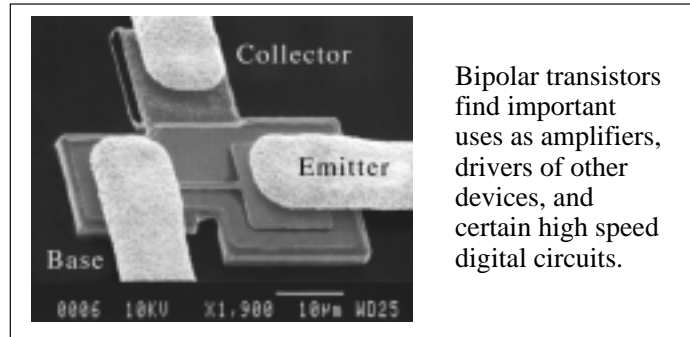
8

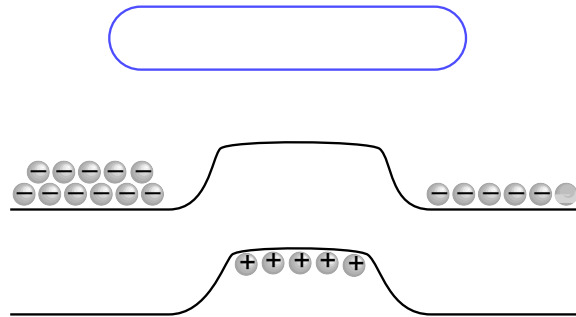
BIPOLAR JUNCTION TRANSISTORS

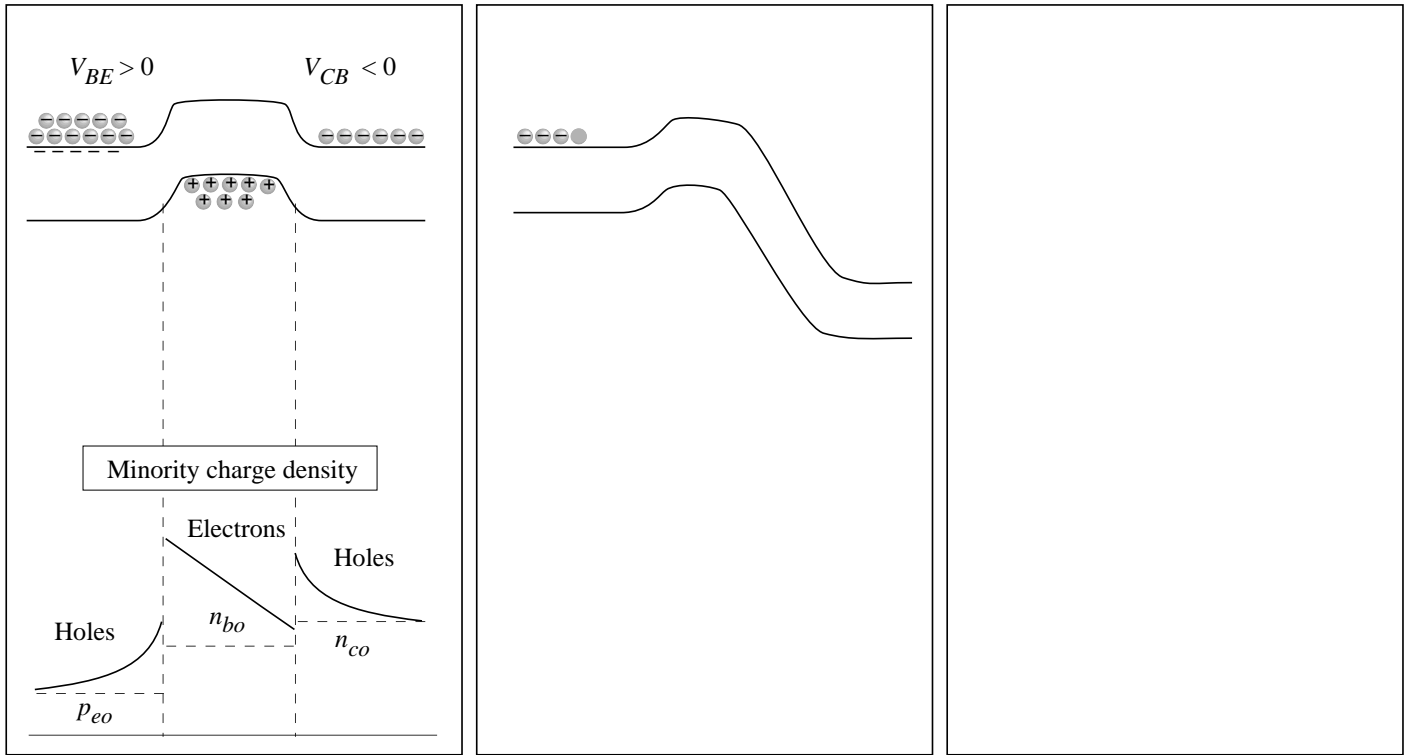


Bipolar junction transistors are important in numerous technologies—amplifiers, oscillators, high speed logic. The following pages provide an overview.

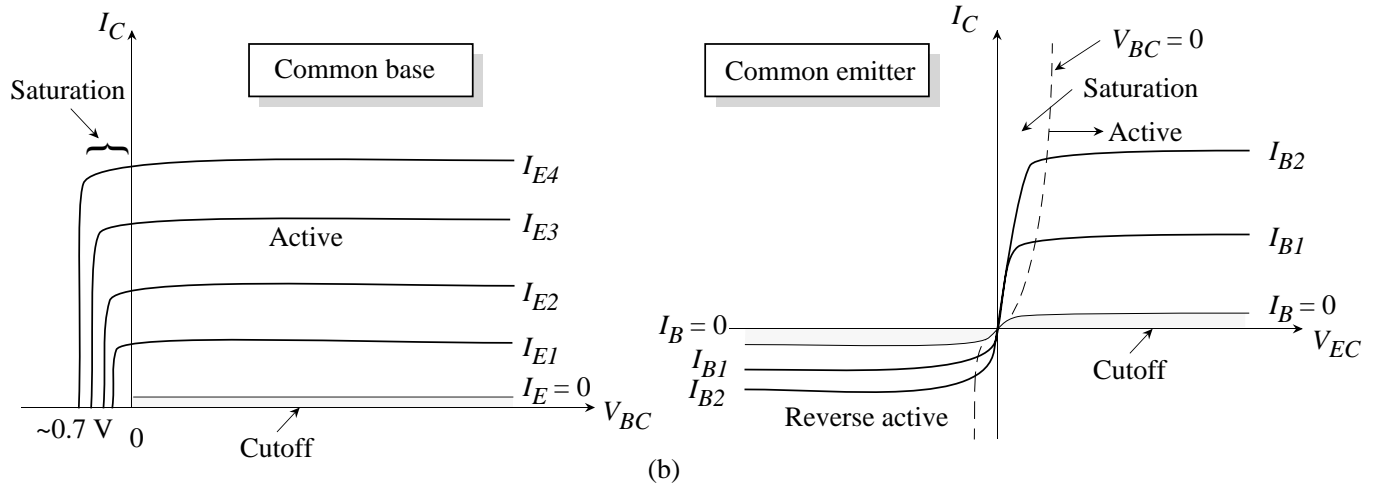
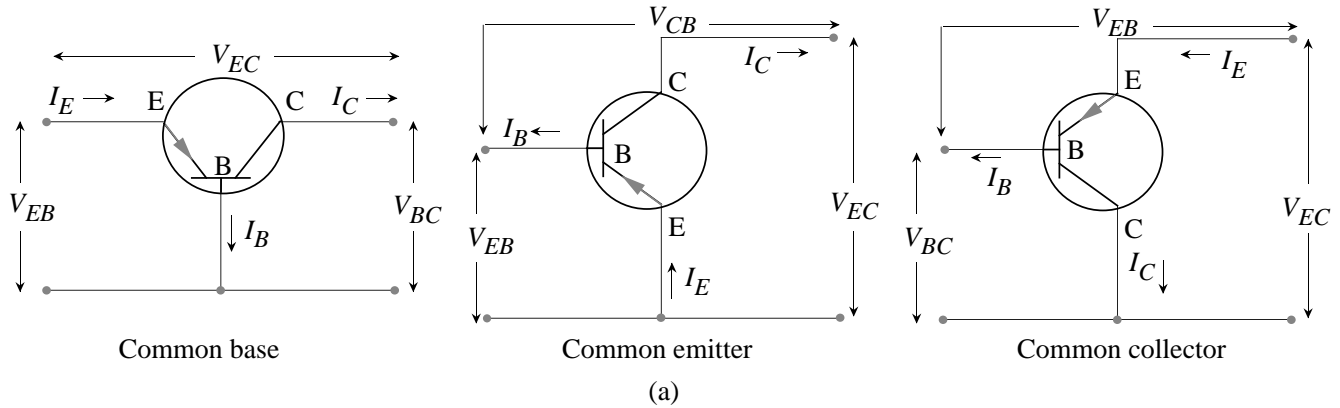
BIPOLAR JUNCTION TRANSISTOR: STRUCTURE







OPERATING CONFIGURATION OF A BIPOLAR JUNCTION TRANSISTOR



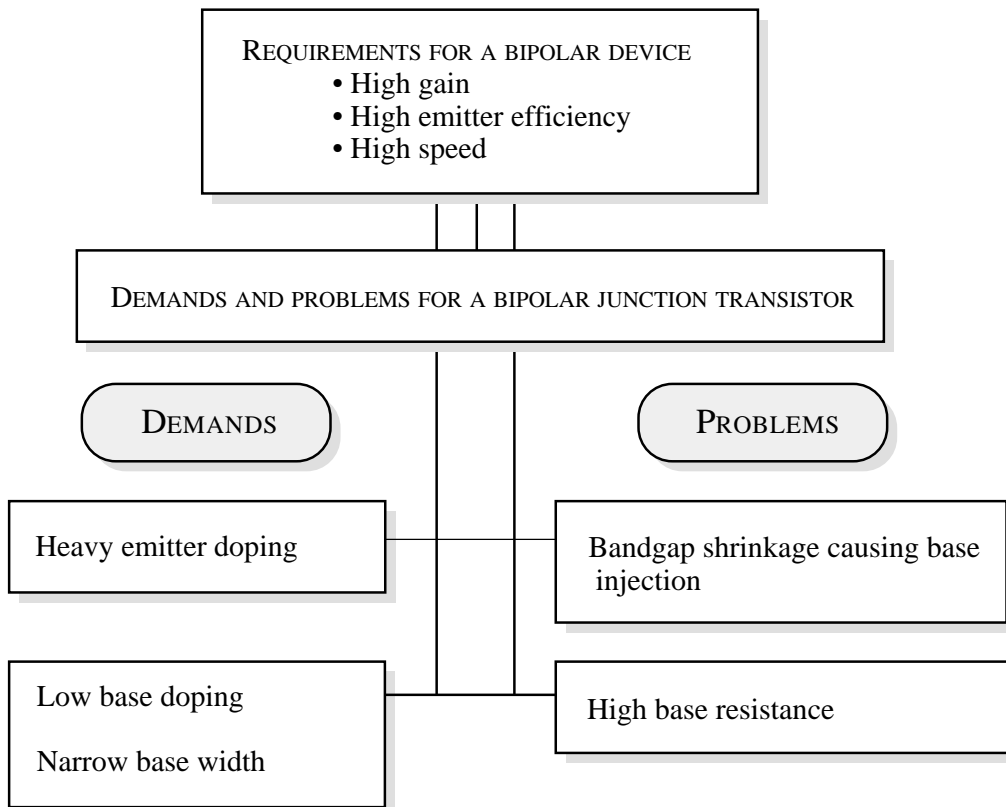
OPTIMIZATION OF A BIPOLAR TRANSISTOR

ISSUES: Emitter doping, base doping, collector doping, base width, emitter thickness

EMITTER EFFICIENCY: $\gamma_e \sim 1 - \frac{p_{e0}D_eW_{bn}}{n_{b0}D_b} \rightarrow$ Emitter doping \gg base doping

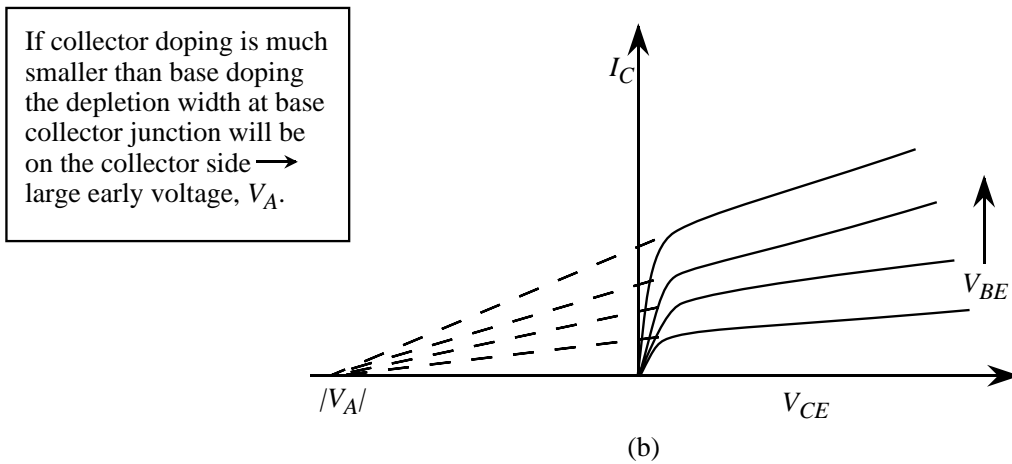
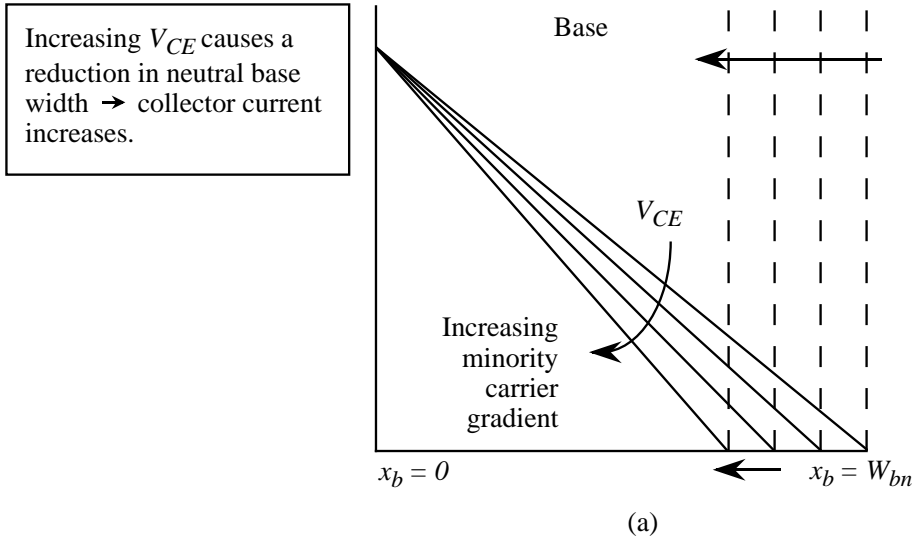
BASE TRANSPORT FACTOR: $B \sim 1 - \frac{W_{bn}^2}{2L_b^2} \rightarrow W_{bn} \ll L_b$

LOW OUTPUT CONDUCTANCE: W_{bn} should not change with collector bias \rightarrow collector doping \ll base doping

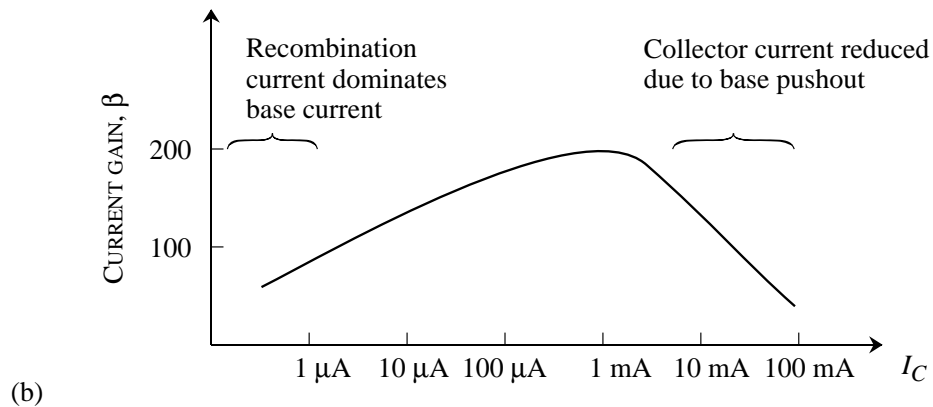
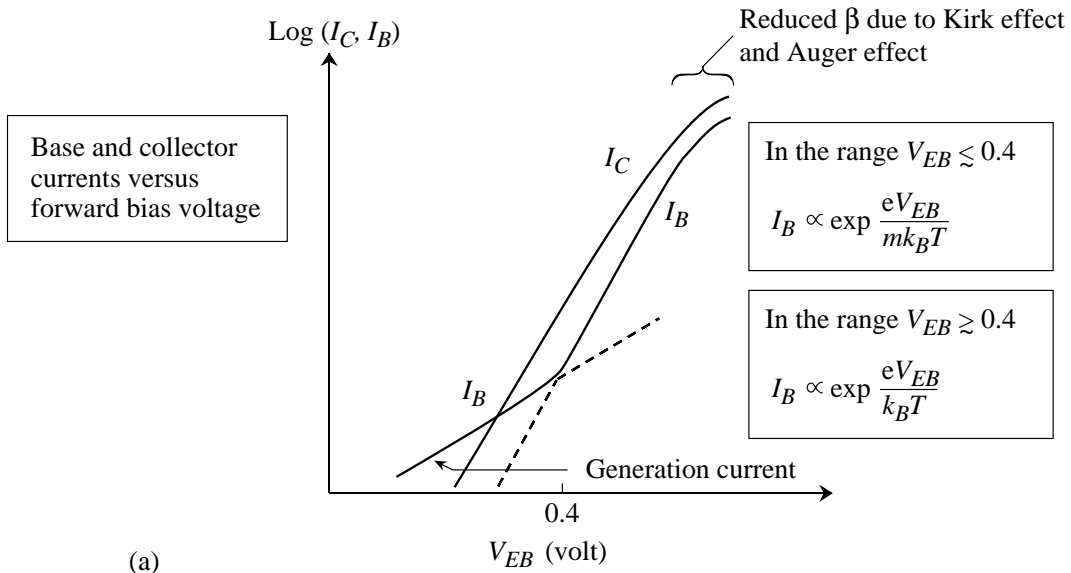


EARLY VOLTAGE AND OUTPUT CONDUCTANCE OF I-V CURVES

Collector current $\propto \frac{1}{W_{bn}}$; W_{bn} = neutral base width



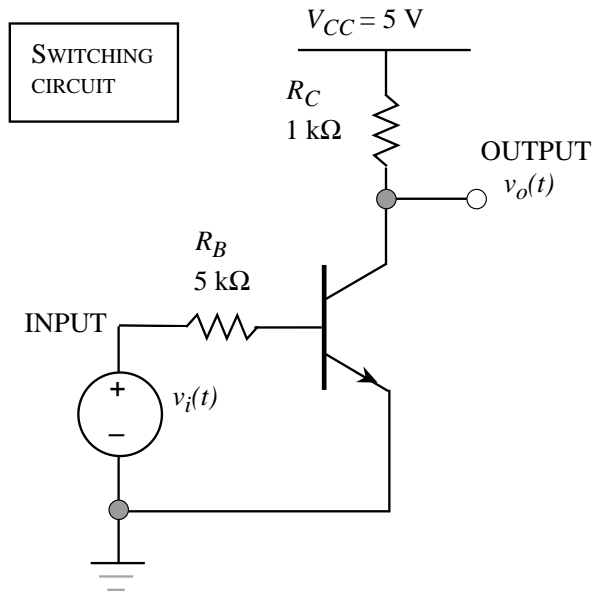
CURRENT GAIN DEPENDENCE ON BASE (COLLECTOR) CURRENT



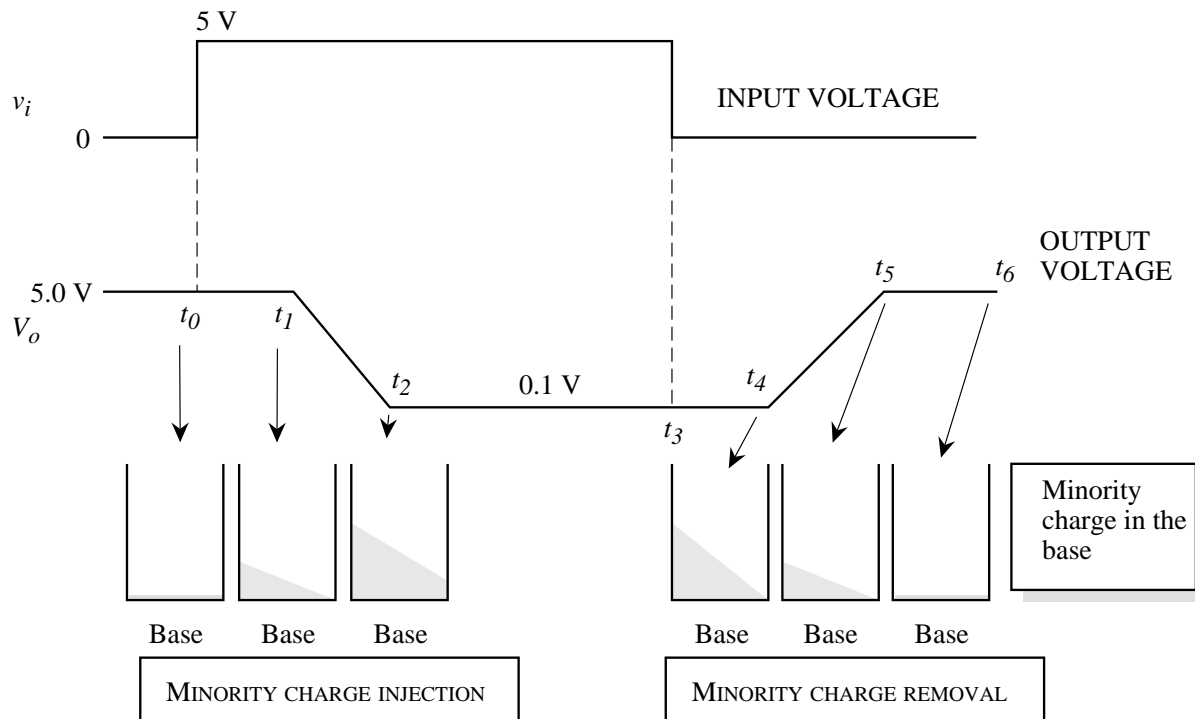
LOW INJECTION REGIME: Current gain is small because of non-ideal generation-recombination current.

HIGH INJECTION REGIME: Current gain drops because the effective base width is pushed out into the collector + carriers ($e-h$) recombine due to Auger effect.

SWITCHING DELAYS IN A BIPOLAR JUNCTION TRANSISTOR



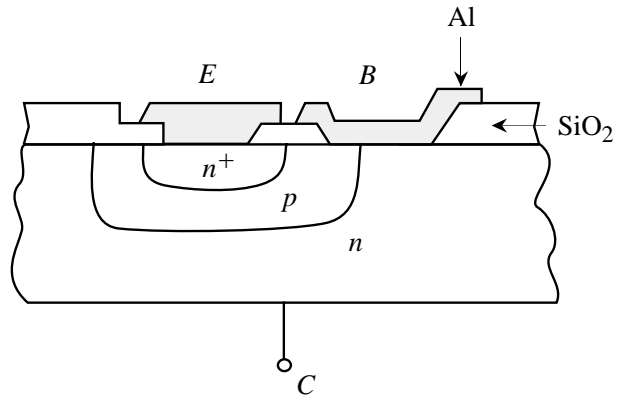
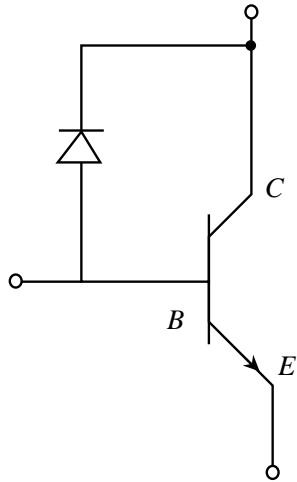
EXAMPLE PARAMETERS			
$V_{BE(on)}$	$= 0.7 \text{ V}$	τ_F	$= 0.1 \text{ ns}$
$V_{BE(sat)}$	$= 0.8 \text{ V}$	τ_{BF}	$= 10 \text{ ns}$
$V_{CE(sat)}$	$= 0.1 \text{ V}$	τ_S	$= 12 \text{ ns}$
C_{je0}	$= 0.5 \text{ pF}$	C_{jco}	$= 0.2 \text{ pF}$
ϕ_e	$= 0.9 \text{ V}$	ϕ_c	$= 0.7 \text{ V}$
m_e	$= 0.50$	m_c	$= 0.5$



IMPORTANT ISSUE: Avoid going into deep saturation.

USE OF A SCHOTTKY JUNCTION FOR HIGH SPEED BIPOLAR DEVICES

MOTIVATION: Do not let the transistor go into deep saturation during switching.

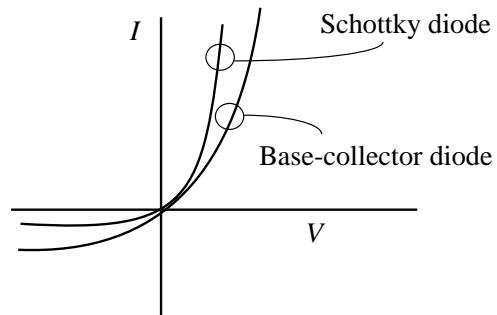


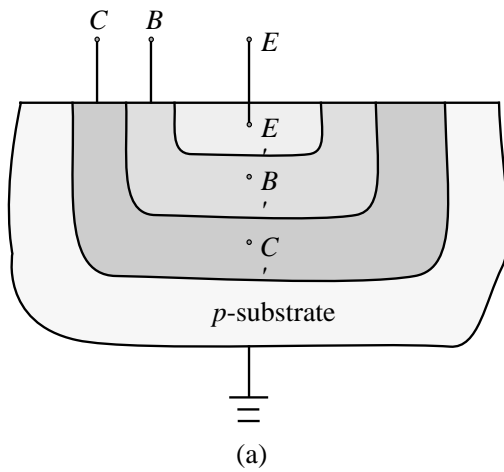
- Collector-Base reverse biased
Schottky diode is reverse biased

Al makes an ohmic contact to the *p*-type base and a Schottky contact to the *n*-type collector

- Collector-Base forward biased
Schottky diode turns ON
and collector is bypassed

Schottky diode is turned ON at a voltage smaller than what it takes the CBJ to be in the saturated mode





EQUIVALENT CIRCUIT PARAMETERS

Base-Emitter Junction (forward biased)

r_e = resistance between E and E'

C_π = diffusion capacitance

r_π = junction resistance

C_{je} = junction capacitance

r_b = resistance between B and B'

Collector-Emitter

$g_m V_{b'e'}$ = current source

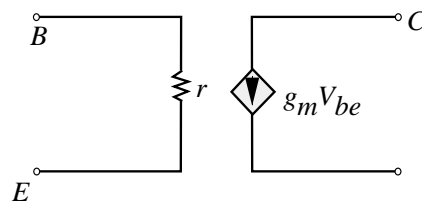
r_o = output resistance

C_s = collector-substrate capacitance

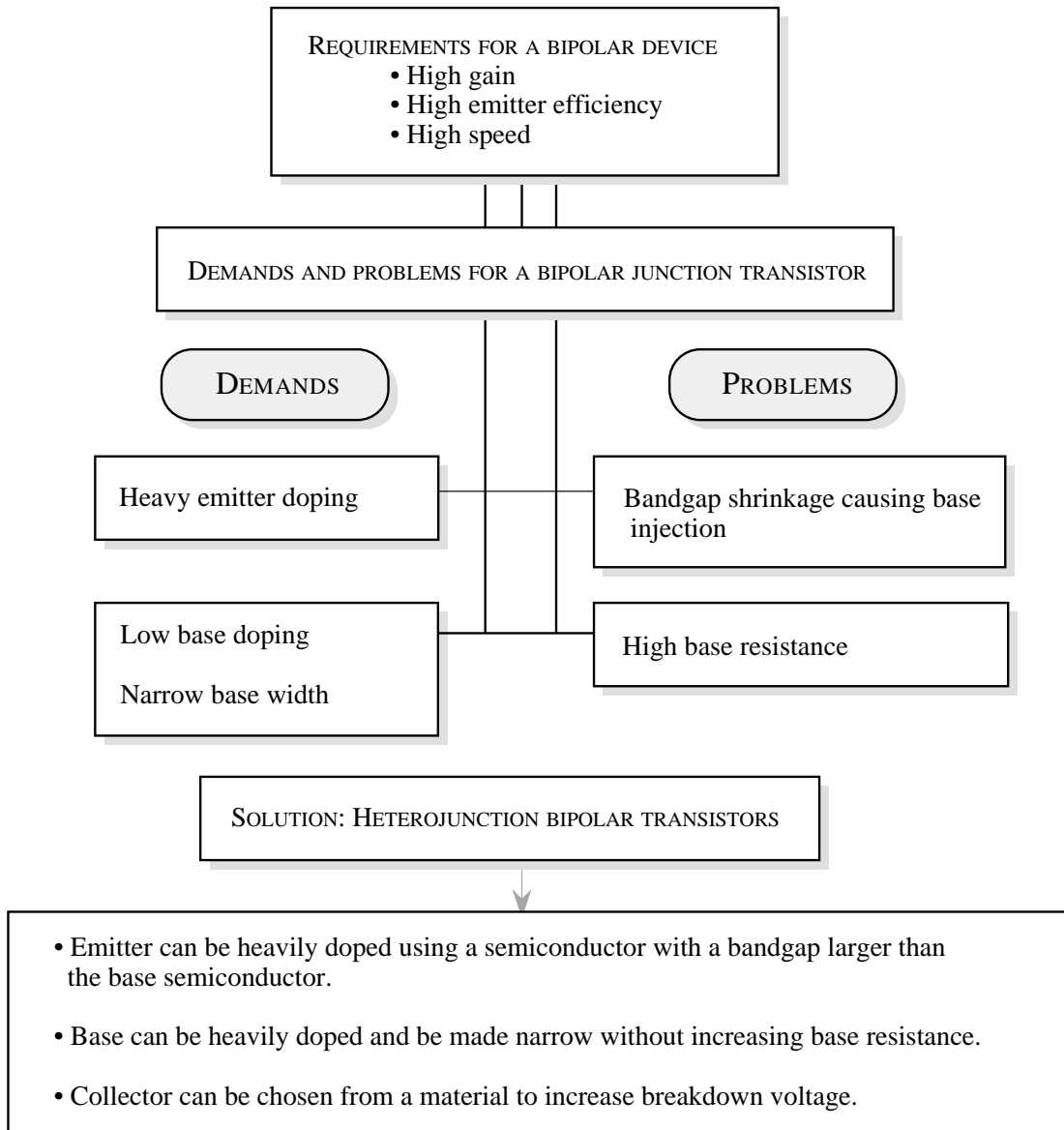
Base-Collector Junction (reverse biased)

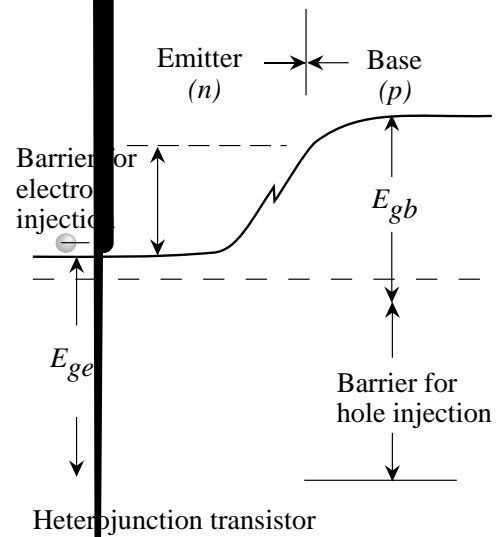
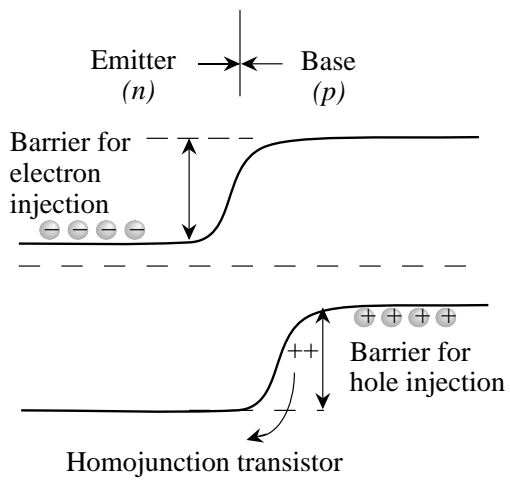
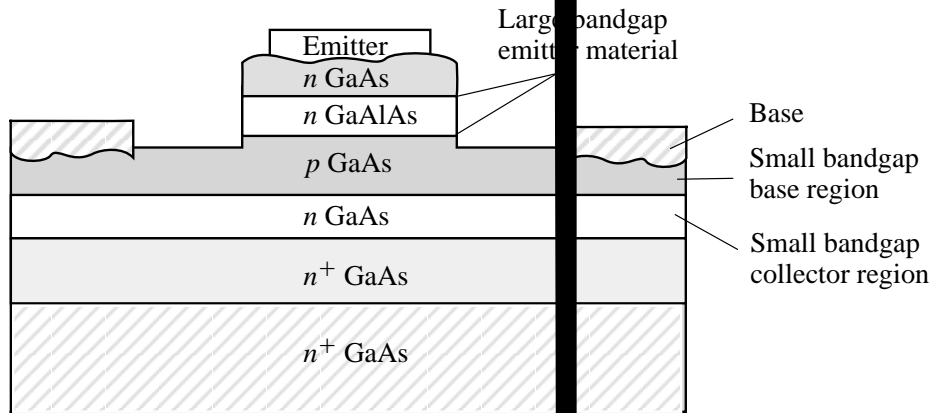
r_μ = junction resistance

C_μ = junction capacitance



ADVANTAGES OF A HETEROJUNCTION BIPOLAR TRANSISTOR





AN OVERVIEW OF ADVANCES IN BIPOLAR TECHNOLOGY

