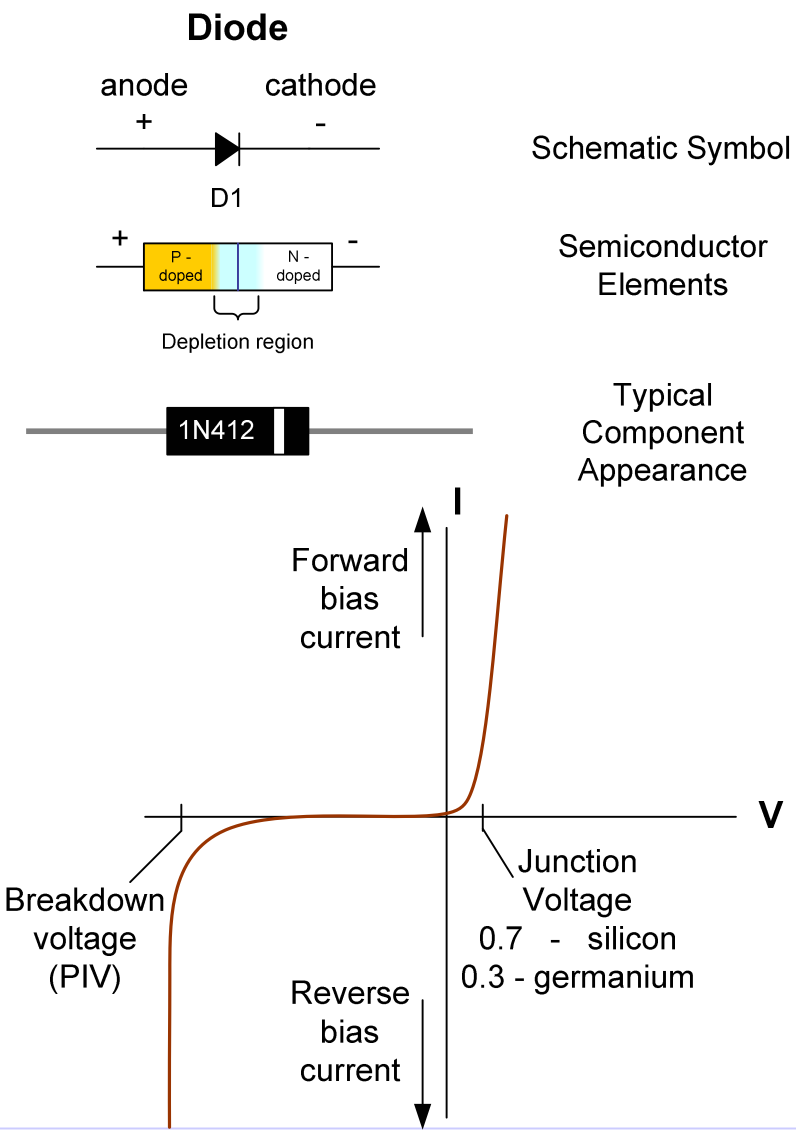
Semiconductor devices

Diodes and transistors

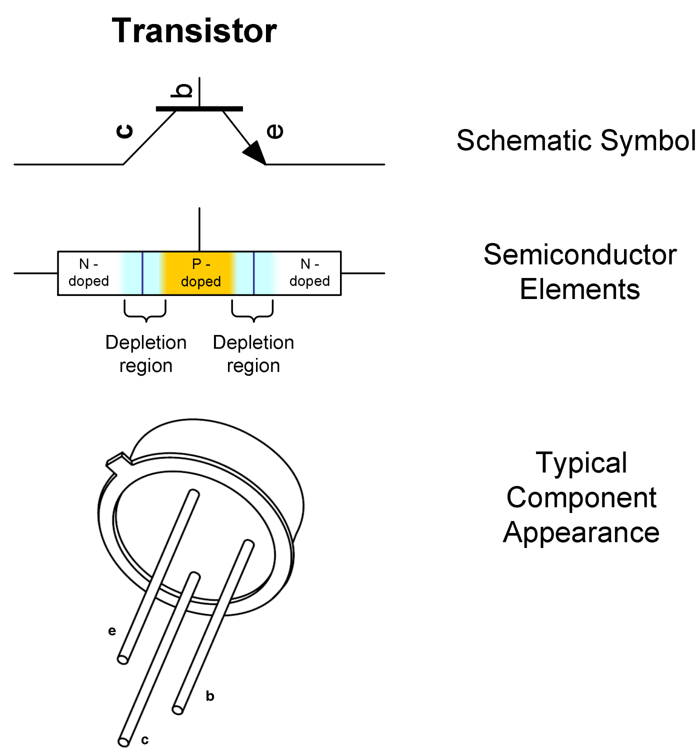
Diode devices

- Check valve behavior
  - Diffusion at the PN junction of P into N and N into P causes a depleted non-conductive region
  - Depletion is enhanced by reverse bias
  - Depletion is broken down by forward bias
- When forward biased
  - High current flow junction voltage
- When reverse biased
  - Very low current flow unless above peak inverse voltage (PIV) (damaging to rectifying diodes, OK for zeners)



Transistor devices

- Construction
  - Analogous to two diodes with a p-p (for an NPN device), or an n-n connection (for a PNP device)
  - Connections
    - Collector
    - Base
    - Emitter
- Nature of the device (NPN)
  - Reverse bias on the C-B junction and a moderate forward bias on the B-E junction causes current flow from C to E. Current is proportional to gain times B-E current in the linear range of the device
  - PNP requires reverse polarities and has reverse current flow.



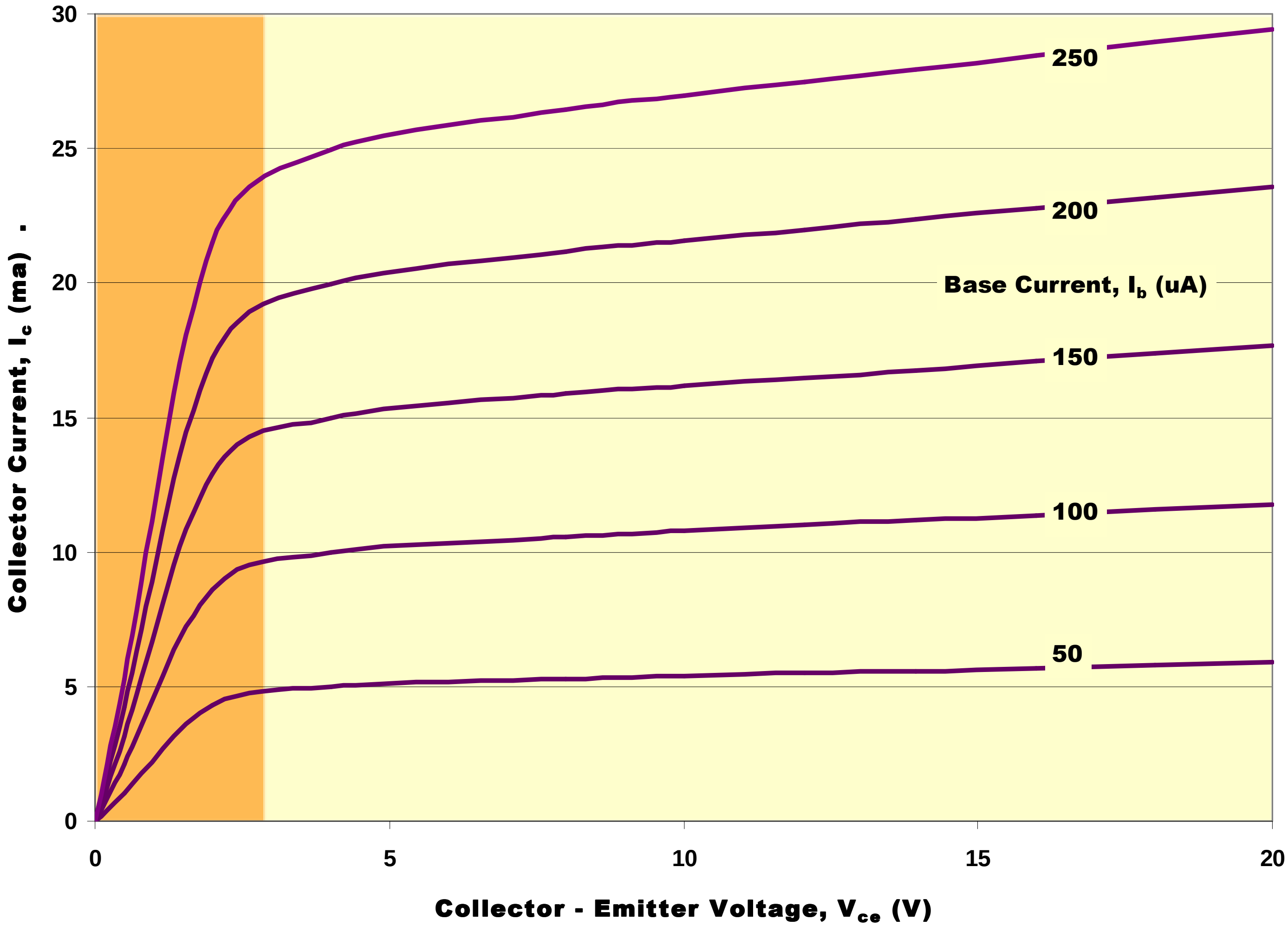
Transistor devices

- The physics of the device are complicated
  - Describes current passing through the reverse biased E-B Junction
- Critical characteristics
  - Primary descriptive equation is the current gain relating base to collector current

$$h_{FE} = \frac{I_C}{I_B}$$

  - Typically DC current gain (h_{fe}) will be 10-400
  - Care must be taken to assure the transistor currents are controlled and the device is never biased in a way that would allow a distructive level of current.
  - Voltage differences must also be controlled below maximums.
  - Un-intentional biasing reverse to the normal application may destroy the device.
  - Thermal dissipation must be managed

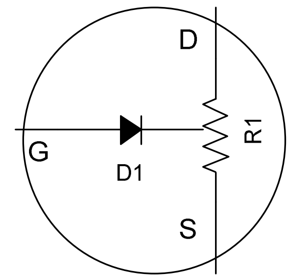
Graphical depiction of amplification



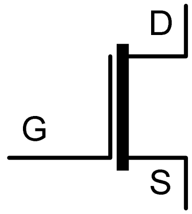
Junction Field Effect Transistors

- Transconductance is controlled by V_{GS}
- Pinched gate technology
- High gate impedance
- Heavily used for power drive circuits
- Application:
  - S-D current is reduced for higher reverse gate bias voltage.
    - R proportional to V_{GS}
    - V_{GS} must be reverse bias to avoid damaging the device

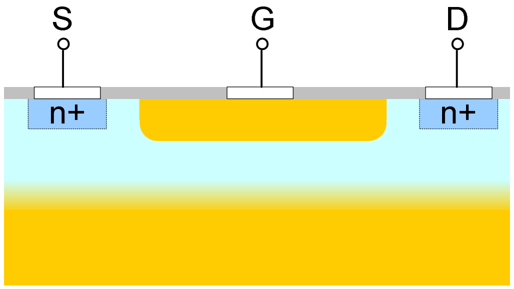
- Field Effect Functional Model
  - N Channel



- Schematic symbol



- Semiconductor elements



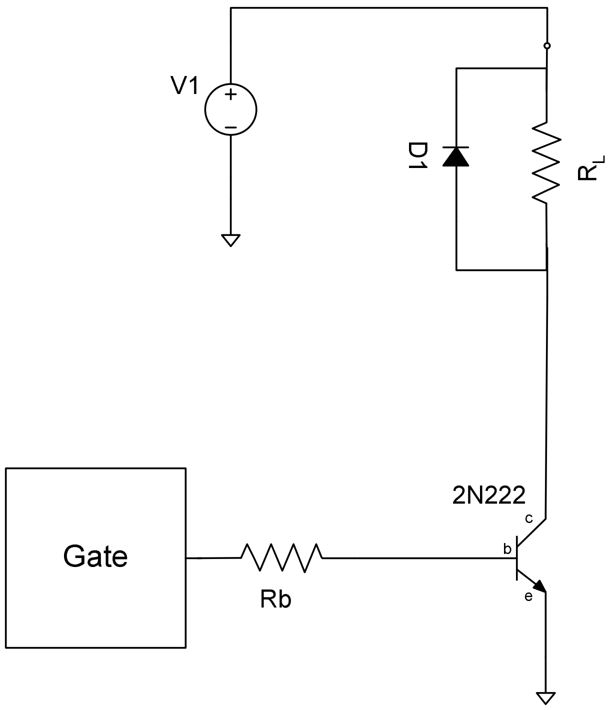
Transistor switching circuits

- Application of a transistor to provide increased switched current
  - Transistor selection
    - Maximum collector current: must be greater than the load current.

$$I_{C\max} > \frac{V_L}{R_L}$$

    - Minimum current gain: h_{FE} should be at least five times the load current divided by the maximum output current from the chip.
  - Base resistor size:

$$R_b = \frac{h_{FE} V_c}{5 I_C}$$



MOSFET