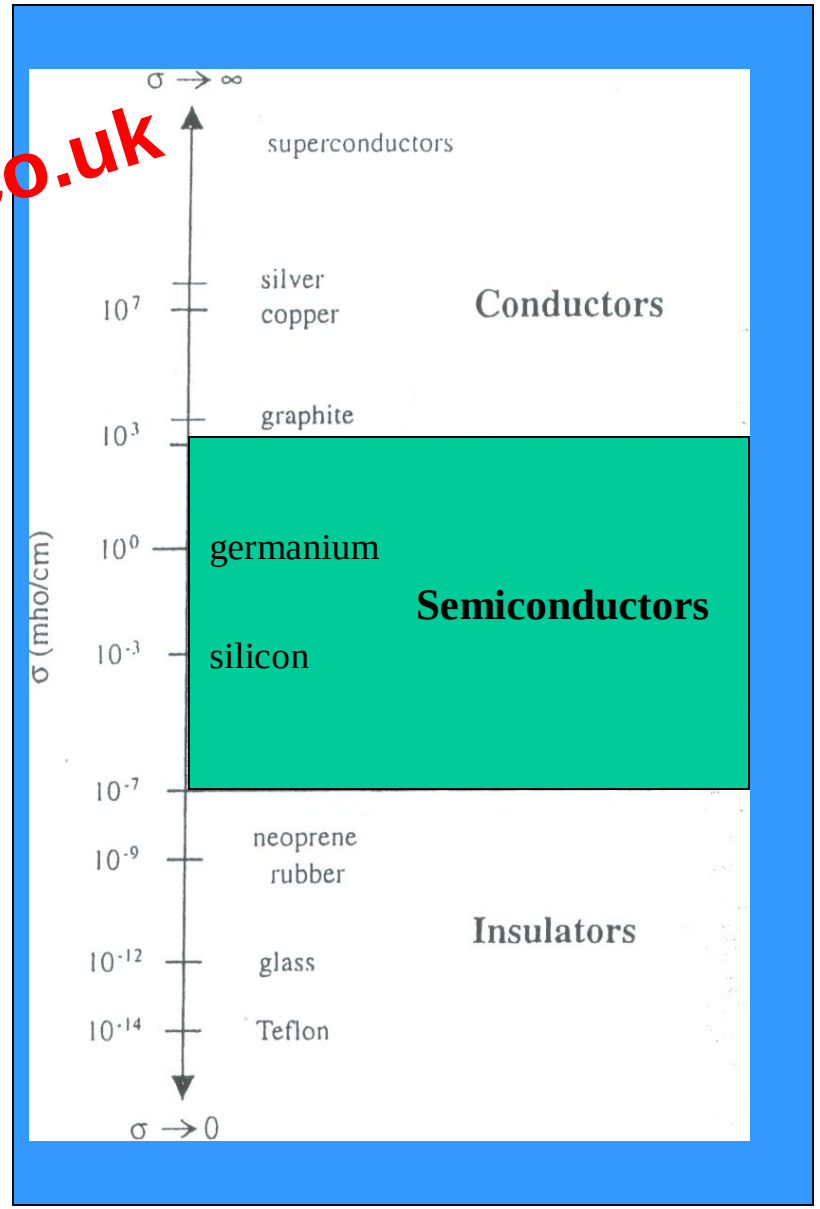
Semiconductor —I

- Materials that permit flow of electrons are called conductors (e.g., gold, silver, copper, etc.).
- Materials that block flow of electrons are called insulators (e.g., rubber, glass, Teflon, mica, etc.).
- Materials whose conductivity falls between those of conductors and insulators are called semiconductors.
- Semiconductors are "part-time" conductors whose conductivity can be controlled.

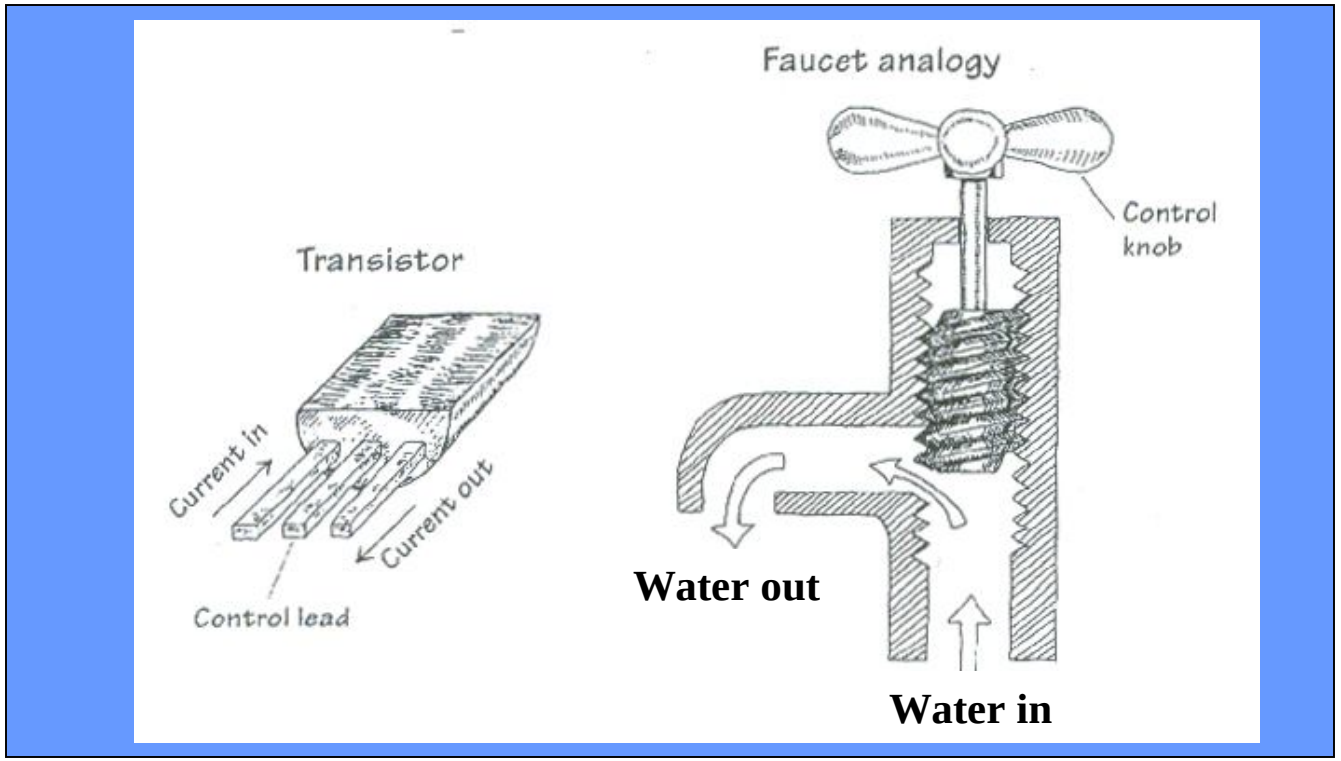


P-Type Silicon —II

- The hole of boron atom points towards the negative terminal.
- The electron of neighboring silicon atom points toward positive terminal.
- The electron from neighboring silicon atom falls into the boron atom filling the hole in boron atom and creating a “new” hole in the silicon atom.
- It appears as though a hole moves toward the negative terminal!

Transistor

- A three lead semiconductor device that acts as:
  - an electrically controlled switch, or
  - a current amplifier.
- Transistor is analogous to a faucet.
  - Turning faucet's control knob alters the flow rate of water coming out from the faucet.
  - A small voltage/current applied at transistor's control lead controls a larger current flow through its other two leads.

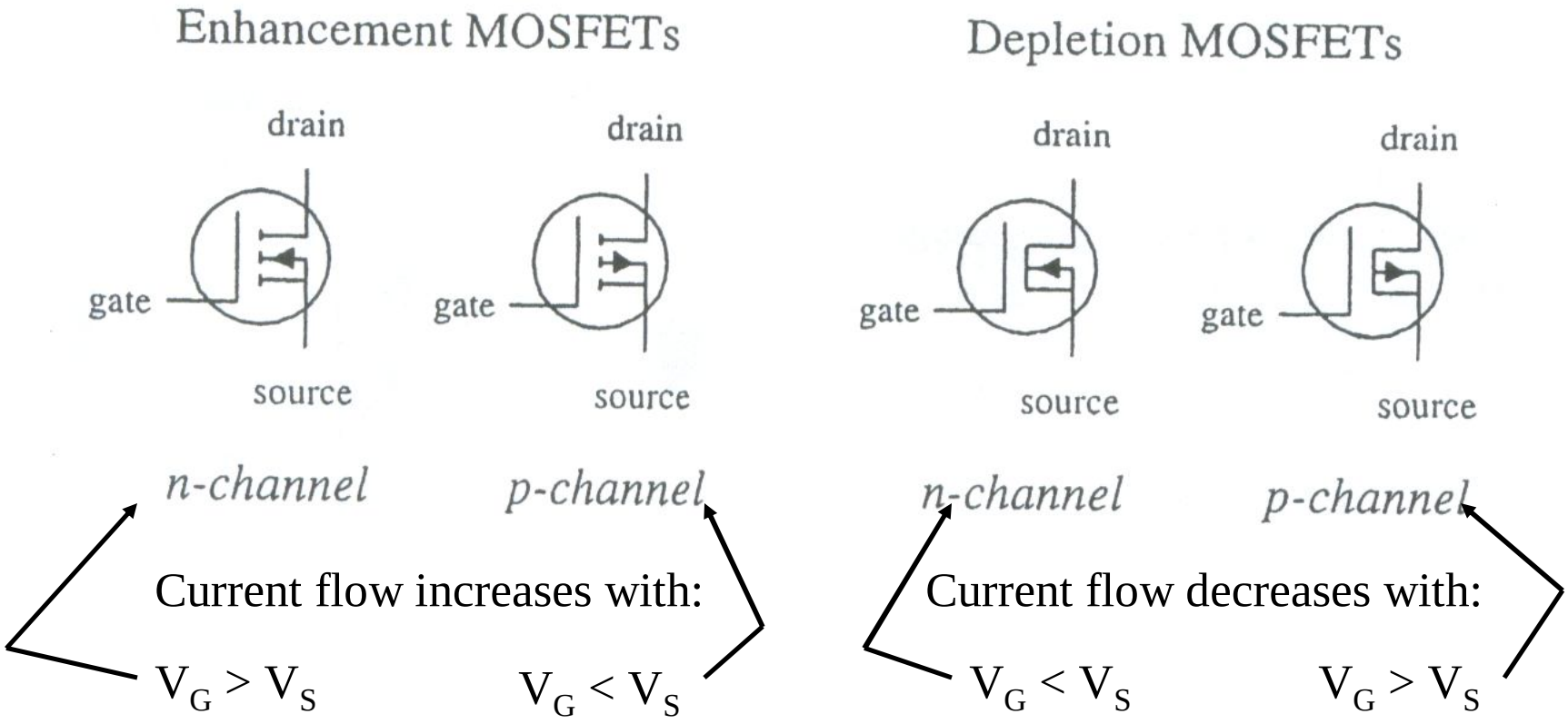


MOSFET

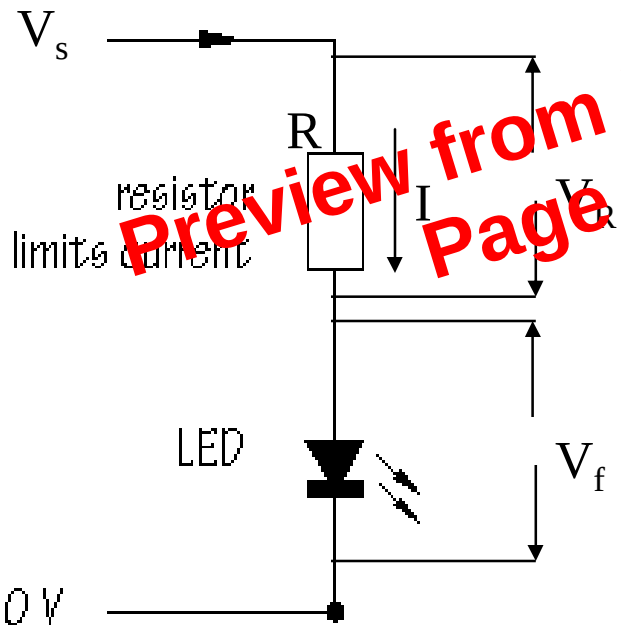
- Metal oxide semiconductor FET.
- Similar to JFET.
- A metal oxide insulator is placed @ the gate to obtain a high input impedance @ the gate
  - gate input impedance approx. $10^{14}\Omega$.
- Use of insulator as described above yields a low gate-to-channel capacitance.
  - If too much static electricity builds up on the gate, then the MOSFET may be damaged.

MOSFET Types

- Enhancement type:
  - Normally off, thus no current flows through drain-source channel when $V_G = V_S$.
  - When a voltage applied @ the gate causes $V_G \neq V_S$ the drain-source channel reduces resistance to current flow.
- Depletion type:
  - Normally on, thus maximum current flows through drain-source channel when $V_G = V_S$.
  - When a voltage applied @ the gate causes $V_G \neq V_S$ the drain-source channel increases resistance to current flow.



LED 101—III



- Let V_s be the supply voltage.
- Let V_f be the required forward bias voltage for the LED.
- Let I be the desired current flow through LED.
- Then, the current limiting resistance R is sized as follow:

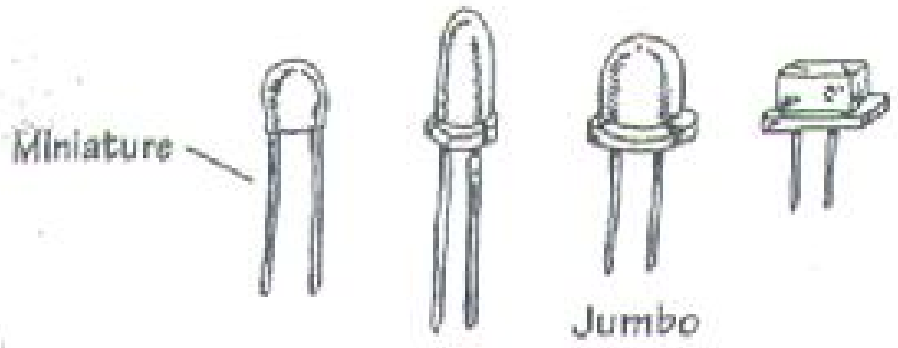
$$V_R = V_s - V_f$$

$$R = \frac{V_R}{I} = \frac{V_s - V_f}{I}$$

- If R is chosen smaller than the above value, a larger current will flow through the LED.
  - LEDs can handle only limited current (varies from 20mA to 100mA).
  - If current through LED is larger than the maximum allowed value, than the LED will be damaged.

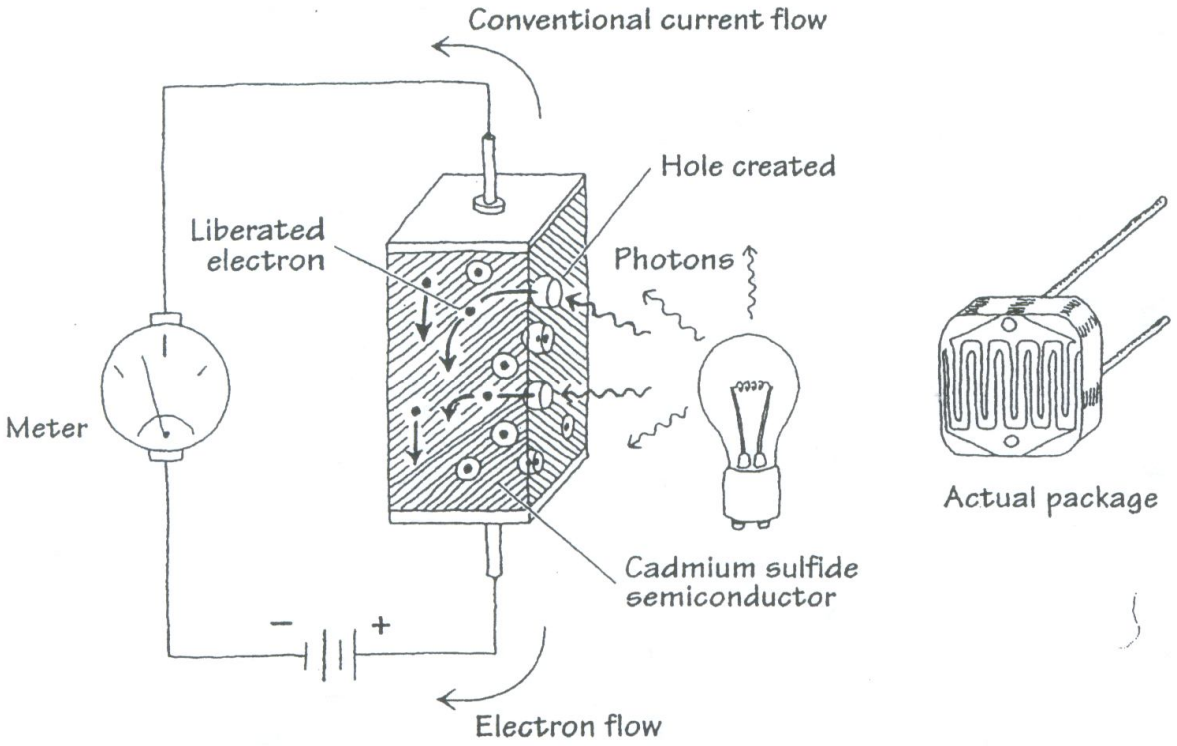
Visible-Light LED

- Inexpensive and durable.
- Typical usage: as indicator lights.
- Common colors: green (~565nm), yellow (~585nm), orange (~615nm), and red (~650nm).
- Maximum forward voltage: ≈ 1.8V.
- Typical operating current: 1 to 3mA.
- Typical brightness levels: 1.0 to 3.0mcd/1mA to 3.0mcd /2mA.
- High-brightness LEDs exist.
  - Used in high-brightness flashers (e.g., bicycle flashers).



How Photoresistor Works

- Special semiconductor crystal, such as cadmium sulfide or lead sulfide is used to make photoresistors.
- When this semiconductor is placed in dark, electrons within its structure resist flow through the resistor because they are too strongly bound to the crystal's atoms.
- When this semiconductor is illuminated, incoming photons of light collide with the bound electrons, stripping them from the binding atom, thus creating holes in the process.
- Liberated electrons contribute to the current flowing through the device.



Phototransistor Applications—Dark Activated Relay

- A phototransistor is used to control the base current supplied to a power-switching transistor that is used to supply current to a relay.
- When light is removed from the phototransistor, the phototransistor turns off, allowing more current to enter into the base of the power-switching transistor.
- This allows the power switching transistor to turns on, and current flows through the relay, triggering it to switch states.
- The 100K pot is used to adjust the sensitivity of device by controlling current flow through the phototransistor.