Lecture 2: Semiconductor Diodes

Breakdown Region

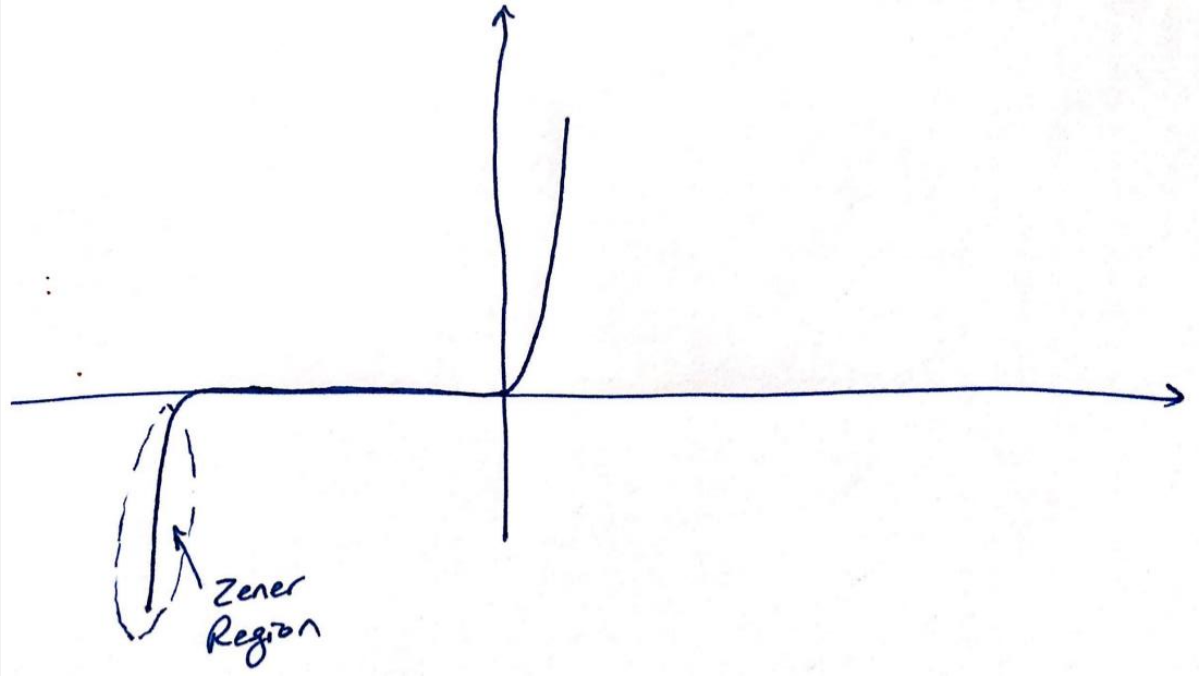
- In the negative region, there is a point where the application of too negative a voltage with the reverse polarity will results in a sharp change in the characteristics.

  $\rightarrow$ *breakdown potential*

- avalanche breakdown vs zener breakdown

‘ The maximum reverse-bias potential that can be applied before entering the breaksown region is called the *peak inverse voltage* (*PIV rating*) or the *peak reverse voltage* (*PRV rating*)’

Zener Region



Effect of Temperature

As temperature increases:

- the required *forward bias voltage* for forward-bias conduction *reduces*,
- the amount of *reverse current* in the reverse-bias condition *increases*,
- *maximum reverse bias avalanche voltage increases*.

Note: Germanium diodes are more sensitive to temperature variations than silicon or gallium arsenide diodes.

Resistance levels

Semiconductors react differently to DC and AC currents.

There are three types of resistance:

- DC (static) resistance
- AC (dynamic) resistance
- Average AC resistance

DC (Static) Resistance

For a specific applied DC voltage (V_D) the diode has a specific current (I_D) and a specific resistance (R_D).

$$R_D = \frac{V_D}{I_D}$$

AC (Dynamic) Resistance

In the forward bias region: $$r'_d = \frac{26\,\text{mV}}{I_D} + r_B$$

- The resistance depends on the amount of current (I_D) in the diode.
- The voltage across the diode is fairly constant (26 mV for 25°C).
- r_B ranges from a typical 0.1 Ω for high power devices to 2 Ω for low power, general purpose diodes. In some cases r_B can be ignored.

In the reverse bias region: $$r'_d = \infty$$

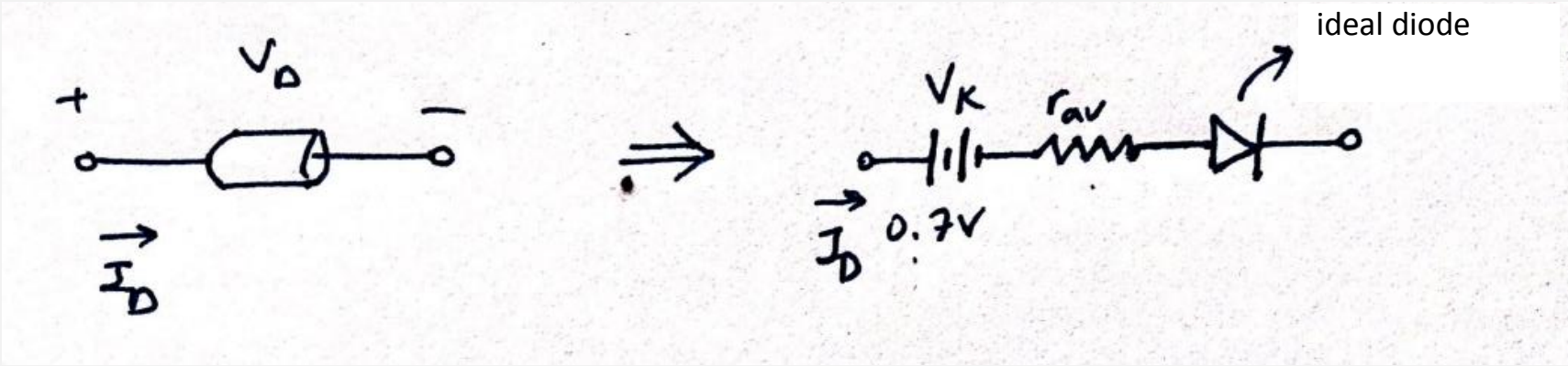
The resistance is effectively infinite. The diode acts like an open.

Average AC Resistance

$$r_{av} = \frac{\Delta V_d}{\Delta I_d}\Bigg|_{\text{pt. to pt.}}$$

AC resistance can be calculated using the current and voltage values for two points on the diode characteristic curve.

Diode Equivalent Circuits



Diode Capacitance

When ***reverse biased***, the depletion layer is very large. The diode's strong positive and negative polarities create capacitance (C_T). The amount of capacitance depends on the reverse voltage applied.

When ***forward biased***, storage capacitance or diffusion capacitance (C_D) exists as the diode voltage increases.

Reverse Recovery Time

Reverse recovery time *is the time required for a diode to stop conducting when switched from forward bias to reverse bias.*

Diode Specification Sheets

Diode data sheets contain *standard information*, making cross-matching of diodes for replacement or design easier.

1. Forward Voltage (V_F) at a specified current and temperature
2. Maximum forward current (I_F) at a specified temperature
3. Reverse saturation current (I_R) at a specified voltage and temperature
4. Reverse voltage rating, PIV or PRV or $V_{(BR)}$, at a specified temperature
5. Maximum power dissipation at a specified temperature
6. Capacitance levels
7. Reverse recovery time, t_{rr}
8. Operating temperature range

Diode Symbol, Packaging and Testing

The anode is abbreviated A

The cathode is abbreviated K

Diodes are commonly *tested* using: *Diode checker, Ohmmeter, Curve tracer*

Diode Checker

Many digital multimeters have a *diode checking function*.
The diode should be tested out of circuit.

A normal diode exhibits its forward voltage:

Gallium arsenide ≅ 1.2 V

Silicon diode ≅ 0.7 V

Germanium diode ≅ 0.3 V

Ohmmeter

An ohmmeter set on a low Ohms scale can be used to test a diode. The diode should be tested out of circuit.

Curve Tracer

A curve tracer displays the characteristic curve of a diode in the test circuit. This curve can be compared to the specifications of the diode from a data sheet.

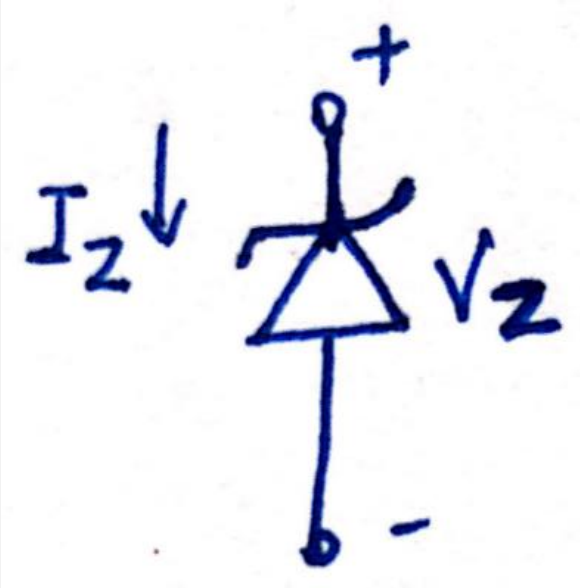
Other Types of Diodes

There are several types of diodes besides the standard *p*-*n* junction diode. Three of the more common are:

- Zener diodes
- Light-emitting diodes
- Diode arrays

Zener Diode

A *Zener diode* is one that is designed to safely operate in its zener region; i.e., biased at the Zener voltage (V_Z).



Common zener diode voltage ratings are between 1.8V and 200V

Light-Emitting Diode (LED)

An LED emits light when it is forward biased, which can be in the infrared or visible spectrum.

The forward bias voltage is usually in the range of 2 V to 3 V.