SCHOTTKY BARRIER (HOT-CARRIER) DIODES

In recent years, there has been increasing interest in a two-terminal device referred to as a Schottky-barrier, surface-barrier, or hot-carrier diode. Its areas of application were first limited to the very high frequency range due to its quick response time (especially important at high frequencies) and a lower noise figure (a quantity of real importance in high-frequency applications). In recent years, however, it is appearing more and more in low-voltage/high-current power supplies and ac-to-dc converters.

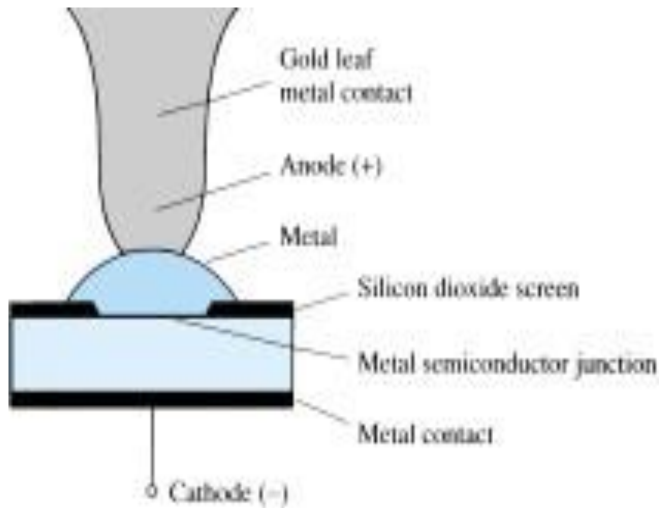


Fig 1. Passivated schottky barrier diode

Its construction is quite different from the conventional p-n junction in that a metalsemiconductor junction is created such as shown in Fig.1. The semiconductor is normally n-type silicon (although p-type silicon is sometimes used), while a host of different metals, such as molybdenum, platinum, chrome, or tungsten, are used. Different construction techniques will result in a different set of characteristics for the device, such as increased frequency range, lower forward bias, and so on. Priorities do not permit an examination of each technique here, but information will usually be provided by the manufacturer. In general, however, Schottky diode construction results in a more uniform junction region and a high level of ruggedness.

In both materials, the electron is the majority carrier. In the metal, the level of minority carriers (holes) is insignificant. When the materials are joined, the electrons in the n-type silicon semiconductor material immediately flow into the adjoining metal, establishing a heavy flow of majority carriers. Since the injected carriers have a very high kinetic energy level compared to the electrons of the metal, they are commonly called –hot carriers.‖

The additional carriers in the metal establish a ―negative wall‖ in the metal at the boundary between the two materials. The net result is a ―surface barrier‖ between the two materials, preventing any further current. That is, any electrons (negatively charged) in the silicon material face a carrier-free region and a ―negative wall‖ at the surface of the metal.

The application of a forward bias as shown in the first quadrant of Fig. 2 will reduce the strength of the negative barrier through the attraction of the applied positive potential for electrons from this region. The result is a return to the heavy flow of electrons across the boundary, the magnitude of which is controlled by the level of the applied bias potential. The barrier at the junction for a Schottky diode is less than that of the p-n junction device in both the forward- and reverse-bias regions. The result is therefore a higher current at the same applied bias in the forward- and reverse-bias regions. This is a desirable effect in the forward-bias region but highly undesirable in the reverse-bias region.

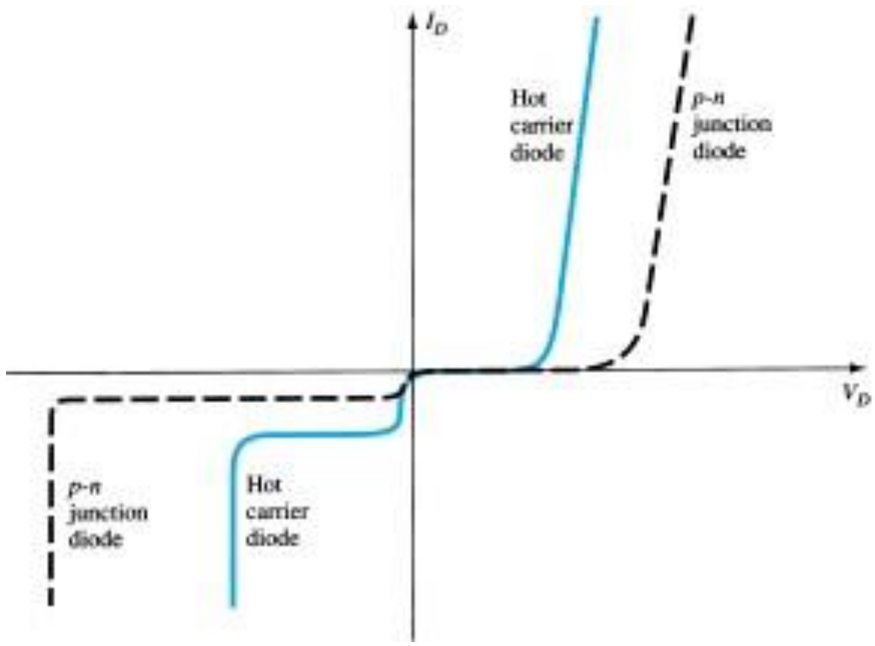


Fig 2. Comparison of characteristics of Hot carrier and pn diode

Applications

- In radar systems,
- Schottky TTL logicfor computers,
- mixers and detectors in communication equipment,
- instrumentation and analog-to-digital converters.

Zener diode

A Zener diode is a type of diode that permits current not only in the forward direction like a normal diode, but also in the reverse direction if the voltage is larger than the breakdown voltage known as "Zener knee voltage" or "Zener voltage". The device was named after Clarence Zener, who discovered this electrical property.

Diode symbol

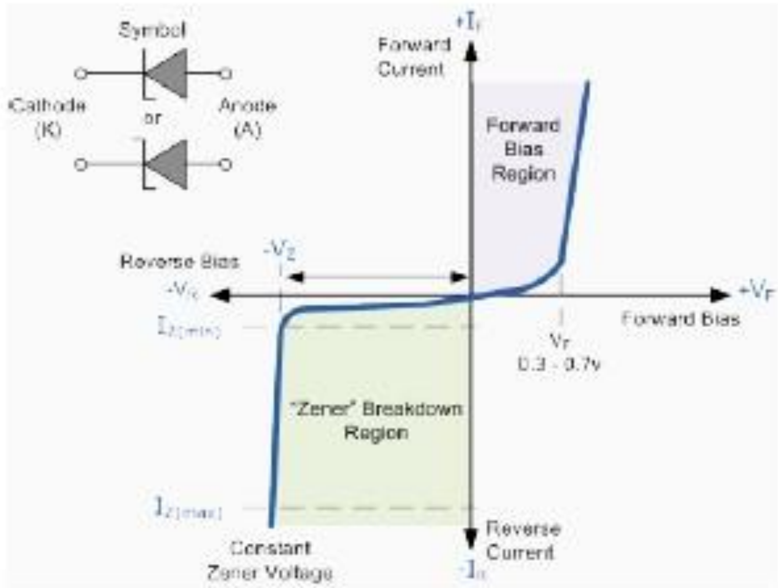
However, the Zener Diode or "Breakdown Diode" as they are sometimes called, are basically the same as the standard PN junction diode but are specially designed to have a low pre-determined Reverse Breakdown Voltage that takes advantage of this high reverse voltage. The point at which a zener diode breaks down or conducts is called the "Zener Voltage" (Vz).

The Zener diode is like a general-purpose signal diode consisting of a silicon PN junction. When biased in the forward direction it behaves just like a normal signal diode passing the rated current, but when a reverse voltage is applied to it the reverse saturation current remains fairly constant over a wide range of voltages. The reverse voltage increases until the diodes breakdown voltage VB is reached at which point a process called Avalanche Breakdown occurs in the depletion layer and the current flowing through the zener diode increases dramatically to the maximum circuit value (which is usually limited by a series resistor). This breakdown voltage point is called the "zener voltage" for zener diodes.

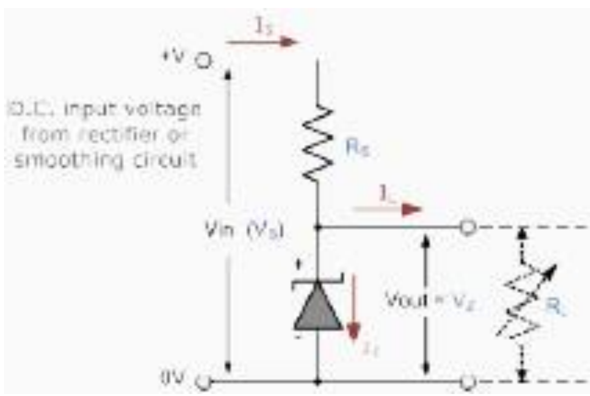
The point at which current flows can be very accurately controlled (to less than 1% tolerance) in the doping stage of the diodes construction giving the diode a specific *zener breakdown voltage*, (Vz) ranging from a few volts up to a few hundred volts. This zener breakdown voltage on the I-V curve is almost a vertical straight line.

Zener diode characteristics

The Zener Diode is used in its "reverse bias" or reverse breakdown mode, i.e. the diodes anode connects to the negative supply. From the I-V characteristics curve above, we can see that the zener diode has a region in its reverse bias characteristics of almost a constant negative voltage regardless of the value of the current flowing through the diode and remains nearly constant even with large changes in current as long as the zener diodes current remains between the breakdown current IZ(min) and the maximum current rating IZ(max).



The Zener Diode Regulator



Zener Diodes can be used to produce a stabilised voltage output with low ripple under varying load current conditions. By passing a small current through the diode from a voltage source, via a suitable current limiting resistor (RS), the zener diode will conduct sufficient current to maintain a voltage drop of Vout. We remember from the previous tutorials that the DC output voltage from the half or full-wave rectifiers contains ripple superimposed onto the DC voltage and that as the load value changes so to does the average output voltage. By connecting a simple zener stabiliser circuit as shown below across the output of the rectifier, a more stable output voltage can be produced.

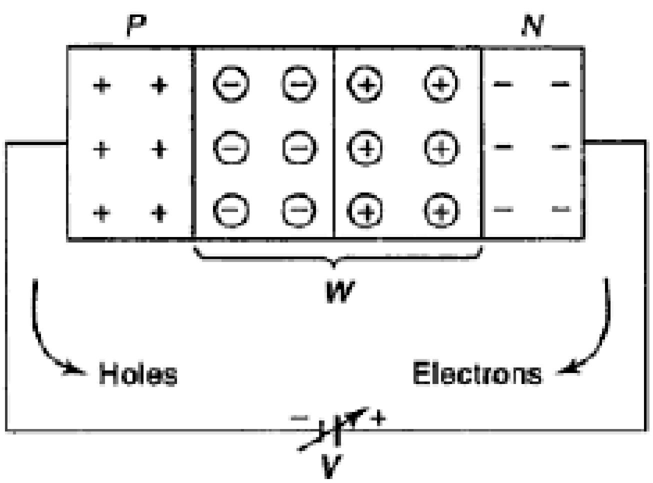
VARACTOR DIODE

A varactor diode is best explained as a variable capacitor. Think of the depletion region as a variable dielectric. The diode is placed in reverse bias. The dielectric is –adjusted‖ by reverse bias voltage changes.

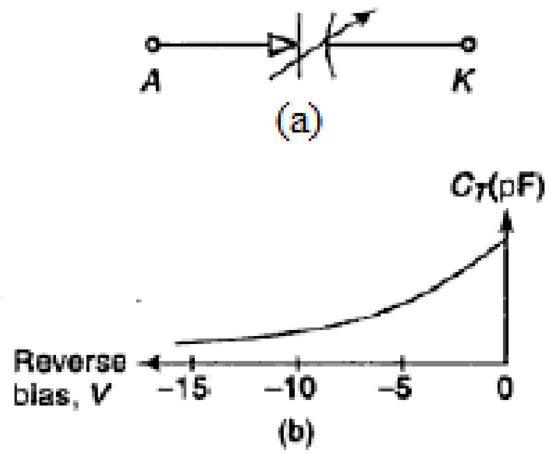
• Junction capacitance is present in all reverse biased diodes because of the depletion region.

• Junction capacitance is optimized in a varactor diode and is used for high frequencies and switching applications.

• Varactor diodes are often used for electronic tuning applications in FM radios and televisions.



Depletion region in a reverse biased PN junction



(a) Circuit symbol of varactor diode (b) Characteristics of varactor diode

• They are also called voltage-variable capacitance diodes.

A Junction diode which acts as a variable capacitor under changing reverse bias is known as VARACTOR DIODE

A varactor diode is specially constructed to have high resistance under reverse bias.

Capacitance for varactor diode are Pico farad. (10-12) range

$CT = \epsilon A / Wd$

CT =Total Capacitance of the junction

Є = Permittivity of the semiconductor material
A = Cross sectional area of the junction
WD= Width of the depletion layer

Curve between Reverse bias voltage Vr across varactor diode and total junction capacitance Ct and Ct can be changed by changing Vr.