What is electronics?

The word electronics is derived from electron mechanics, which means to study the behavior of an electron under different conditions of applied electric field.

Electronics definition

The branch of engineering in which the flow and control of electrons in vacuum or semiconductor are studied is called electronics. Electronics can also be defined as the branch of engineering in which the electronic devices and their utilization are studied.

The motion of electrons through a conductor gives us electric current. This electric current can be produced with the help of batteries and generators.

The device which controls the flow of electrons is called electronic device. These devices are the main building blocks of electronic circuits.

Electronics have various branches include, digital electronics, analog electronics, microelectronics, nanoelectronics, optoelectronics, integrated circuit and semiconductor device.

History of electronics

Diode vacuum tube was the first electronic component invented by J.A. Fleming. Later, Lee De Forest developed the triode, a three element vacuum tube capable of voltage amplification. Vacuum tubes played a major role in the field of microwave and high power transmission as well as television receivers.

In 1947, Bell laboratories developed the first transistor based on the research of Shockley, Bardeen and Brattain. However, transistor radios are not developed until the late 1950's due to the existing huge stock of vacuum tubes.

In 1959, Jack Kilby of Texas Instruments developed the first integrated circuit. Integrated circuits contain large number of semiconductor devices such as diodes and transistors in very small area.

Advantages of electronics

Electronic devices are playing a major role in everyday life. The various electronic devices we use in everyday life include

Computers

Today, computers are using everywhere. At home, computers are used for playing games, watching movies, doing research, paying bills and reservation of tickets for railways and airlines. At school, students use computers to complete their assignments.

Mobile phones

Mobile phones are used for variety of purposes such as for sending text messages, making voice calls, surfing internet, playing games, and listening songs.

ATM

ATM is an electronic telecommunication device particularly used for withdrawing money at anytime from anywhere. ATM stands for automated teller machine. The customer can withdraw money up to a certain limit during anytime of the day or night.

Pen drive

Pen drive is particularly used for storing large amount of data and also used for transferring data from one device to another. For example, the data stored in the computer can be transferred to the pen drive. The data stored in this pen drive can be retrieved at anytime.

Television

Television is an electronic device primarily used for entertainment and knowledge. It is used for watching movies for entertainment, news for knowledge, cartoons for children's.

Digital camera

Digital camera is a camera used for taking pictures and videos. This images and videos are stored for later reproduction.

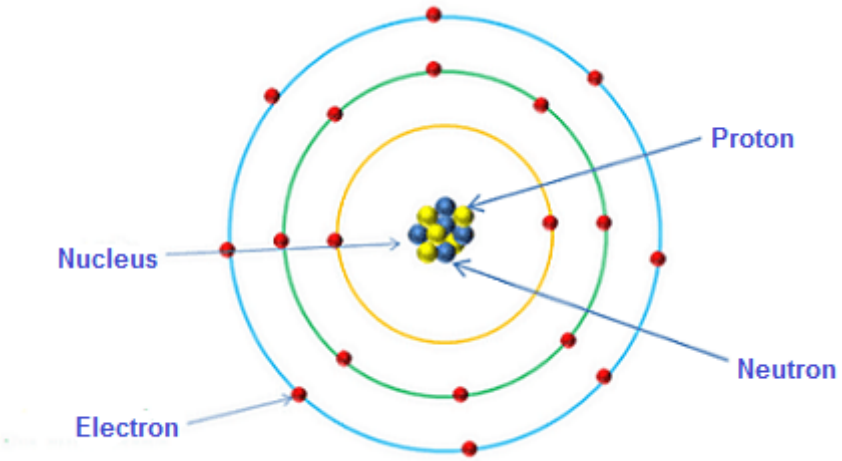
Electron Emission and its Types

Generally, emission refers to a process by which any object becomes free. In the similar way, the process by which the free electrons becomes free from the metal and enters into the vacuum is called electron emission.

Atom

We know that every solid, liquid, and gas is made up of atoms. The size of these atoms is very small. These atoms consist of even smaller particles such as protons, electrons, and neutrons.

The strong nuclear force between the neutrons and protons makes them stick together to form a nucleus at the center of an atom. Protons have positive charge and neutrons do not have any charge. Hence, the overall charge of a nucleus is positive.



Electrons are the negatively charged particles, which continuously revolve around the nucleus of an atom. These electrons are revolving around the nucleus of an atom because of the electrostatic force of attraction between the electrons and the nucleus.

Electrons revolve around the nucleus in different orbits or shells. The electrons, which are revolving at the outermost shell of an atom, are called valence electrons. The valence electrons and the atomic nucleus are present at greater distance. Hence, the electrostatic force of attraction present between the valence electrons and nucleus is very small. Thus, the valence electrons are loosely attached to the nucleus.

What is electron emission?

When a small amount of external energy is applied to the valence electrons, they gain enough energy and break the bonding with the parent atom. The electron, which breaks the bonding with the parent atom, moves freely from one place to another

place. These electrons, which move freely within the metal, are called free electrons. However, these free electrons cannot escape from the surface of a metal.

It is because the free electrons in the metals do not have enough energy to escape from metal. The free electrons, which try to escape from the metal, are pulled by positive electric force of atomic nucleus towards the metal. Hence, free electrons cannot escape from metal without sufficient energy. Thus, the positive atomic nucleus of the metal opposes the free electrons, which try to escape from the metal.

In order to make the free electrons to escape from the metal, an additional external energy is required. This additional external energy is applied in the form of heat, electric field, or light.

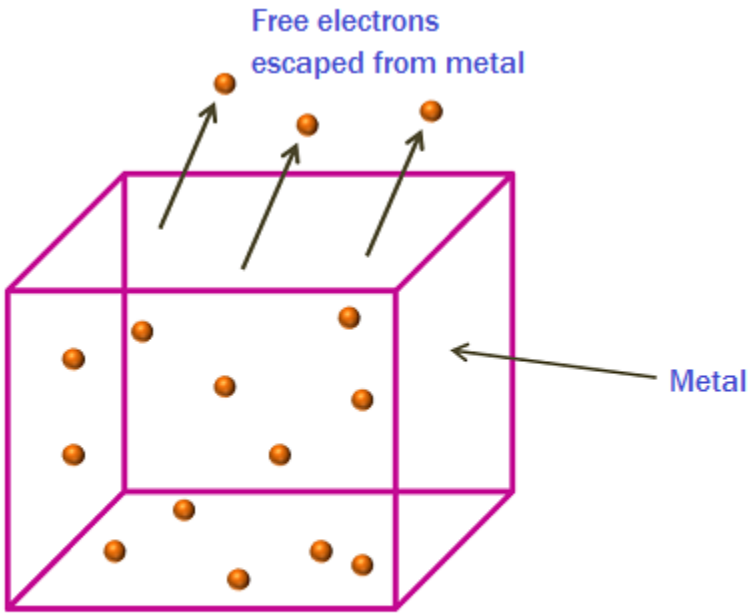


Fig: Electron emission

When the external energy in the form of heat, light, or electric field is applied to the metal, the free electrons gain enough energy and break the bonding with the metal. Free electrons, which break the bonding with metal, will jumps into the vacuum. The free electrons in the vacuum are not associated with the metal.

The process by which, these free electrons break the bonding with metals and jumps into the vacuum is called electron emission. The amount of external energy required to remove an electron from the surface of a metal is called work function. Work function is measured in joules.

The free electrons in the vacuum have higher energy than the electrons that are revolving around the nucleus because the free electrons in the vacuum had gained additional energy from the source of heat or light.

The process of electron emission is somewhat similar to the ionization process. In ionization process, electrons are removed only from the atom and not from the metal whereas in electron emission process electrons are removed from the atom as well as from the metal.

Different methods of electron emission

The different methods to emit free electrons from the metal surface include:

- **Thermionic emission**
- **Electric field electron emission**
- **Photoelectric emission**
- **Secondary emission**

1- Thermionic emission

The process by which free electrons are emitted from the surface of a metal when external heat energy is applied is called thermionic emission.

Thermionic emission occurs in metals that are heated to a very high temperature. In other words, thermionic emission occurs, when large amount of external energy in the form of heat is supplied to the free electrons in the metals.

Metals under normal temperature

When a small amount of heat energy is applied to the metal, the valence electrons gain enough energy and break the bonding with the parent atom. The valence electron, which breaks the bonding with the parent atom, becomes free. This electron, which breaks the bonding with the parent atom, is called as the free electron.

The free electrons in the metal have some kinetic energy. However, they do not have enough energy to escape from the metal. The attractive force of the atomic nuclei opposes the free electrons, which try to escape from the metal.

Free electrons in the metal have less energy compared to the free electrons in vacuum. Hence, free electrons require extra energy from the outside source in order to jump into the vacuum.

Metals under high temperature

When heat energy applied to the metal is increased to a higher value, the free electrons gain enough energy and overcome the attractive force of the atomic nucleus, which holds the free electrons in the metal. The free electrons, which overcome the

attractive force of the nuclei, break the bonding with the metal and jumps into the vacuum.

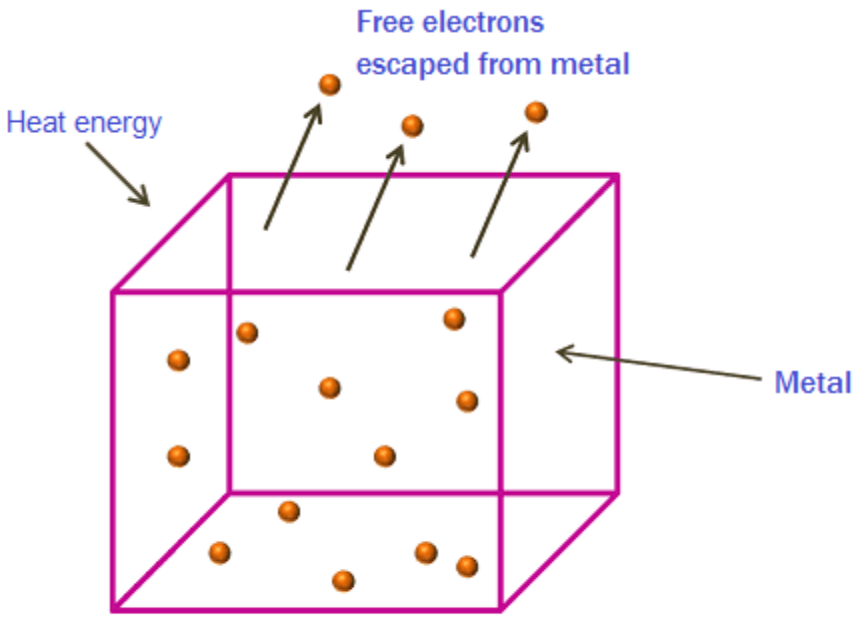


Fig: Electron emission

The free electrons, which are escaped from the surface of a metal when heat energy is supplied, are called thermions. Thermionic emission process plays a major role in the operation of electronic devices.

Thermionic emission depends on heat applied to the metal and work function of the metal

The number of free electrons escaped from the metal is depends on the amount of heat applied to the metal and the work function of the metal.

Heat applied to the metal:

If large amount of heat is applied to the metal, large number of free electrons gains enough energy and breaks the bonding with the metal. The free electron, which breaks the bonding with the metal, jumps into the vacuum.

On the other hand, if less amount of heat is applied to the metal, less number of free electrons gains enough energy and breaks the bonding with the metal. The free electron, which breaks the bonding with the metal will jumps into the vacuum.

Hence, the number of free electrons emitted from the metal increases with increase in heat. Thus, the free electrons emitted from the surface of metals are directly proportional to the temperature of the metals.

The minimum temperature at which the metal starts emitting the free electrons is called threshold temperature.

If the temperature of the metal is below the threshold temperature, the metal does not emit the free electrons. On the other hand, if the temperature of the metal is equal to the threshold temperature or greater than the threshold temperature, the metal emits the free electrons.

Work function of the metal:

The amount of external heat energy required to remove the free electron from the metal is called work function or threshold energy. The work function of metals is measured in electron volts (eV).

Metals that have low work function will require less amount of heat energy to cause the free electrons to escape from the metal. Hence, the metals with low work function emit large number of free electrons at high temperature.

On the other hand, metals that have high work function will require more amount of heat energy to cause the free electrons to escape from the metal. Hence, the metals with high work function emit less number of free electrons at high temperature.

Thus, the emission of free electrons from the metal is inversely proportional to the work function of a metal.

Applications of thermionic emission

The components, which are made by the process of thermionic emission are used in the electronic devices such as cathode ray tube, radio etc.

2- Electric field electron emission

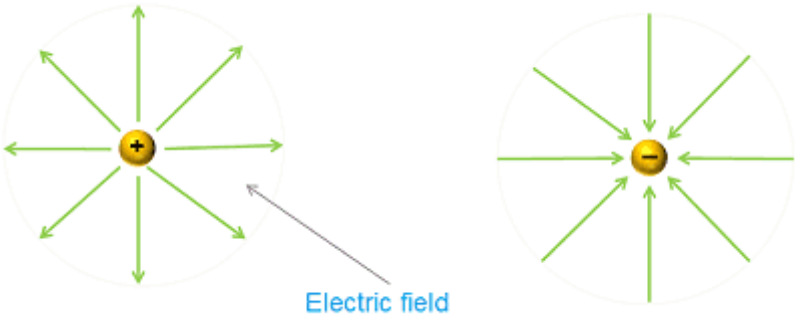
Electric field electron emission is the process by which free electrons are emitted from the metal surface when strong electric field is applied.

Electric field electron emission is also called as electron field emission, field electron emission and field emission. Electric field electron emission occurs not only in metals, but also in liquids.

Field electron emission occurs in metals that are placed at very strong electric field. In other words, field electron emission occurs when large amount of energy in the form of electric field is applied to the free electrons in the metals.

Electric field

Electric field is the region around a positively charged particle (proton) or negatively charged particle (electron) within which other positively charged particle (proton) or negatively charged particle (electron) experience an attractive or repulsive force.



Protons have positive electric field or electric charge whereas electrons have negative electric charge. We know that two opposite charges attract each other and same charges repel each other. Protons and electrons have opposite charges or different charges. Hence, when the electron is placed in the electric field of a proton, it gets attracted to the proton.

On the other hand, two protons or two electrons have the same charge. Hence, when one electron is placed in the electric field of another electron, they move away from each other. Similarly, when one proton is placed in the electric field of another proton, they move away from each other.

Metals in the absence external electric field

When no external electric field is applied to the metals, electrons cannot escape from the metals. However, some valence electrons in the metals become free from the parent atoms.

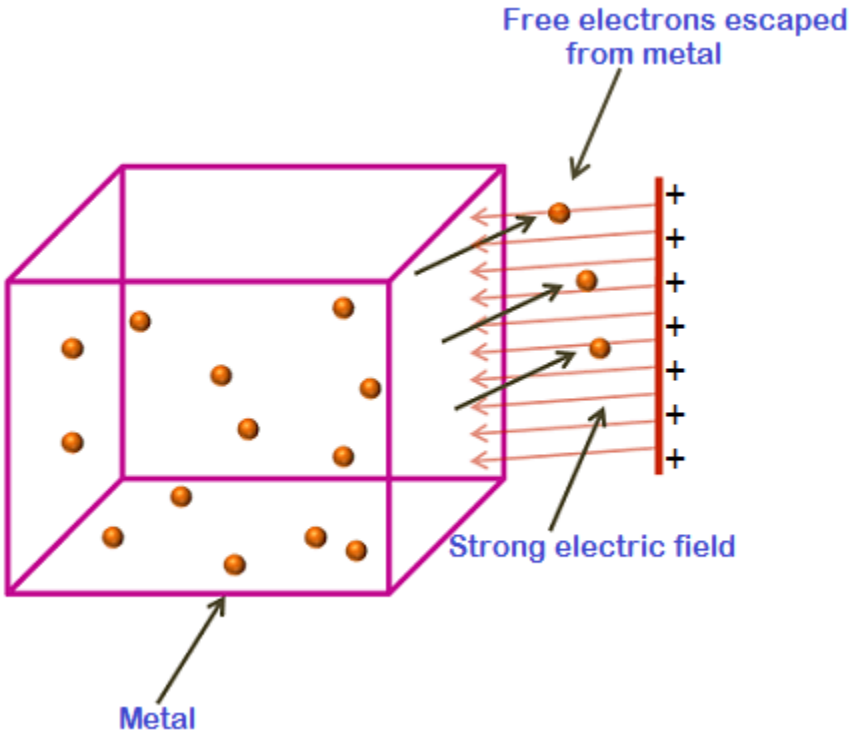
Under normal temperature, some valence electrons gain sufficient energy from the heat and break the bonding with the parent atom. The electron, which breaks the bonding with the parent atom, moves freely from one region to another region within the metal. These electrons are called as free electrons.

The free electrons moving from one region to another region have some kinetic energy. However, the free electrons do not have sufficient energy to escape from the metal surface. The strong attractive force of the nuclei prevents the free electrons, which try to escape from the metal.

The free electrons need sufficient energy from the external electric field to overcome the attractive force of the nuclei. The free electron, which overcomes the attractive force of the nuclei escape easily from the metal surface.

Metals in the presence of external electric field

When a strong positive electric field is applied to the metal, the free electrons in the metal experience an attractive force. These electrons gains extra energy from the external electric field.



If the strong electric field applied to the metal is great enough, the free electrons in the metal gains enough energy and break the bonding with metal or overcome the attractive force from the atomic nuclei. The free electrons which break the bonding with the metal will jumps into the vacuum.

Electric field electron emission depends on strength of the electric field and work function of the metal

The number of free electrons emitted from the surface of metal depends on the strength of the electric field applied to the metal and the work function of the metal.

Strength of the electric field

If very strong electric field is applied to the metal, large number of free electrons gains sufficient energy and overcomes the attractive force of the nuclei. The free electrons, which overcome the attractive force of the nuclei, will jumps into the vacuum.

On the other hand, if weak electric field is applied to the metal, less number of free electrons gain sufficient energy and overcomes the attractive force of the nuclei. The

free electron, which overcomes the attractive force of the nuclei, will jumps into the vacuum.

Hence, the number of free electrons emitted from the metal surface increases with increase in the strength of the electric field. Thus, the free electrons emitted from the metal surface are directly proportional to the strength of the electric field.

Work function of a metal

The minimum external energy required to emit the free electrons from the surface of a metal is called work function.

Metals with low work function require less electric field strength to emit free electrons from the metals. On the other hand, metals with high work function require high electric field strength to emit free electrons from the metals.

Thus, the electron emission from the metal surface is inversely proportional to the work function of metal.

3- Photoelectric emission

The process by which free electrons are emitted from the metal surface by the application of light is called photoelectric emission.

It is also defined as, the process by which free electrons are released from the metal when it absorbs light energy. Photoelectric emission is also called as photoemission or photoelectron emission or photoelectric effect.

In this method, light or photons is used to remove the free electrons from the solid metal. Hence, the free electrons emitted from the solid metal are called photoelectrons and current produced due to this process is called photoelectric current.

Metals without light energy

When the light energy is not applied to the metals, the free electrons cannot escape from the metals. However, some of the valence electrons become free from the atoms.

At normal temperature, some valence electrons get enough energy from the heat source. The valence electrons, which gets sufficient energy will breaks the bonding with the parent atom and becomes free.

The free electrons, which breaks the bonding the parent atom, have some kinetic energy. So, they move freely from one point to another point. However, they do not have enough energy to become free from the metal. The strong attractive force of the nuclei prevents the free electrons, which try to escape from the metal.

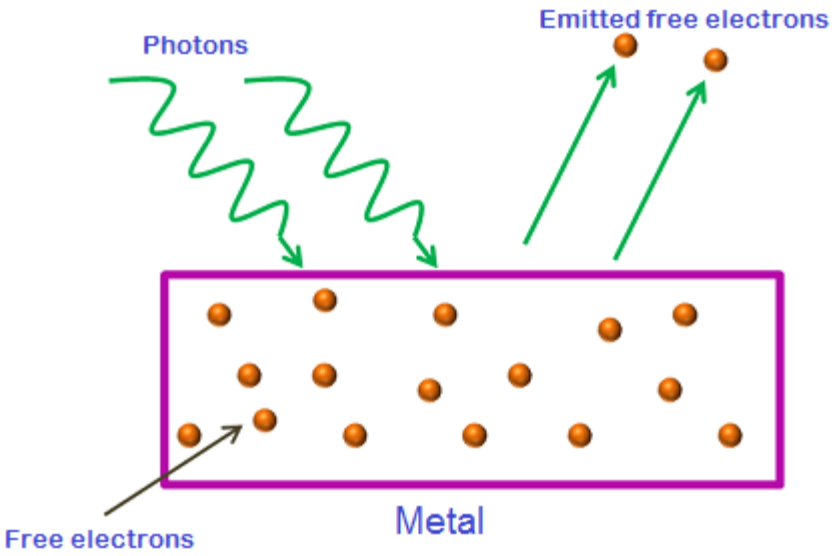
To overcome the attractive force of the nuclei, the free electrons need sufficient energy from the light. The free electrons, which break the bonding with metal, will moves into the vacuum.

Photons and its effect on metals

Photons are the smallest particles of light. Unlike electrons and protons, photons have no mass. However, photons have energy.

Visible light and all other forms of light such as radio waves, microwaves, infrared light, ultraviolet light, X-rays, andgamma rays are made up of photons. However, the energy of photons is not same for all these lights. For example, gamma rays (photons) have more energy than the infrared light (photons). The energy of photons is depends on its frequency, whereas the intensity of light is depends on the number of photons.

When the light energy is applied to the metal, the free electrons gains energy. In other words, when the light particles (photons) hits free electrons in the metal, they transfer their energy to the free electrons. The free electrons, which gains extra energy from the light, will try to the overcome the attractive force of the nuclei.



If the light energy applied to the metal is further increased to a higher value, the free electrons in the metals gain sufficient energy and overcome the strong attractive force of the nuclei. The free electrons, which overcome the attractive force of the nuclei, will jumps into the vacuum.

Photoelectric emission depends on the frequency of light and does not depends on the intensity of light.

Frequency of light

The energy of photons is depends on its frequency. Photons with low frequency have low energy whereas photons with high frequency have high energy. High-energy photons or high frequency photons are needed to emit the free electrons from the metals.

When the high-energy photons are applied to the metals, free electrons are escaped from the metal surface. The minimum energy or the minimum frequency that the photons required to remove the free electrons from the metals is called threshold frequency or threshold energy of photons. This threshold frequency is not same for all metals. It is different for different metals.

If the light energy applied to a metal reaches or exceeds the threshold frequency, it starts emitting the free electrons. On the other hand, if the light energy applied to a metal is below the threshold frequency, it does not emit the free electrons.

Intensity of light

The number of photons strikes the free electrons in the metal depends on the intensity of light. Low intensity light has less number of photons. Hence, if low intensity light is applied to the metal, less number of photons strikes the free electrons in the metal.

On the other hand, high intensity light has more number of photons. Hence, if high intensity light is applied to the metal, more number of photons strikes the free electrons in the metal.

High frequency and low intensity light

If high frequency and low intensity light is applied to the metal, less number of photons hits the free electrons in the metals. However, each individual photon, which hit the free electron, has energy or frequency greater than the threshold frequency or threshold energy.

Hence, each individual photon provides enough energy to the free electron to escape from the metal. Thus the free electrons emitted from the metal surface is depends on the frequency of light.

Low frequency and high intensity light

If low frequency and high intensity light is applied to the metal, more number of photons hits the free electrons in the metals. However, each individual photon, which hits the free electron, has energy or frequency less than the threshold frequency or threshold energy.

Hence, each individual photon does not provide enough energy to the free electron to escape from the metal. A single electron absorbs energy from a single photon. They cannot absorb energy from more than one photon to escape from the metal. Thus, the free electrons emitted from the metals do not depend on the intensity of light.

4- Secondary electron emission

Secondary electron emission is the emission of free electrons from the metal surface, which occurs when the high-speed electrons or primary electrons hit the free electrons or secondary electrons in the metal.

Metals under normal temperature

Under normal temperature, some of the valence electrons gain sufficient energy from the heat source and breaks the bonding with the parent atom. The valence electrons that break the bonding with the parent atom moves freely from one point to another point within the metal are called free electrons.

Free electrons have some kinetic energy. But, they do not have sufficient energy to escape from the metal. The attractive force of the nuclei resists the free electrons that try to escape from the metal. The free electrons in the metal need sufficient energy from the outside source to escape from the metal.

Metals bombarded with high speed electrons

When the high-speed electrons strike the metal surface, they transfer their kinetic energy to the free electrons in the metals. The free electrons that gains sufficient energy will overcomes the strong attractive force of the nuclei and escapes from the metal.

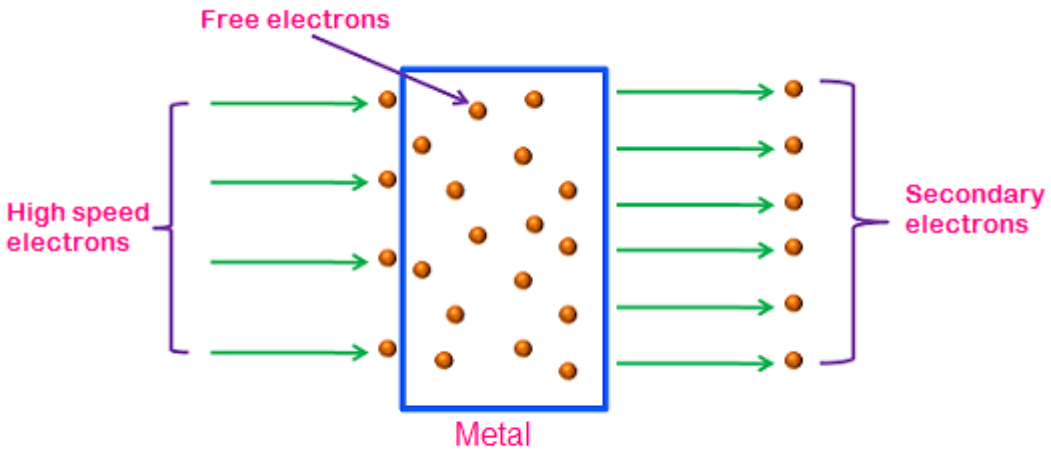


Fig: Secondary electron emission

The high-speed electrons that strike the free electrons in the metal are called primary electrons whereas the free electrons emitted from the metal surface are called secondary electrons. We are emitting the secondary electrons from the metal surface. Hence, the process of emitting the secondary electrons from the metal surface is called secondary emission.

Secondary electron emission depends on the number of primary electrons and energy of primary electrons

Number of primary electrons

When large number of high-speed or high-energy electrons strikes the free electrons in the metal, large number of free electrons gains enough energy and jumps into the vacuum. On the other hand, when small number of high-speed or high-energy electrons strikes the free electrons in the metal, small number of free electrons gains enough energy and jumps into the vacuum.

Energy of primary electrons

The minimum energy provided by the primary electrons to emit the secondary electrons from the metal is called threshold energy.

The secondary electrons are emitted from the metal surface, when they gains energy that is equal to or greater than the threshold energy.

If the energy provided by the primary electrons is equal to or greater than the threshold energy, metal starts emitting the free electrons. On the other hand, if the energy provided by the primary electrons is less than the threshold energy, metal do not emit the free electrons.

Uses of secondary electron emission

Secondary electron emission is used in the image intensifier and photomultiplier tubes.

Secondary electron emissive materials

Commonly used electron emissive materials include alkali antimonide, lead oxide, magnesium oxide, and gallium phosphide.