PHENOMENON OF PHOTO EFFECT IN SEMICONDUCTORS

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Abstract: This article describes the phenomenon of photoeffect in semiconductors, its theoretical foundations, types and practical application. The internal and external types of photoeffect, their mechanism and the processes occurring in p-n junction, photodiode and photoresistor are explained in detail. Also, special attention is paid to its application in solar cells, optical communication systems and other fields.

Key words: Semiconductors, photoeffect, internal photoeffect, external photoeffect, p-n junction, photodiode, photoresistor, solar cells, optoelectronics, light energy, electric charge carriers.

Introduction:

Semiconductors are important materials in modern electronics and optoelectronics. Due to their unique properties, the photoelectric effect - the occurrence of electrical phenomena under the influence of light - has been widely studied and technologically used. This article discusses the theoretical foundations, types and practical applications of the photoelectric effect in semiconductors.

The photoelectric effect is the phenomenon of the formation of electric charge carriers or an increase in their mobility when light interacts with a substance. This process is divided into three types:

- External photoelectric effect: The emission of electrons from the surface of a substance under the influence of light.
- Internal photoelectric effect: The formation of electron and hole pairs inside a semiconductor due to the energy of light.
- Photoconductivity: The increase in the electrical conductivity of a semiconductor due to the energy of light.

The photoelectric effect is the emission of electrons from a body under the influence of light. This phenomenon was first observed by G. Hertz in 1887 and quantitatively investigated by A. Stoletov. In 1898, Lenard and Thomson determined that the particle emitted from the cathode as a result of the photoelectric effect was an electron based on the flow of particles in a magnetic field (Figure 1). To study the photoelectric effect, a glass container with air sucked out of it and cathode and anode plates inside it are taken [1-7].

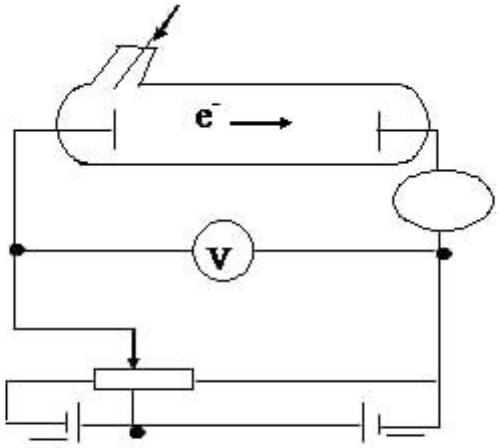

Figure 1. Observation of the external photoelectric effect phenomenon.

If the spectral composition of the light incident on a particular photocathode does not change, the saturation value of the photocurrent is directly proportional to the luminous flux.

The maximum value of the initial velocities of photoelectrons emitted from a particular photocathode does not depend on the intensity of the light. If the wavelength of the light changes, the maximum velocities of the photoelectrons also change.

For each photocathode, there is a "red limit" beyond which the photoeffect does not occur under the influence of light with a longer wavelength. The value of does not depend at all on the intensity of the light, it depends only on the chemical nature of the photocathode material and the state of its surface [6-11].

There is no significant time lag between the incidence of light on the photocathode and the formation of photoelectrons.

The phenomenon of the release of electrons from substances under the influence of light is called the external photoeffect. This phenomenon was discovered in 1887 by G. Gers and studied in 1890 by the Russian physicist Stoletov. If an electron removed from an atom or molecule remains as free electrons inside the substance, such a phenomenon is called the internal photoeffect.

Based on his many delicate experiments, Stoletov determined the following laws of the photoelectric effect.

The strength of the saturation photocurrent is proportional to the light flux incident on the cathode: that is, the greater the light flux, the greater the photocurrent. Here k is a coefficient characterizing the light sensitivity of the cathode material.

The kinetic energy of photoelectrons is directly proportional to the frequency of the incident light and does not depend on the light flux [12].

Regardless of the intensity of the incident light, the photoelectric effect begins to occur at a certain frequency (wavelength), and this frequency depends on the material from which the cathode is made [13].

There are the aforementioned inconsistencies between the wave theory of light and the photoelectric effect. Therefore, in 1905, A. Einstein proposed the quantum theory of light. Applying Planck's theory to light, Einstein argued that not only is light emitted in quanta, but that both the emission and absorption of light energy are quantized [14-18].

In this case, light is considered as photons (particles of light). A photon with energy transfers its energy to an electron in the metal. If this energy is large enough, an electron is released from the metal. The rest of the energy is manifested as the maximum kinetic energy of the electron that has escaped from the metal [19].

In semiconductors, the internal photoeffect and photoconductivity phenomena are often observed.

Semiconductors have a specific structure of energy bands: the valence band and the conduction band. If the energy of the light photons is greater than the size of the occupation band (energy gap) of the semiconductor, they transport electrons from the valence band to the conduction band. As a result, pairs of free electrons and holes are formed. This process changes the electrical properties of the semiconductor.

Photoelectric effect in p-n junctions: In semiconductors with p-n junctions, light activates the movement of electrons between the p and n regions, which creates a photoelectric voltage. This process is widely used in photoelectric sensors and solar cells [20-22].

Photoelectric effect in photodiodes and photoresistors: Photodiodes and photoresistors are made of light-sensitive materials. As the light intensity increases, the electric current or resistance changes [23-24].

The photoelectric effect has a wide range of practical applications in semiconductors:

Solar cells: Operate on the basis of the photoelectric effect to generate electricity from sunlight;

Photodiodes and photodetectors: Used to convert light signals into electrical signals;

Phototransistors: Used to amplify signals in optoelectronic devices;

Optical communication systems: Used to transmit information via light.

Conclusion

The photoelectric effect in semiconductors is of great importance in the development of modern technologies. The study of the relationship between light and electricity serves to create new devices and efficiently use energy resources. Therefore, the photoelectric processes in semiconductors are constantly under the attention of scientific and applied research. During the study of the photoelectric effect, I learned that it is divided into two types: external photoelectric effect and internal photoelectric effect. The external photoelectric effect is mainly observed in metals through the energy of light with a small wavelength. We also studied the penetration of dielectrics and metals into them based on the internal photoelectric effect. The photoelectric effect increases the electrical conductivity of dielectrics and semiconductors. In conclusion, the photoelectric effect is an important phenomenon of quantum mechanics and allows us to deeply study the effect of light on matter. This phenomenon also plays a key role in understanding and developing photovoltaic elements, photosynthesis, and many other technologies.

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