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TEACHING CURRENT IN SEMICONDUCTORS IN PHYSICS LESSONS

Feruza Babadjanova
Academic Lyceum of TTLII
Physics Teacher, +998- 90- 958- 22- 13

Abstract
The development of technology puts forward new tasks, which require new materials to solve. Thus, the development of aviation led to the development of light alloys, the progress of rocket science led to the creation of refractory and fire-resistant materials. Our time is marked by plastics and semiconductors, which have raised the level and level of technical virgin land.

Keywords: semiconductors, current in semiconductors, electrolytes, electrical conductivity, conductors, dielectrics

The study of the topic "current in semiconductors" should begin with the study of the physical properties of semiconductors and the mechanisms of electrical conductivity in them. If the current in metals and electrolytes is due to the presence of free electrons or ions there, which is simply postulated, then in order to understand the effects in semiconductors, it is necessary to study the mechanisms of generation, recombination and movement of free charge carriers. The material to be studied turns out to be very large in volume.

The material concerning the principles of operation of the most common electronic devices is presented. When studying the topic "Current in semiconductors", this material should follow the sub-topic "Electrophysical properties of semiconductors". It is possible that the proposed material will be redundant. In this case, it can be subjected to additional reduction by discarding intermediate calculations.

Semiconductors are substances that occupy an intermediate position between conductors and dielectrics in terms of specific electrical conductivity. They have a number of specific properties that sharply distinguish them from conductors and dielectrics, the main of which is the strong dependence of the specific conductivity on the influence of external factors (temperature, light, electric field, etc.). Semiconductors include elements of the fourth group of the periodic table, as well as chemical compounds of elements of the third and fifth groups of type AIII BV (GaAs, InSb) and the second and sixth groups of type AII B VI (CDs, BbS, CdFe). Silicon and GaAs gallium arsenide occupy a leading place among the semiconductor materials used in semiconductor electronics. An electronic semiconductor or an n-type

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semiconductor (from the Latin “negative”) is a semiconductor in whose crystal lattice, in addition to the main (tetravalent) atoms, there are impurity pentavalent atoms called donors. In such a crystal lattice, four valence electrons of the impurity atom are occupied in covalent bonds, and the fifth ("extra") electron cannot enter into a normal covalent bond and easily separates from the impurity atom, becoming a free charge carrier. In this case, the impurity atom turns into a positive ion. At room temperature, almost all impurity atoms are ionized. Along with the ionization of impurity atoms, thermal generation occurs in an electronic semiconductor, as a result of which free electrons and holes are formed. However, the concentration of electrons and holes resulting from the generation is significantly less than the concentration of free electrons formed during the ionization of impurity atoms, because the energy required to break covalent bonds is significantly more than the energy spent on the ionization of impurity atoms. The concentration of electrons in an electronic semiconductor is denoted by nn, and the concentration of holes is pn. In this case, the electrons are the main charge carriers, and the holes are the minor ones.

In this article I am going to present a sample method I use in my physics lesson at academic lyceum effectively.

Topic: Electronic devices based on p-n junction: gate diode, LED, laser diode, solar cell, solar battery.

The purpose and objectives of the lesson:

Educational: to expand students' knowledge of devices based on p-n-junction.

Educational: to continue the education of the culture of intellectual work, the development of personality qualities - perseverance, purposefulness, creative activity, independence.

Developing: to expand the scientific outlook of students on the phenomena they observe every day.

Equipment and visual aids: Power supply, laser pointer, solar cells, solar battery, demonstration stand, information posters.

Lesson progress:

1. Organizational moment: (Task: creating a favorable psychological mood and activating attention).

Preparation for repetition and generalization of the material covered:

1. The students receive test tasks (time to complete 7 minutes):

- What is electric current?
- What kind of conductivity do free electrons create?
- Particles creating p-conductivity - tAg
- What process is called diffusion?

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Schematically depict the structure of the p-n junction.

3. The main stage.

New material. Valve (rectifier) diodes are designed to convert alternating voltage (current) to constant voltage (current) (for recording). For rectifier diodes, the main property is the one-way conductivity of the p-n junction. Being connected to an alternating voltage circuit, the diode passes current to the load in only one direction (rectifies the graph of the time dependence of the current). With the help of additional reactive elements, it is possible to turn a unidirectional pulsating current into an almost constant one. Structurally, single diodes are a plastic case with terminals, inside of which there is a semiconductor crystal. The figure shows one of the types of case rectifier diodes and the symbol of such diodes on electrical circuits. The designation contains a triangular arrow showing the directions of current transmission by the diode.

An LED is a semiconductor device that generates optical radiation (when an electric current passes through it). The physical basis of the action of LEDs is the recombination of free electrons and holes, accompanying the direct current through the p-n junction (for recording). The color of the radiation is determined by both the semiconductor materials used and the alloying impurities.

A laser diode is a laser in which the active medium is the excited volume of a semiconductor, and the working area is a p-n junction, similar to the p-n junction of a conventional LED (for recording). In a laser diode, a semiconductor crystal is made in the form of a very thin rectangular plate. Such a plate is an optical waveguide, where the radiation is limited in a relatively small space. An n-region is created in the upper layer of the crystal, and a p-region is created in the lower layer. The result is a flat p-n junction of a large area. The two sides of the crystal are polished to form smooth parallel planes that form an optical resonator. A random photon of spontaneous radiation emitted perpendicular to these planes will pass through the entire optical waveguide and be reflected several times from the ends before coming out. Passing along the resonator, it will cause forced recombination, creating new and new photons with the same parameters, and the radiation will be amplified (the mechanism of forced radiation). As soon as the gain exceeds the loss, laser generation will begin.

Laser diodes can be of several types. In the main part of them, the layers are made very thin, and such a structure can generate radiation only in a direction parallel to these layers. On the other hand, if the waveguide is made wide enough compared to the wavelength, it will be able to work at several wavelengths already. Such a diode is called multimode. The use of such lasers is possible in cases where high radiation power is required from the device, and the condition of good convergence of the beam is not set (that is, its significant scattering is allowed or necessary). Such areas of application are: printing devices, chemical industry, pumping of other lasers. On the other hand, if good beam focusing is required, the width of the waveguide should be made comparable to the wavelength of the radiation. Such devices are used in optical storage devices, laser sights, as well as in fiber-optic technology. It should be noted, however, that such lasers can support several longitudinal modes, that is, they can emit at different wavelengths simultaneously.

A photocell is an electronic device that converts photon energy into electrical energy (for recording). The most effective, from an energy point of view, devices for converting solar energy into electrical energy are semiconductor photovoltaic converters (FEPs), since this is a direct, single-stage energy transfer. The conversion of energy into FEP is based on the photovoltaic effect that occurs in inhomogeneous semiconductor structures when exposed to solar radiation.

The heterogeneity of the FEP structure can be obtained by doping the same semiconductor with various impurities (creating p-n junctions) or by connecting different semiconductors with different band gap widths. The energy of electron separation from the atom (creation of heterojunctions), or by changing the chemical composition of the semiconductor, leading to the appearance of a gradient of the band gap width. Various combinations of these methods are also possible. The conversion efficiency depends on the electrophysical characteristics of the inhomogeneous semiconductor structure, as well as the optical properties of the FEP, among which the most important role is played by photoconductivity. It is caused by the phenomena of the internal photoelectric effect in semiconductors when they are irradiated with sunlight.

A solar battery is one of the generators of alternative types of energy that convert solar electromagnetic radiation into electricity (for recording). The production of solar panels is developing rapidly in a variety of directions. Solar panels are very widely used in tropical and subtropical regions with a large number of sunny days. They are especially popular in the Mediterranean countries, where they are placed on the roofs of residential buildings to heat water and generate electricity. In the future, they will probably be used to recharge electric vehicles.

Based on the results, it can be argued that semiconductors are a rapidly developing branch of solid state physics and this is evidenced by the Nobel Prize awarded in 2000 to academician Zh.I. Alferov for the study of heterojunctions, the development of technology for their formation and for the organization of the production of semiconductor devices based on heterojunctions.

The intensive development of electronics is associated with the emergence of a variety of new semiconductor devices and integrated circuits that are widely used in computing, astronautics, automation, radio engineering and television, in measuring equipment installations, medicine, biology, etc.

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