MECHANISM OF INFLUENCE OF SURFACE STRUCTURAL DEFECTS ON THE PHOTOVOLTAIC EFFECT IN A UNIAXIAL $CuAlS_2$ CRYSTAL WITH A SUPERLATTICE

GASIMOGLU IBRAHIM

Azərbaycan Respublikası Elm və Təhsil Nazirliyi, H.M.Abdullayev adına Fizika İnstitutu.
Az 1143 Bakı şəhəri, H.Cavid pr.131
E-mail: gasımoğlu@yahoo.com

In the presented study, the formation of layered periodic structures with an artificial lattice is reported in the CuAlS2 single crystal, which is a group of uniaxial crystals, during the technological process. It was carried out by measuring the physical parameters of single crystals that meet the modern requirements of nanotechnology and spintronics, photovoltaic effect, photoconductivity, return effect, Volt-Ampere characteristic.

Key words: Chalcopyrite, periodic structure, uniaxial crystal.
PACS: 61.80.Ed.

$CuAlS_2$ single crystal belongs to the group of semiconductor compounds Ai Bii Cvi2 and crystallizes in the chalcopyrite structure, the spatial symmetry group is $\bar{4}2m$. The energy of the closed band is E_g=1.81eV (T=300K). This combination has a great advantage in the manufacture of semiconductor devices, especially in the manufacture of photocells and light recording devices. It is usable for technical purposes. The substance was obtained by the Bridgeman-Stockbarger method. We determined the type of the crystal according to the sign of the electromotive force, which is positive, that is, p-type. Its resistance is R= 8 ohm at room temperature. X-ray and Raman analyzes showed that the obtained substance is a semiconductor (fig.1)

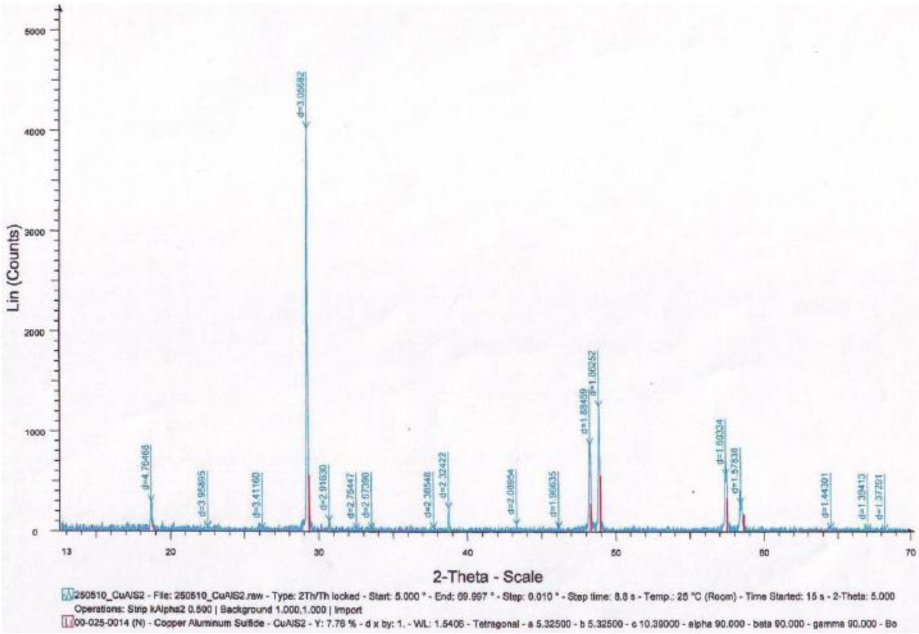

Fig. 1. X-ray analysis spectrum of $CuAlS_2$ single crystal.

Relevance of the topic: In contrast to their double counterparts, the transport processes occurring in triple compounds have not yet been fully studied. The topic is relevant because the harmonic waves formed on the surface due to the layered periodic structures formed during technological processes promise new perspectives. And it is considered important in terms of studying the nature of interactions between the nanostructures formed on the crystal surface and the crystal itself [1].

Case study: A newly obtained compound $CuAlS_2$ single crystal is suitable for practical application. There is a need to apply new technologies and measure new physical parameters to increase the useful work ratio. The reliability and stability of microelectronic devices is determined by their resistance to temperature. Among classical semiconductors, Ge and Si are considered the main materials. The energy of the closed zones is Eg=0.78eV, Eg=1.21eV, respectively. During application, devices made of these semiconductors lose their quality after 100-2000. During the application,

131, H.Javid ave, AZ-1143, Baku
Institute of Physics
E-mail: jophphysics@gmail.com

attention should be paid to the correct selection of the semiconductor material. We preferred uniaxial, porous, chalcopyrite structural compounds [2]. One of the semiconductors we are experimenting with is $CuAlS_2$. Eg=1.81eV. Since the energy of the closed zone is very valuable, devices made of this semiconductor will be resistant to high temperatures. We believe that these semiconductors will be among the attractive objects of modern microelectronics, since they are crystals that do not have an inversion center due to the creation of an artificial cage during the technological process, porosity, synchronism, pyozeoeffect, double entanglement, and crystals.

Conducting the experiment:

It can be determined from the Volt-Ampere characteristic that the dispersion law of electrons in semiconductors is not quadratic. During the experiment, whether the graph is continuous or discrete, it behaves as an indicator of the processes taking place inside the crystal or on its surface. We can monitor what is happening on the surface of the crystal by measuring the Volt-Ampere characteristic. We can see that the graph expressing conductivity as a function of constant electric field, both in weak fields and in strong fields, is not linear. In crystals with an artificial lattice, the conduction band splits into sub-mini-bands in non-stationary conditions, so we observe anisotropic conduction in the spectra. This type of conductivity is due to lakalization of waves in potential holes on the crystal surface.

The graph obtained in the experiment conducted by the combined scattering method allows us to say that the maxima are caused by free electrons and charged particles whose connection with the main substance is weakened (Figure 2). This suggests that the charged particles are locally formed around the nanostructures in the set [3]. In the volt-ampere characteristic, we observe the resonance maximum, equal, periodically repeating waves (Figure 3). These two properties are empirical indications that the crystal has an artificial lattice. In another experiment, we observe Clone steps. The fact that the graph takes such a shape indicates the movement of the defects created during the technological process, especially during processing with chemical reagents, together with the spiral dislocations towards the surface of the crystal. It is interesting that the energy shown by the axis vertically lowered from the linear part of the spectrum to the voltage axis, which represents recombination, is the same as the energy of the connected zone of the semiconductor (Eg=1.81eV). That is, the energy of the connected zone from the Volt-Ampere characteristic is simple.

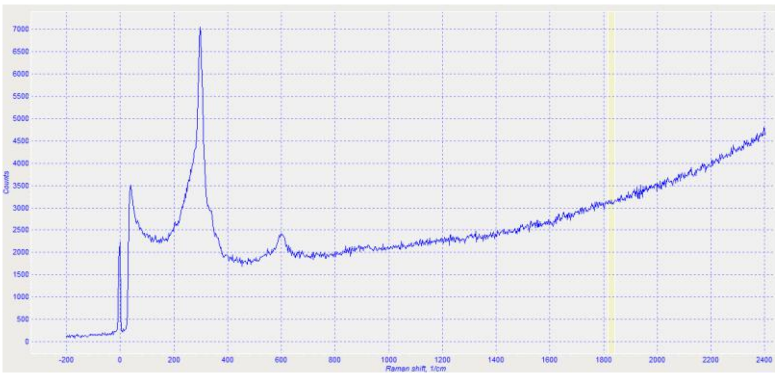

Fig.2. $CuAlS_2$ Raman scattering spectrum.

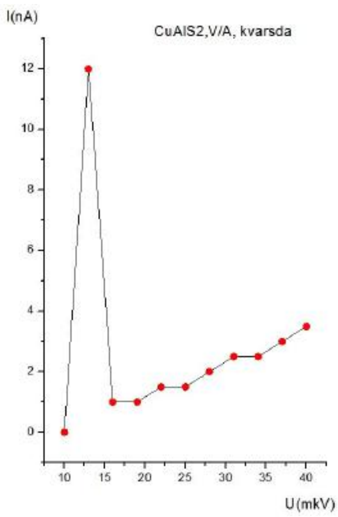

Fig. 3. $CuAlS_2$ single crystal spectrum with resonance maximum on quartz.

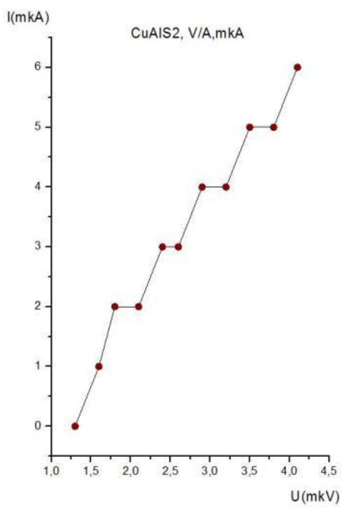

Fig. 4. $CuAlS_2$ single crystal Volt-Ampere characteristic. We determined the energy of the closed zone by drawing a vertical line from the first step to the stress axis.

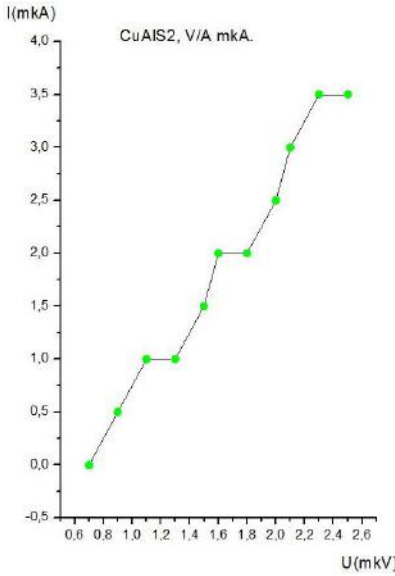

Fig.5. $CuAlS_2$ single crystal Volt-Ampere characteristic. We determined the energy of the closed zone by drawing a vertical line from the second step to the stress axis.

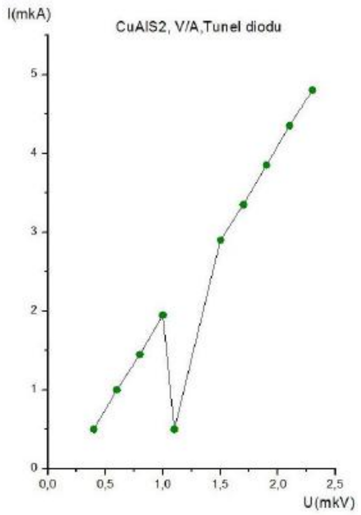

Fig.6. Volt-Ampere Characteristics of a $CuAlS_2$ Single Crystal Tunnel Diode.

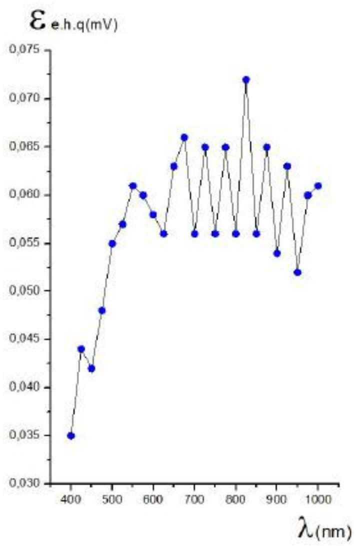

Fig.7. $CuAlS_2$ single crystal. The spectrum of the dependence of the electromotive force on the wavelength of modulated light by the capacitor method. Amplifier mode 100 mV.

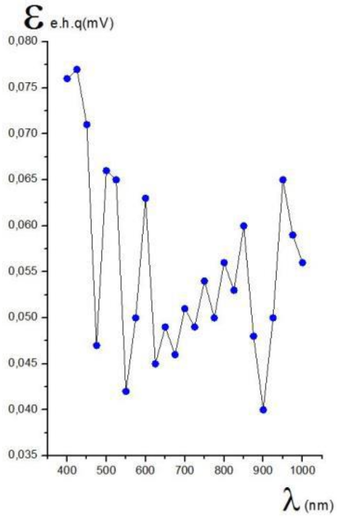

Fig.8. Dependence of electric motive force on wavelength of modulated light by $CuAlS_2$ single crystal capacitor method. Amplifier mode 300mV.

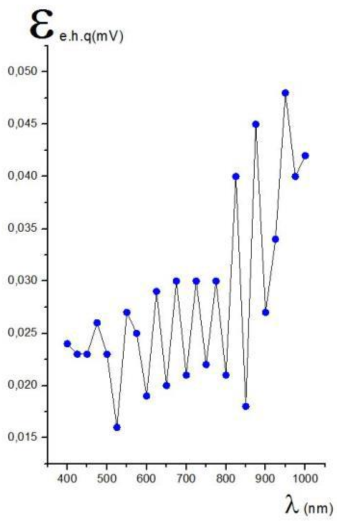

Fig.9. Dependence of the electromotive force on the wavelength of the modulated light by the $CuAlS_2$ single crystal capacitor method. Amplifier mode 1V.

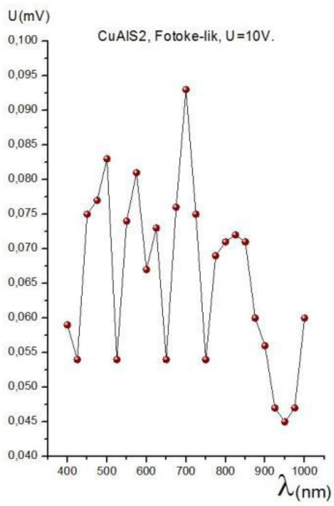

Fig.10. $CuAlS_2$ single crystal photoconductivity. External field U=10V, Amplifier mode

300mV.

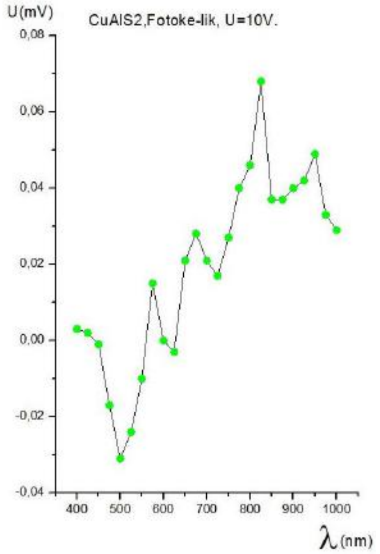

Fig.11. $CuAlS_2$ single crystal photoconductivity. External field U=10V, Amplifier mode 1V.

Final result

1. Using a new technology, a uniaxial triple semiconductor with an artificial lattice and a periodic structure ($CuAlS_2$) was grown. 2. The Volt-Ampere characteristics of the tunnel diodes of photocells that can work at low voltages (mV) were measured. 3. The method of calculating the energy of the Closed zone from the Volt-Ampere characteristic has been developed. And the energy value was calculated (Eg=1.81eV). 4. When reducing the value of the external field to semiconductors by half (U=4.5mkV, U=2.6mkV), the speed of spiral dislocation increased twice. 5. The energy of the zone connected to the spectrum, which expresses the dependence of the electric motive force on the wavelength of the modulated light, was calculated (Eg=1.81eV). 6. It was determined that there is a negative differential resistance from the spectrum of photoconductivity.

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