# GROWTH AND SOME OPTICAL PROPERTIES OF NANOPARTICLES GaSe, FORMED IN THE VOLUME OF GLASS MATRIX

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**ABSTRACT**

The nanoparticles of gallium selenide in the volume of glass matrix are obtained with the help of the crystallization in the matrix method. The X-ray diffraction investigations show, that the nanoparticles of gallium selenide with structure δ-GaSe form in the glass matrix. In the obtained structures, the photoluminescence radiation spectrums (at the excitation wave length 510nm) have half-widths of lines ~0,23eV with the radiation maximum 710nm.

**Keywords:** nanoparticles, matrix method, photoluminescence, radiation, spectrums.

## 1. INTRODUCTION

Last years, the big attention has been paid for the working of the obtaining technology and studying of nanoparticle physical properties of layered gallium selenide semiconductor [1-5]. The confinement of particle sizes leads to very interest physical phenomena. With the decrease of the particle sizes, the material physical properties change significantly. The decrease of the particle sizes increases the ratio of surface square (S) to the particle volume (V) and increases the influence of the surface atoms in the physical and thermodynamical properties of nanoparticales. For example, the decrease of nanoparticle sizes CdSe from 10nm to 1nm increases the past of surface atoms practically from 20% till 100% [6]. The increase of the ratio (S/V) at the decrease of the particle sizes increases the portion of surface energy in the free energy. In the result of which, the materials, which are unstable in the volume state, can be stable in the form of nanoparticle [7]. The semiconductor nanoparticles are perspective materials in the computing devices, medicine and device construction [6]. The one of the important tasks of the computing device is the increase of system speed, which can be solved with the help of nanoparticles, having the high nonlinear -optical properties [6]. Such materials can allow to create the calculation systems(computing device ), working in the terahertz areas. That's why the working of new technologies and materials for the high-speed calculation technique present the big interest. The composite materials on the base of nanoparticles of layered semiconductor GaSe, which has the high nonlinear -optical properties, can become the one of such materials. As it is known, with the decrease of nanoparticle sizes, in the result of quantum-sized effect, the change of GaSe band gap in the wide interval makes this material the interest object of scientific investigations.

## II. THE OBTAINING TECHNOLOGY AND STRUCTURE OF NANOPARTICLES

The meaning of the technology is that nanoparticle material (or its components) and matrixes are taken into quartz ampoule or corund crucible. The matrix fusing point should be lower, than nanoparticle material fusing point. Moreover, components (anions and cations) of nanoparticle dissolve in the melt of matrix material and create the homogeneous mixture. After that the mixture is cooled by the definite program. At the mixture cooling, the super saturation on semiconductor components appears in the system. At the same time, the creation of buds and nanoparticle forming begins. The process of nanoparticle forming in the matrix melt volume accompanies with the creation of buds of different sizes and carrying out of crystallization process. Moreover, the

absorption of small particles by the big ones is very benefit. In the result of which, the nanoparticle crystallization centers form. The forming of these centers in the matrix melt volume decrease of super saturation factor around the nanocrystal. In this connection, the probability of new bud creation around nanoparticles decreases. The sizes of the created microcrytals depend on the mixture duration time at such temperature. After that the mixture is cooled till the room temperature by the definite program.

The GaSe nanoparticles in the volume of glass matrix are formed by us by the following method. The glass and components of nanoparticle (Ga and Se) are taken in the quartz ampoule. The metallic Ga and Se in the stoichiometric weight ratio are mixed with the well ground glass and are taken in the quartz ampoule. The nanomaterial components are 5% in the weight ratio with matrix. The quartz ampoule is pumped, with the help of fore vacuum pump and is unbrazed. After that the ampoule is taken in the muffle stove and is heated till the temperature $1200^0$C. The heating time was near 90 minutes. Moreover, the homogeneous mixture creates. The Ga and Se components reflect in the volume and totally dissolve in the glass melt. After that the homogeneous melt is cooled by the special program. The melt is kept at the temperature $850^0$C during 60 minutes, later the melt is cooled till the room temperature. The obtained composite material is porous one. The planes, prepared from this material, are treated by the thermal relieving at the temperature $570^0$C during hours. In the result of this process, the nonhomogeneous of composite material destroys.

The GaSe nanoparticle structure is defined with the help of X-ray-structural analysis. The glass, in the volume of which the gallium selenide nanoparticles are formed, is pumped out in the mortar. After that the powder X-ray-grams are taken (fig.1).

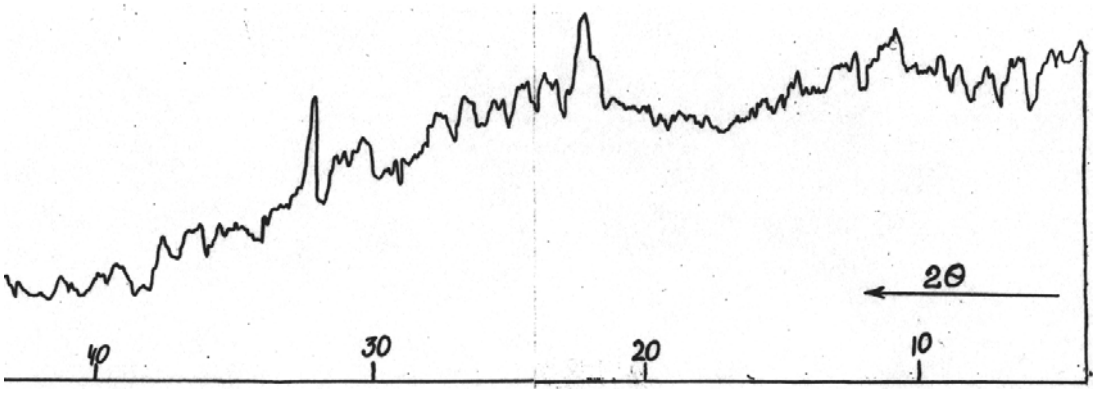


Fig1.X-ray diffraction from powder GaSe:glass

The analysis results are shown in the table 1. As it is seen from the table, the observable values of spacing of lattice planes significantly don't differ from standard values.

**Table 1**

| № | Observable value d in $A^0$ | Standard value d in $A^0$ | I | hkl |
|---|---|---|---|---|
| 1 | 7,993 | 7,988 | 40 | 004 |
| 2 | 3,998 | 3,994 | 100 | 008 |
| 3 | 3,234 | 3,232 | 36 | 101 |
| 4 | 2,899 | 2,90 | 42 | 105 |
| 5 | 2,776 | 2,779 | 94 | 106 |
| 6 | 2,5226 | 2,527 | 12 | 108 |
| 7 | 2,3989 | 2,392 | 30 | 109 |
| 8 | 1,874 | 1,8697 | 15 | 1014 |

The value of spacings of lattice planes is equal to phase $\delta - GaSe$. The nanoparticle sizes $\delta - GaSe$ are founde from the ratio [11].

$$d = \frac{0.9\lambda}{\beta \cos\theta} \quad (1),$$

where b is intensity half-width of diffraction line, measured in radians, л=1,5406$A^0$ is wave length CuK$\alpha$, $\theta$ is diffraction angle. The average value of particle sizes GaSe, calculated from the equation (1), is equal 1, 56nm. Such small value for nanoparticle sizes

of gallium selenide is explained by the fact, that duration time for crystallization process is chosen very few. In the result of this, the process of nanoparticle enlargement (coalescence) is difficulty. Besides, probably, the high temperature ($850^0$C) harms to the increase of the particles in the direction Van-der-Vasl connections.

## III. THE PHOTOLUMINESCENCE IN GASE NANOPARTICLES

The optical properties of gallium selenide nanoparticles, formed in the methanol volume are investigated in detail in the work [1]. The particle sizes in these experiments change from 2nm till 6nm. The average particle size is 4,0nm. The half-width of radiation line decreases in 1.5 times in the comparison with the previous samples.

The radiation spectrums (fig.2a) and excitation spectrums (fig.2b) in the GaSe nanoparticles: glass at the temperature 90K, are investigated by us. At the excitation by photos with the energy л=510 nm, the not wide band with half-width, which is equal to 0.23 eV and radiation maximum at 710nm (1,75eV) are observed. The nanoparticle excitation spectrums have very wide band with half-width E=0,42eV, and maximum is situated in the region 2,42 eV.

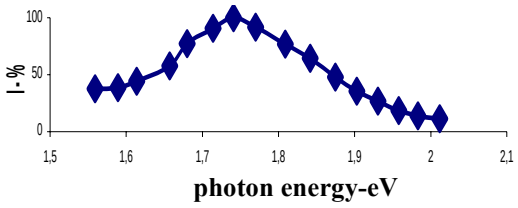


Fig.2a Emission spectra of nanoparticles GaSe

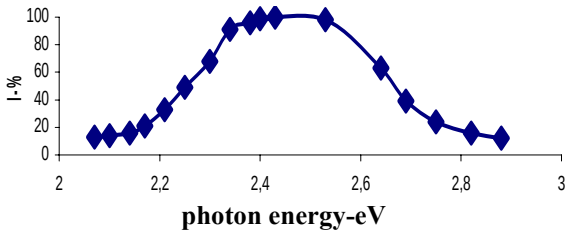


Fig 2b Excitation spectra of nanoparticles GaSe

The observable by us wide excitation spectrum is evident about the wide material of particle distribution on the sizes. In the result of which, the width of the prohibited band in the dependence on the sizes, changes in the wide range, according to the ref [8].

$$\Delta E = \frac{\pi^2 \hbar^2}{2m^* d^2} \qquad (2)$$

where h is Plank constant, d is particle size, $m^*$ is effective mass of electrons and holes, $\pi$ =3,14 constant. In the result of which, the edge of fundamental absorption in the nanoparticles spreads.

The temperature dependence of photoluminescence of GaSe nanoparticles, formed in the glass matrix is investigated also by us. The dependence of radiation intensity maximum (л710nm) on the sample heating temperature in the temperature range (80-270) K is investigated (fig.3). As it is seen from the figure 3, in the temperature interval (80-120)K, the radiation intensity increases~15%, and in the temperature interval (120-200)K, the intensity change doesn't significant (less, than 2%). The last increase leads to the insignificant intensity increase of photoluminescence (~7%). Such step of temperature dependence is explained by the fact, that nonradiated transfers are situated near radiated transfer. At the temperature increase, the carrier transfer from the nonradiated transfers into theradiated one takes place, in the result of which the radiation intensity increases. The last heating leads to the radiation level saturation. In the temperature interval (200-270)K the decrease of the carrier concentration in the radiated level takes place and radiation concentration in the radiated level takes place and radiation intensity decreases.

## IV. CONCLUSION

Thus, for the first time, the gallium selenide nanoparticles in the volume of glass matrix are formed by the crystallization method. By X-ray-structural analysis, it is shown, that the nanoparticles with the structure б-GaSe form in the glass matrix. The wide value of excitation spectrum half-width is explained by the distribution of particle sizes in the big range. It is shown, that maximum radiation intensity of photoluminescence weakly depends on the temperature.

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