TEMPERATURE DEPENDENCE ELECTROCONDUCTIVITY IN STRONG ELECTRICAL FIELDS OF MONOCRYSTALS OF FIRM SOLUTIONS $(Ga_2S_3)_{1-X}(M_2O_3)_X$ (were M_2- Eu, Sm, $0.01 \leq X \leq 0.07$)

B.G.Tagiev, O.B.Tagiev, I.B.Baxtiyarov, H.B.Kanbarova.

Electrophysics and Electrical Materials
Oktay58@ mail.ru, phone(99412)4396795, fax:(99412)4396795
Institute of physics Azerbaijan National Academy of Sciences.

Baku 370143, Azerbaijan
E-mail: Oktay@physics.ab.az

ABSTRACT

The temperature dependence electroconductivity of monocrystals of firm solutions $(Ga_2S_3)_{1-x}(M_2O_3)_x$ (where M_2- Eu, Sm, $0.01 \leq x \leq 0.07$) and Ga_2S is investigated in the field of performance of the law of Om and in an interval of electrical fields, where the essential role is played by field ionization of traps.

Keywords: temperature, electroconductivity, fields, ionization, monocrystals.

I. INTRODUCTION

The firm solutions $(Ga_2S_3)_{1-x}(M_2O_3)_x$ first synthesized by the authors /1-2/ crystallize in monoclinic syngony, is high-resistance (10^7~10^{10} Om.cm), high-bandgap (Eg=2.5-3.5eV) semiconductors.

In jobs /1-3/ the crystal structures of monocrystals Ga_2S_3- Eu_2O_3 and Ga_2S_3- Sm_2O_3 are investigated. The crystal structures of these connections are very close to each other. The method of the physical-chemical analysis constructs the diagram of a condition of a cut Ga_2S_3- Eu_2O_3 and Ga_2S_3- Sm_2O_3. A cut is quasibinar and diagram of these connections concern to eutectic type, the solubility on a basis Ga_2S_3 at room temperature is made 18,5 mol % Eu_2O_3 and 20,5 mol % Sm_2O_3.

In the present job are investigated temperature dependence electroconductivity in strong electrical fields of monocrystals of firm solutions $(Ga_2S_3)_{1-x}(M_2O_3)_x$, (where M_2- Eu, Sm, $0.01 \leq x \leq 0.07$). The measurements electroconductivity of alloys of firm solutions of systems $(Ga_2S_3)_{1-x}(M_2O_3)_x$, (where M_2- Eu, Sm,) show, that in comparison Ga_2S_3 the value of the electroconductivity of the investigated firm solutions decreases.

Connection Ga_2S_3 and the firm solutions on its basis are defective semiconductors with stereometrical cationic vacancies, and this feature is shown in temperature dependence electroconductivity of similar semiconductors /4-6/.

II. TECHNIQUE OF EXPERIMENT

The firm solutions $(Ga_2S_3)_{1-x}(M_2O_3)_x$ (where M_2- Eu, Sm, $0.01 \leq x \leq 0.07$) were synthesized by a method of solid-phase reaction from double connections Ga_2S_3, Eu_2O_3 and Ga_2S_3, Sm_2O_3 taken in stochiometric parities, in quartz ampoules pumped out up to 10^{-4} mm. Hg.col.. , at 1100±20 ^{0}C. Synthesis spent during 6-7 hour with periodic hashing. To cultivation of a monocrystal $(Ga_2S_3)_{1-x}(M_2O_3)_x$ was applied a diffusive method of gas-transport process, where as a carrier was used crystal iodine three times cleared by sublimation. The difference of temperature at reception of a monocrystal made 30^{0}C. The received monocrystals represented parallel-sided of a plate. The researches were spent on samples by thickness 70-130mkm, the contacts were created melting India in sandwich execution, i.e. In- $(Ga_2S_3)_{1-x}(M_2O_3)_x$ -In.

III. EXPERIMENTAL RESULTS.

Measurement electroconductivity were spent in an interval of temperatures 77÷400K. For the majority of researched samples on dependence lgσ from 10^3/T three sites are allocated: high-temperature (250÷400K), intermediate (160÷250K) and low temperature (77÷160K).

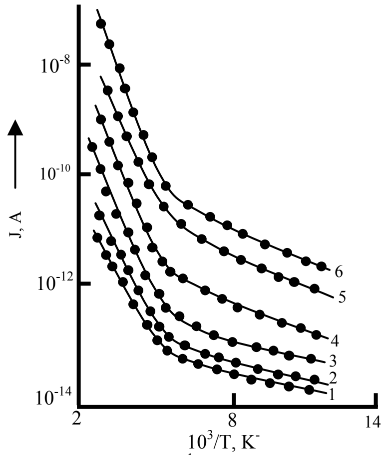

Fig.1.The temperature dependence current of Ga_2S_3 monocrystal samples with thinkness 95mkm in diffence intensivity U,V: 1-30, 2-40, 3-60, 4-100, 5-150, 6-200

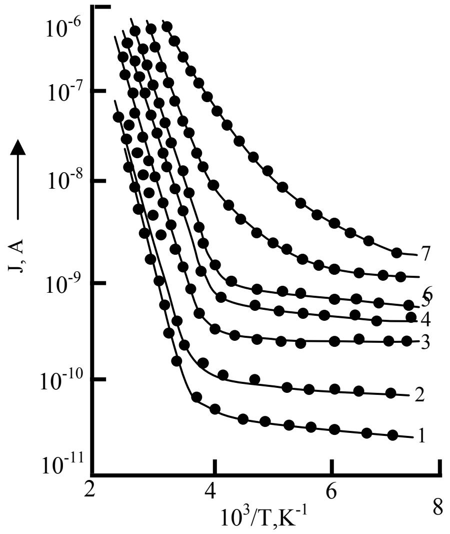

Fig.2.The temperature dependence current of $(Ga_2S_3)_{0,99}(Eu_2O_3)_{0,01}$monocrystal samples with thinkness 100 mkm in diffence intensivity U,V:1-10, 2-20, 3-60, 4-90, 5-120, 6-200, 7-300

Fig 1÷5show, that at high temperatures lgσ linearly depends on return temperature. It means, that in strong electrical fields electroconductivity of monocrystals of firm solutions $(Ga_2S_3)_{1-x}$ $(M_2O_3)_x$ and Ga_2S_3 exponentially depends on temperature.

It is valid, in the field of performance of the law of Om the temperature dependence electroconductivity of semiconductors is expressed by the formula /7/:

$$\sigma(0) = \sigma_0 e^{-\frac{E_t}{rkT}} \qquad (1)$$

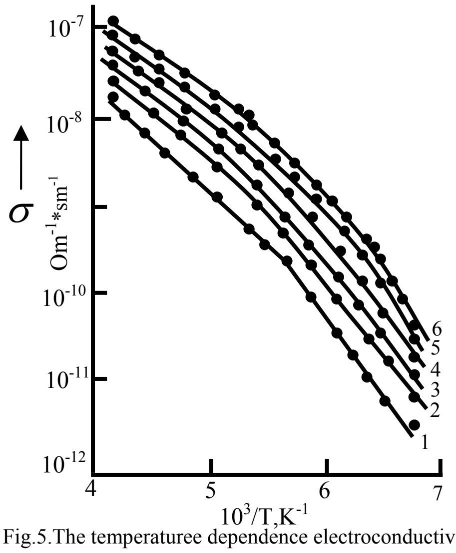

Fig.5.The temperaturee dependence electroconductivity of $(Ga_2S_3)_{0,95}(Eu_2O_3)_{0,05}$ monocrystal samples with thinkness 70 mkm in diffence intensivity U,V: 1-30, 2-60, 3-90, 4-140, 5-200, 6-290

Where - σ_0 electroconductivity of the semiconductor at 10^3/T=0, r -parameter of indemnification, which varies from 1 up to 2.

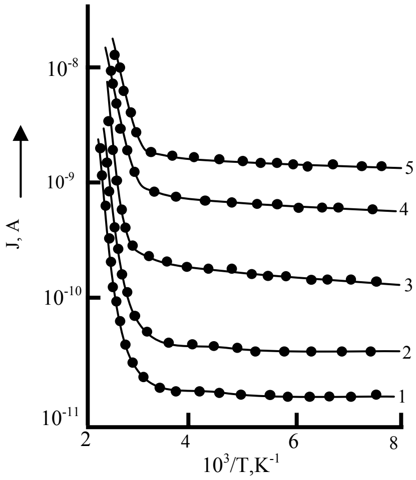

Fig.3.The temperature dependence current of $(Ga_2S_3)_{0,99}(Sm_2O_3)_{0,01}$monocrystal samples with thinkness 100 mkm in diffence intensivity U,V: 1-20. 2-30. 3-50. 4-60. 5-200

In case of indemnification we have:

$$\sigma = \sigma_0 e^{-\frac{E_t - 2e\sqrt{eF/\varepsilon}}{kT}} \qquad (2)$$

Here e- a charge of electron , F-intensity of an electrical field, ε - permittivity concerning an electronic part of polarization, E_t -energy of activation of traps in monocrystals Ga_2S_3 and $(Ga_2S_3)_{1-x}$ $(M_2O_3)_x$ at strong electrical fields.

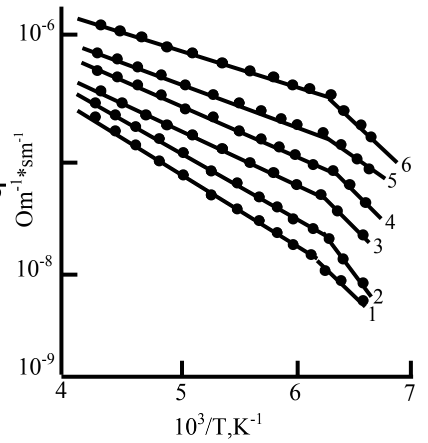

Fig.4.The temperaturee dependence electroconductivity of $(Ga_2S_3)_{0,96}(Eu_2O_3)_{0,04}$ monocrystal samples with thinkness 90 mkm in diffence intensivity U,V: 1-3, 2-7, 3-15, 4-30, 5-60, 6-90

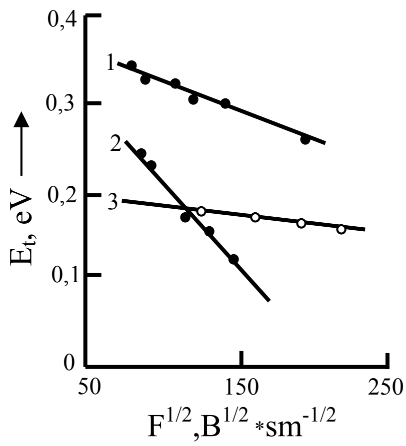

Fig.6. The dependence of energy of activation E_t from electric field for monocrystal samples: 1-$(Ga_2S_3)_{0.99}(Eu_2O_3)_{0.01}$, 2-$(Ga_2S_3)_{0.95}(Sm_2O_3)_{0.05}$, 3-$Ga_2S_3$.

From (2) it is visible, that at $E(F)=0,$ i.e., $E_t(0)=\left(\frac{e^3}{\pi\varepsilon\varepsilon_0}\right)^{1/2}F^{1/2}$ electroconductivity of semiconductors should not depend on temperature.

How it is visible from fig. 1÷5, the inclination of a high-temperature site of dependence $\lg\sigma\left(10^3/T\right)$ with growth of intensity of an electrical field decreases. Expressions (2) shows, that the inclination of straight linees $\lg\sigma=f\left(\frac{1}{T}\right)$ or effective energy of activation of carriers of a current at presence of a strong electrical field decreases on size $\left(\frac{e^3}{\pi\varepsilon\varepsilon_0}\right)^{1/2}F^{1/2}$.

Dependence of energy of activation E_t from $F^{1/2}$ is submitted in a fig. 6. It is visible, that according to expression (2) E_t linearly decreases with growth $F^{1/2}$.

Considering conclusions of the theory /8/ that EPF in semiconductors and dielectrics takes place then, when minimal distance between the next traps is equal $2r_m$, it is possible to estimate their concentration from the following expression:

$$N_t=\left(\pi\varepsilon\varepsilon_0F_{кр}e^{-1}\right)^{3/2} \qquad (3)$$

For concentration of traps (fig. 6) the meanings of size $N_t=6\cdot10^{13}\div4\cdot10^{14}\,см^{-1}$ are received depending on structure of firm solutions $(Ga_2S_3)_{1-x}(M_2O_3)_x$.

As show a fig. 4 and 5 intermediate sites of dependence $\lg\sigma\left(10^3/T\right)$ are characterized by continuous reduction of energy of activation of carriers of a charge with downturn of temperature. This site in process of growth of an electrical field extends. The similar dependence is found out in many semiconductors /8-10/ and is explained by the mechanism hopping.

On low temperature site of dependence $\lg\sigma\left(10^3/T\right)$ is observed weak thermosetting process, and the current (electroconductivity) with growth of an electrical field grows. One of possible mechanisms of weak dependence of a current from temperature at various electrical fields is the tunneling, facilitated in temperature, electron through a barrier reduced by size $\sqrt{\frac{e^3F}{\pi\varepsilon\varepsilon_0}}$. The low temperature site also is characteristic for hopping of conductivity in the field of strong electrical fields and field ionization dopedof levels resulting in tunneling without participation temperatures.

For the majority of samples, since some of temperature, the increase of energy of activation of carriers of a current with downturn of temperature is revealed. It is well illustrated on fig. 4 and 5. For a sample $(Ga_2S_3)_{0,96}$ $(Eu_2O_3)_{0,04}$ one is found out, and for a sample $(Ga_2S_3)_{0,95}$ $(Eu_2O_3)_{0,05}$ - two inclinations. As was already marked, the similar dependence is characteristic for the defective and compensated semiconductors /4-6/.

IV. CONCLUSION

The temperature dependence electroconductivity in strong electrical fields consists of three sites: high-temperature (250÷400K), intermediate (160÷250K) and low temperature (77÷160K). The high-temperature site is caused ionization of traps by an electrical field, intermediate and low temperature sites are accordingly characteristic for hopping of conductivity and tunneling through a barrier reduced by size $\sqrt{\frac{e^3 F}{\pi\varepsilon\varepsilon_0}}$.

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