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Nanosize Clusters in InAs and InP Compounds and Their Solid Solutions InP_xAs_{1-x}

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Abstract: The compounds of indium arsenide, indium phosphide and their solid solutions are important materials for optoelectronics, microelectronics and nanotechnology. The stabilization of nanoparticles is a major problem in modern nanotechnology. The presented work can provide valuable information in the indicated direction. It has been shown that, it is possible to create nanoscale clusters and stable point type defects in crystals with the help of hard radiation. Investigations of very slow diffusion processes in irradiated crystals allow to reveal "abnormal" behavior of nanoscale clusters. It has been shown that in certain materials, the curves of the frequency dependence of the optical absorption coefficient near the fundamental edge at 300 K for a long time (about two years) do not shift to the "restoration", but move to the opposite direction. We studied the electrical and optical properties and the heat treatment processes of crystals irradiated with fast neutron fluence ($2 \cdot 10^{18}$ n / cm^2) and high-energy (50 MeV) electrons ($6.0 \cdot 10^{17}$ e / cm^2). As a result, the mechanism of revealed "anomalous" phenomena has been established. We found that nanosize clusters contribute to a significant increase in the basic parameter of the thermoelectric material's thermoelectric efficiency. Scattering mechanism s of electrons on nanosize clusters has been also established. In addition the possible influence of nanoscale clusters as well as small point type defects on important parameters of the materials, in particular, the charge carriers concentration and mobility, electrons effectivemass, dispersion of the conduction band, and crystal lattice vibrations have been analyzed. Using the properties of small defects, radiation-resistant materials were created, with standing very high dose of hard radiation.

Keywords: Nanosize Clusters, Radiation, Semiconductors

1. Introduction

Semiconductor compounds InAs and InP and their solid solutions InP_xAs_{1-} are important materials for optoelectronics, microelectronics and nanotechnology [1 – 6]. The introduction of nano-size clusters (NSCs) in materials can dramatically change their properties both in positive and negative sides. Therefore, the study of physical and chemical properties of nano clusters is an important task.

The nanosize clusters can give to material completely new, sometimes unique properties, which can serve as a basis for the creation of high-performance devices. In particular, in given paper we consider the question of improving the thermoelectric properties of InP_xAs_{1-x} solid solutions and creation of effective thermoelectric materials. It is well known that the stabilization of nanoparticles is a major problem in modern nanotechnology [7 – 9]. In the presented work investigation in that direction is carried out. Another interesting question is also the creation of NSCs of different dimensions and establishing objective laws of electrons scattering on them, which is also the goal of this study.

2. Experimental

Experimental samples of InAs, InP and InP_xAs_{1-x} solid solution crystals with composition of x = 0, 0.1, 0.2, ..., 1 were grown by the horizontal zone-melting method. The composition was determined by X-ray and optical absorption analysis. High degree of homogeneity of InP–InAs solid solutions was confirmed by several methods, among which the most important are X-ray microanalysis and performance of Vegard law.

The measurements of electrical and optical properties in the range of 4.2 – 300 K have been carried out in metallic cryostat. Ohmic contacts were obtained by alloying of indium at 350°C. The measurements of thermoelectrical parameters have been carried out in the range of 77 – 350 K on special equipment. The crystals were irradiated by fast neutrons up to fluencies of $2 \cdot 10^{18}$ n / cm^2 and high-energy (50 MeV) electrons of fluencies of $6 \cdot 10^{17}$ e / cm^2) as well as with energy of 3 and 7.5 MeV.

3. Results and Discussion

3.1. Stabilization

To achieve the stabilization of nanoparticles is an important problem in nanotechnology [7 – 9]. Our results provide interesting information in this direction. There have been implemented the studies of heat treatment processes of materials containing nanosized clusters. At the same time, in order to have a deeper understanding of the complex processes of the NSCs change, measurements were also carried out in the very slow regime at room temperature. There have been revealed interesting "abnormal" phenomenon.

The Figure 1 shows dependence of optical absorption coefficient, near the fundamental edge on the photon energy for InP crystals.

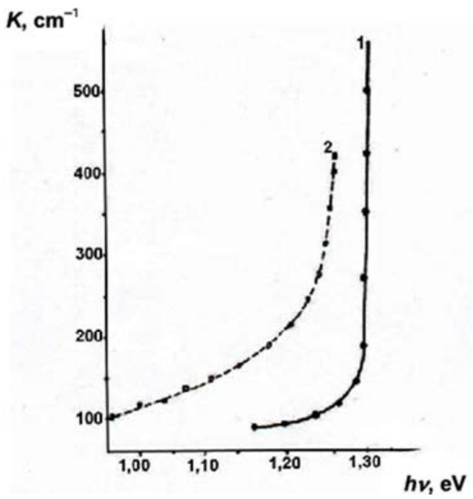

Figure 1. Dependence of optical absorption coefficient near the fundamental edge on the photon energy for InP crystals (with electrons initial concentration $1 \cdot 10^{16}$ cm^{-3}) irradiated with 50 MeV energy electrons (fluence was of $5.9 \cdot 10^{17}$ e / cm^2). Curves: 1 – before and 2 – after irradiation.

The Figure 2 shows dependence of the optical absorption coefficient on the photon energy for $InP_{0.8}As_{0.2}$ irradiated with fast neutrons $2 \cdot 10^{18}$ n / cm^2 (electrons initial concentration is $3.8 \cdot 10^{16}$ cm^{-3}).

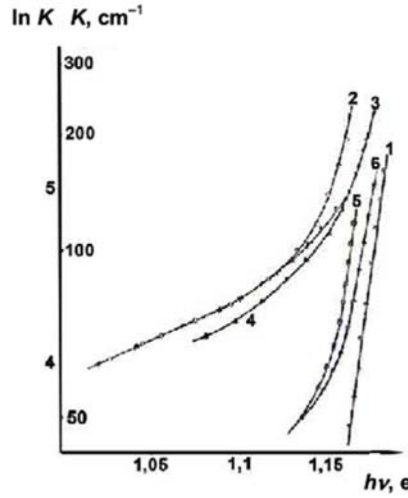

Figure 2. Dependence of the optical absorption coefficient on the photon energy for $InP_{0.8}As_{0.2}$ irradiated with fast neutrons $2 \cdot 10^{18}$ n / cm^2 (with electrons initial concentration $3.8 \cdot 10^{16}$ cm^{-3}). 1 – before and 2 – after irradiation, 3 – two years after irradiation at 300 K, after annealing at 4 – 300, 5 – 500, and 6 – 600°C.

The Figure 2 is typical picture of thermal annealing process of irradiated semiconductor. It is characteristically that after radiation, as in case of InP, the Curve 2 sharply shifts from original state (Curve 1) to lower energy. But as result of thermal annealing it monotonically shifts to original state. It is interesting to notice that very slow processes proceeding during two years do not drop out of the general law. However, in a solid solution with 70 % content of phosphorus (Figure 3) there has been detected "abnormal" phenomenon.

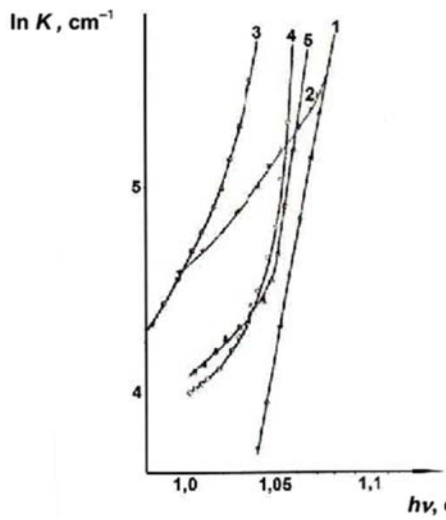

Figure 3. Dependence of the optical absorption coefficient on the photon energy for $InP_{0.7}As_{0.3}$ irradiated with fast neutrons 2 10^{18} n / cm^2 (with electrons initial concentration $2.2 \cdot 10^{17}$ cm^{-3}). 1 – Before and 2 –after irradiation, 3 – two years after irradiation, after annealing at 4 –300 and 5 – 500°C.

From Figure 3 it is clear that after irradiation by fast neutron fluence the Curve 2 shifts from the starting position (Curve 1) in the right direction to the side of low energy (Curve 2), exactly as in InP (Figure 1) and $InP_{0.8}As_{0.2}$ (Figure 2) samples. However, after soaking the sample at room temperature for two years, when there flow very slow diffusion processes, Curve 3, instead of offset towards a recovery (Curve1), is displaced in the opposite direction, similar to the effect of irradiation.

We were able to identify the observed phenomenon in crystals of InAs too. The results are shown in Figure 4.

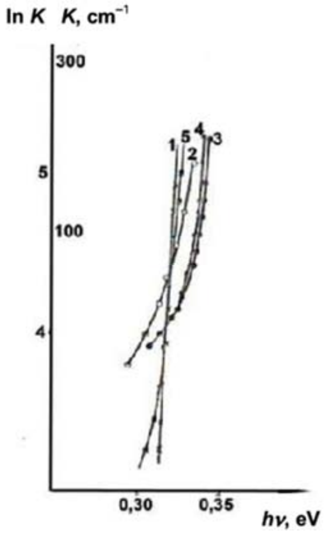

Figure 4. *Dependence of the optical absorption coefficient on the photon energy for InAs irradiated with fast neutrons 2 · 10^{18} n / cm^2 with electrons initial concentration 3 · 10^{16} cm^{-3} at the process of annealing. 1 – before and 2 – after irradiation, 3 – after irradiation two years at 300 K, after annealing at 4 – 300 and 5 – 500℃.*

From Figure 4 it is seen that the Curve 2 after the exposure shifts to higher energy. However, after a long exposure time (two years) at 300 K, Curve 3 continues moving in the "wrong" direction – in the same direction as during irradiation. On the base of mentioned it can be concluded that revealed an "anomaly" is not a rare exception.

On the basis of our new and earlier studies of the properties of crystals InAs, InP and InP_xAs_{1-x} we have managed to establish the mechanism of this phenomenon.

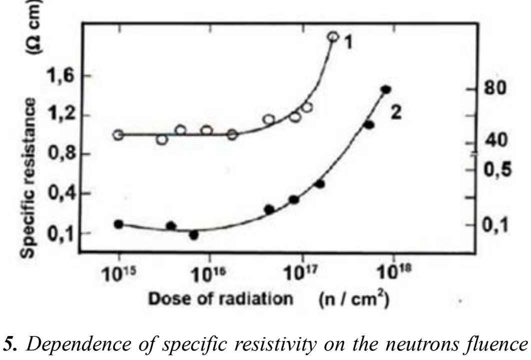

Figure 5. *Dependence of specific resistivity on the neutrons fluence for the InP crystal with the initial concentration of electrons in the samples: 1 – 4.1 · 10^{17} (left axis) and 2 – 1.5 · 10^{16} cm^{-3} (right axis).*

In the Figure 5, there is presented dependence of specific electrical resistivity versus fast neutrons fluence for n-type InP crystals. It is seen that after irradiation resistivity of material increases sharply, which is the result of sharp reducing in electron concentration. The same dependence is shown for $InP_{0.6}As_{0.2}$ and $InP_{0.8}As_{0.2}$ solid solutions in Figure 6.

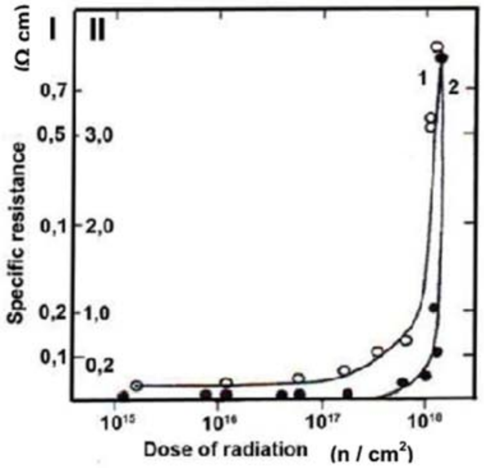

Figure 6. *Dependence of specific electrical resistivity on the fast neutrons fluence: 1 – $InP_{0.6}As_{0.4}$ with electrons initial concentration 4.5 · 10^{17} cm^{-3}, (left axis – I) and 2 – $InP_{0.8}As_{0.2}$ with electrons initial concentration 4.0 · 10^{16} cm^{-3} (right axis – II).*

It is seen that the character of changes is preserved but the increase of resistivity weakens in comparison with the crystals of the indium phosphide.

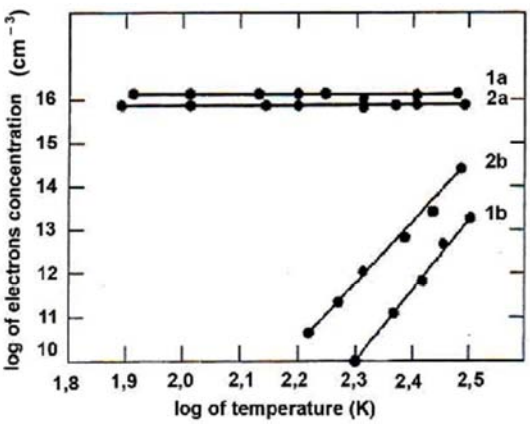

Figure 7. *Electrons concentration dependence on the temperature for InP with electrons initial concentration 1.5 · 10^{16} cm^{-3} (1a and 1b) and 1.18 · 10^{16} cm^{-3} (2a and 2b): 1a and 2a – before, and 1b and 2b –after irradiation with fast neutrons (2 · 10^{18} n / cm^2) and electrons (50 MeV, 6 · 10^{17} e / cm^2).*

Dependence of electrons concentration on the temperature is shown for InP in Figure 7. It is seen that after irradiation, the properties of materials change abruptly.

With the character of the electrons concentrations change under high-energy electrons irradiation remains the same as in the case of fast neutrons radiation, but the fall of concentration is weaker.

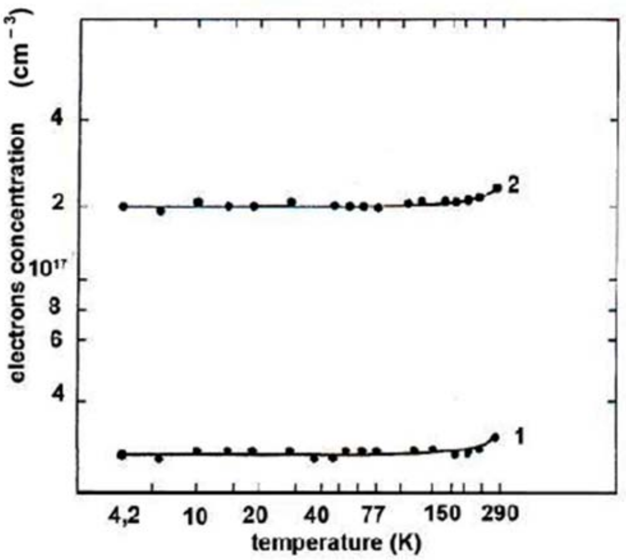

Figure 8. *Electrons concentration dependence on the temperature for crystals of InAs with the initial concentration of $3 \cdot 10^{16}$ cm^{-3}. Curves: 1 – before and 2 – after irradiation with fast neutrons $2 \cdot 10^{18}$ n / cm^2.*

The Figure 8 shows that InAs develops opposite properties in comparison with InP, as it was shown by Aukerman [10]. Unlike InP, after their radiation electron concentration increases in InAs. In InAs-rich solid solutions, general character of properties remains the same as in case of InAs, but electrons concentration increase is diminished. Doping does not affect tangibly the material behavior with irradiation. We have shown that InAs has unique radiation properties consisting in the fact that the radiation increases the electrons concentration in the indium arsenide at the any conditions. This behavior is peculiarity of InAs. Our results are confirmed by Walukievich [11] and Gerstenberg [12].

Under the hard irradiation the nanoscale cluster sands defects of smaller sizes, so-called point-type defects are formed in the material. In the case of the investigated materials interstitial atoms of arsenic and phosphorus play an important role.

Our analysis leads to the conclusion that namely these defects determine the value of the carriers concentration. They are radiation donors and acceptors. We have shown that these defects are related to phosphorus atoms in InP and the most of its alloys, and in InAs to arsenic atoms. As it is seen in the Figure 7, defects should have energetic levels located near the middle of the gap and they should therefore be amphoteric native defects. Therefore they serve as the capture centers for electrons and holes too, that observed for nearly all of the compounds of III–V except InAs. We think that in InAs because of its unique radiation properties the interstitial arsenic atoms play the role of donors, which have energy levels located near the bottom of the conduction band and so causing fixation (stabilization) of the Fermi level.

The Figure 9 shows frequency dependence of the optical absorption coefficient near the fundamental edge, for InAs crystals before and after irradiation with fluence of electrons, and after irradiation with fluence of electrons.

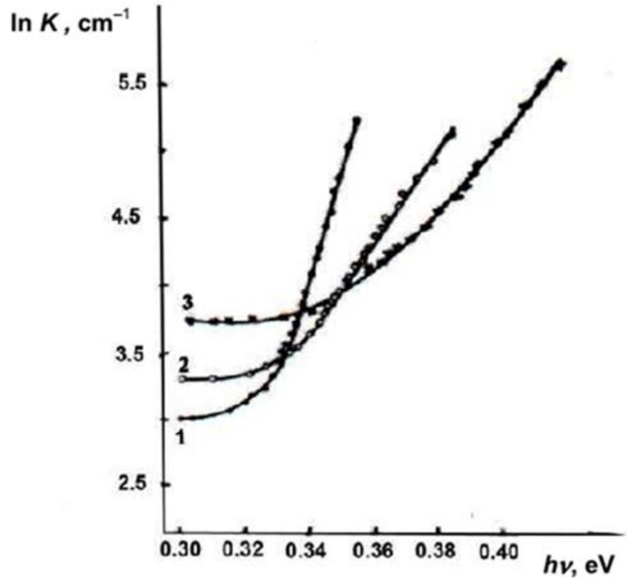

Figure 9. *Dependence of the optical absorption coefficient on the photon energy for InAs. 1 – before and 2 – after irradiation with electrons fluence $7 \cdot 10^{17}$ e / cm^2, and 3 – after irradiation with electrons fluence $3 \cdot 10^{18}$ e / cm^2.*

The observed shift of the curves in the direction of higher energy is explained by the fact that the radiation causes the birth of radiation donors because of which concentration of electrons also increases sharply. This, in turn, causes the Burstein effect [13], and the corresponding shift of the curves to higher frequencies.

It has been shown above that in InP reverse picture takes place – decrease of carriers concentration, so there Burstein effect is not observed. From Figure 1 it is clear that in given case the opposite effect takes place, namely, radiation causes displacement of the optical absorption in the direction of the low-energy region. The observed phenomenon is caused by the fluctuation of concentrations of charged radiation defects, which leads to the appearance of the tails of density of states, and to a certain narrowing of the band gap [14, 15].

Implemented study allows explaining the anomalies identified in the optical absorption spectra of InAs (Figure 4) and the alloy $InP_{0.7}As_{0.3}$ (Figure 3).

In InAs, the shift of Curve 3 (Figure 4) is not in the direction of restoration, but in the opposite side, at 300 K, is a result of allocation, “evaporation” of arsenic atoms from the nanoclusters. Point type defects in the cluster are electrically non-active elements. Therefore, they cannot play the role of donors or acceptors. But going into interstitial positions in the crystal lattice, arsenic atoms gain properties of donors. In this way, concentration of electrons increases and, as a result of the effect of Burstein, absorption edge shifts towards higher energies, just as in the case of irradiation of crystals (Figure 9).

Similar process develops in the case of $InP_{0.7}As_{0.3}$ too (Figure 3). The only difference is that in the given case phosphorus atoms allocate from the nano-dimensional clusters, causing a sharp decrease of the concentration of carriers and appearing the tails of density of states in the band gap, as in the case of irradiated InP (Figure 1).

Observing of anomalies only in the alloy with $x = 0.7$ is due to the specifics of the ratio of radiation donors and acceptors in the materials.

As a result of irradiation in semiconductors there are created Frenkel pairs –interstitial atoms and their vacancies. They interact with impurities and other defects and form associations. Interstitial atoms are exclusively mobile in silicon and germanium. Watkins [16] has shown that they can move in the silicon lattice at very low temperatures. Their moving is even the athermal [17]. From our research it follows, that in investigated by us compounds, opposed to silicon and germanium, interstitials mostly do not create associations with the impurities and they are table. They are more stable than the nanosize clusters.

At the same time, the heat treatment processes in the investigated materials have been studied in detail. In addition a large batch of rigidly irradiated crystals has been maintained constantly at liquid nitrogen temperature for one year. Parallel periodic measurements of electrical and optical properties of cooled and uncooled crystals have been made. It was found that identified in given paper radiation defects created by irradiation with fast neutrons and electrons are stable at room temperature and above. Wherein this stability takes place for a long time. Appropriate repeated measurements of material parameters were carried out throughout the year.

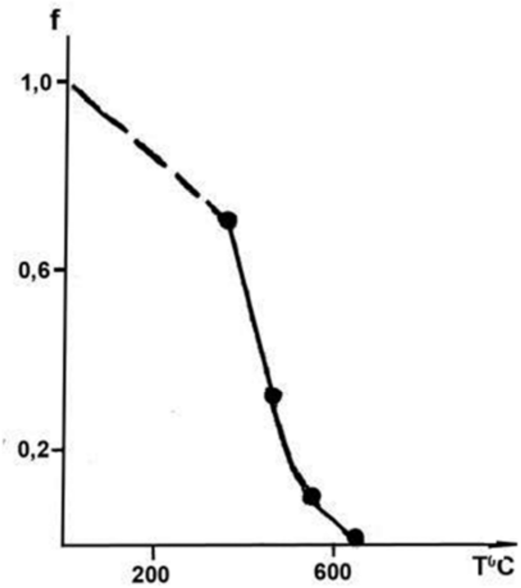

Figure 10. Dependence of share of not annealed defects on the annealing temperature in the indium phosphide with electrons initial concentration $1.6 \cdot 10^{17}$ cm^{-3} irradiated by electrons with an energy of 50 MeV.

The Figure 10 shows the dependence of the share of not annealing defects on the annealing temperature in the indium phosphide irradiated with electrons with energy of 50 MeV. It is clearly seen that defects are not fully annealed up to 600°C.

An interesting picture is revealed in $InP_{0.2}As_{0.8}$ solid solutions irradiated with fast neutrons.

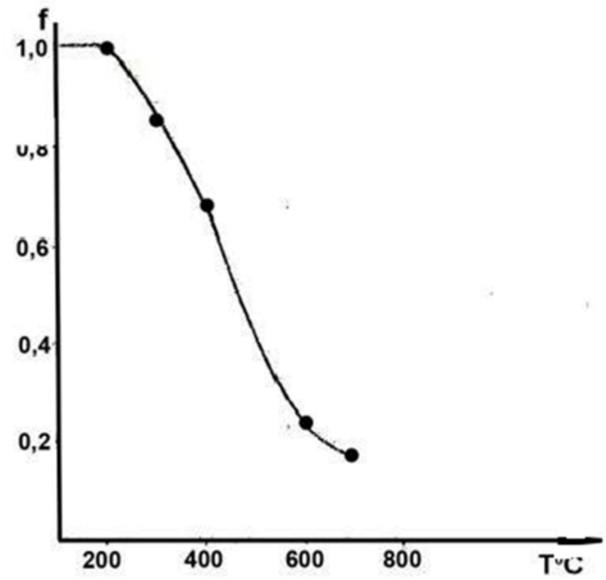

Figure 11. Dependence of share of not annealed defects on the annealing temperature in the $InP_{0.2}As_{0.8}$ with electrons initial concentration $8.4 \cdot 10^{16}$ cm^{-3} irradiated by fast neutrons.

As can be clearly seen from Figure 11, defects exhibit extremely high stability up to 200°C. As a result of our research it can be made an important conclusion that, unlike silicon and germanium in III–V compounds, in particular, in the investigated materials, point Frenkel defects are characterized by high stability.

On the base of carried out investigation there have also been obtained radiation-resistant materials. The phenomenon of mutual compensation of radiation donors and acceptors has been discovered in investigated InP_xAs_{1-x} solid solutions. It may be noted that we have led up to the phenomenon of mutual compensation of radiation donors and acceptors and to creation of radiation-resistant materials with the help of discovered two mode behavior of InAs–InP solid solutions lattice vibrations [18], that points to the preservation of individual properties of InP and InAs sublattices in solid solutions. These results were confirmed at the Oxford Clarendon Laboratory [19], at the Saclay Nuclear Research Centre [20], and in the work [21].

Noted phenomenon is a result of opposite directed radiation processes taking place in the irradiated InAs–InP solid solutions. The radiation creates donor type defects in the sublattice of InAs and electrons concentration increases. The contrary process occurs in the sublattice of InP. Radiation originates acceptor type defects and the carriers' concentration decreases. The noted effect is going on in the all alloy composition. Exact mutual compensation of radiation donors and acceptors is achieved by selecting of the alloys definite composition. As a result, the main parameter of semiconductors electrons concentration remains constant even under the hard radiation with fluencies of $2 \cdot 10^{18}$ n / cm^2. So there has been created radiation-resistant material for composition $x = 0.3$.

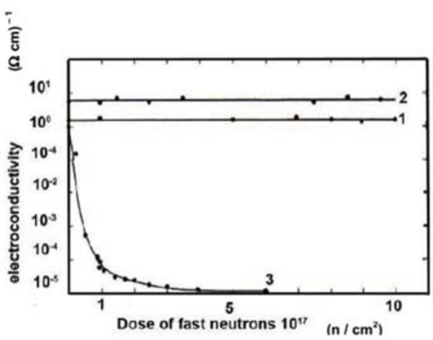

Figure 12. *Specific conductivity dependence on the fluence of fast neutrons for $InP_{0.3}As_{0.7}$ with electrons initial concentration $1.5 \cdot 10^{17}$ cm^{-3} (Curve 1) and $7.0 \cdot 10^{17}$ cm^{-3} (Curve 2); Curve 3 – Si.*

Dependence of conductivity on the fluence of fast neutrons for $InP_{0.3}As_{0.7}$ with electrons initial concentration $1.5 \cdot 10^{17}$ cm^{-3} (Curve 1) and $7 \cdot 10^{17}$ cm^{-3} (Curve 2) is presented in Figure 12. For comparison, dependence for Si is shown on the same figure. The presented figure clearly demonstrates that unlike Si the conductivity of $InP_{0.3}As_{0.7}$ solid solutions do not change during irradiation with fast neutrons up to $2 \cdot 10^{18}$ n / cm^2.

3.2. Increasing in Thermoelectrical Efficiency

As it is well known the thermoelectrical efficiency of materials Z is given by relationship:

$$Z = \alpha^2 \sigma / \kappa;$$

where σ is the electrical conductivity, α is the thermoelectric power, and κ is the thermal conductivity.

Thermoelectric power (as well as Z) of InP, GaAs, InAs, their solid solutions and of more other semiconductors decreases sharply under their radiation.

Noted clearly is demonstrated in the Figure 13, where Curves 1a and 1b relate to indium phosphide before and after irradiation.

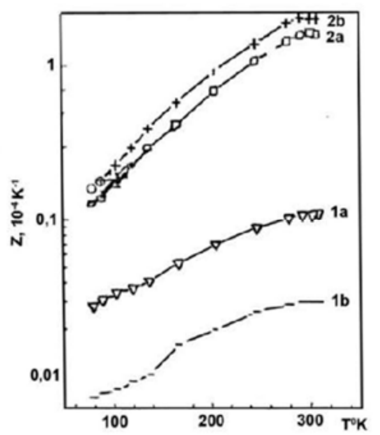

Figure 13. *Dependence of thermoelectrical efficiency of InP_xAs_{1-x} solid solutions on temperature. (a) before and (b) after irradiation. Curves: 1a, 1b – InP, 3a and 3b – InP_xAs_{1-x}.*

However, we have developed the technology and created InP_xAs_{1-x} solid solutions of defined composition (know-how) in which, as a result of irradiation with fast neutrons the value of Z does not reduce. As it was noted at irradiation there are formed nanosize clusters on which there occurs intense phonons' scattering. That in its turn causes reduction in thermal conductivity and, accordingly, increase of thermoelectric efficiency. Simultaneously, in noted InP_xAs_{1-x} solid solution, the electrical conductivity grows. As a result the increase in value of σ / κ significantly exceeds the fall in the value of α^2 and ultimately the value of thermoelectric efficiency does not decrease but increases significantly. Marked is shown in Figure 13 (Curves 2a and 2b).

Thus with introduction in semiconductors by radiation nanosize clusters and other radiation defects, it is possible to increase the value of thermoelectrical efficiency.

So there was developed InP_xAs_{1-x} alloy efficiently converting thermal energy into electrical energy at a highly radiation conditions. The latter is very important for their application in Space at atomic power stations, and nuclear reactors.

3.3. Current Carriers Scattering on Nanosize Clusters

The Figure 14 shows the temperature dependence of the electron mobility in the not irradiated solid solution of intermediate composition $InP_{0.5}As_{0.5}$. It is evident that there is reached a very good agreement between the experimental and theoretical data in a wide temperature range.

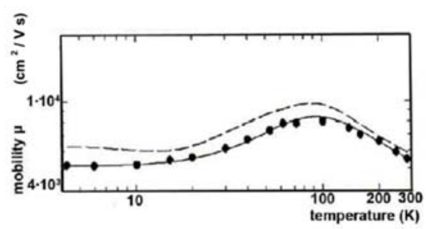

Figure 14. *Temperature dependence of current carries mobility in $InP_{0.5}As_{0.5}$ solid solution with electrons initial concentration $1.3 \cdot 10^{17}$ cm^{-3}. Curves: solid – experimental and dashed – theoretical data.*

Calculations performed using the existing theories [22 – 27] show that the main mechanisms of carrier scattering are the scattering on the optical lattice vibrations, point type ionized impurities, and neutral centers and on "alloy" disorders. After irradiation, InP–InAs solid solutions with fast neutrons (with fluence of $2 \cdot 10^{18}$ n / cm^2), the picture changes abruptly. Irradiation leads to decrease of mobility at all fixed temperatures in the whole investigated temperature range (Figure 15).

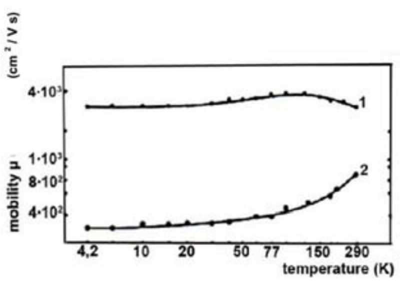

Figure 15. *Temperature dependence of charge carriers mobility for $InP_{0.6}As_{0.4}$ solid solution with electrons initial concentration $4.7 \cdot 10^{17}$ cm^{-3}). 1 – before and 2 – after irradiation with fast neutrons.*

After irradiation much stronger temperature dependence of mobility is observed than it was expected as a result of scattering on the point ionized defects. Such strong temperature dependence of mobility after irradiation is result of action of nanosize clusters introduced into material in the process of irradiation.

For updating mechanisms defining mobility of experimental samples after irradiation quantity studies of mobility have been implemented. Theoretical calculations of the mobility component μ_{Disorder}, provided by radiation defects (disorder regions) introduced at irradiation with maximum dose of fast neutrons of fluence $2 \cdot 10^{18}$ n / cm^2, were fulfilled for InAs–InP alloys. The mobility component μ_{Disorder}, was defined from the relationship:

$$1 / \mu_{\text{Disorder}} = 1 / \mu_{\text{Before}} - 1 / \mu_{\text{After}},$$

where μ_{Before} is the mobility before irradiation and μ_{After} – mobility after irradiation. Calculation results of μ_{Disorder} obtained from experimental data of mobility μ_{Before} and μ_{After} by this equation were compared with the theory of scattering on the point centers and scattering on disorder regions [22, 28]. The calculation of mobility component μ_{Disorder} introduced by radiation has been implemented for all samples. For demonstration we show the result for $InP_{0.6}As_{0.4}$ solid solution in the middle of InAs–InP system (Figure 16).

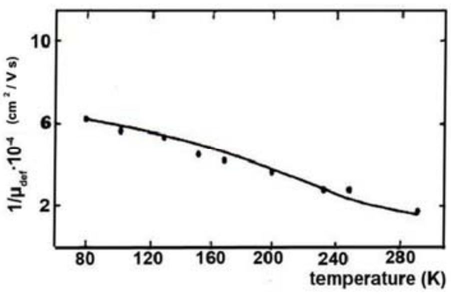

Figure 16. *Temperature dependence of charge carriers mobility component introduced by fast neutrons irradiation for $InP_{0.6}As_{0.4}$ solid solution with electrons initial concentration $4.7 \cdot 10^{1}7$ cm^{-3}); Curve – theoretical calculation.*

The calculations showed that the theory of scattering on disorder regions – nanosize clusters give good agreement with experiment. The same results were achieved on the crystals irradiated with 50 MeV electrons.

It is known, that scattering of the electrons waves is determined by disorders in the arrangement to atoms, which extend over a distance the length of a quarter of the electron wave. Disorders of smaller size of the heterogeneities vary from 6 to 50 nm. According to estimates by mobility data at electrons concentration ~ 10^{16} cm^{-3} at 300 K the electron mean free path l is of the order of the size (12 – 60 nm) of the nanoparticles d: $l \sim d$. Therefore, $l << d$ and scattering of charge carriers on nanosize clusters is not essential.

The following isochronous annealing results of irradiated crystals show that after annealing at 500 – 600 °C, the temperature (T) dependence of carriers mobility approaches to $\mu(T)$ for alloys before irradiation.

3.4. Effect of Nanoscale Clusters on Other Properties of the Material

There have been carried out the studies of the spectra of the plasma reflection and reflection in the region of optical phonons. A typical spectrum of plasma reflection of InAs before and after irradiation by fast neutrons (fluence $2 \cdot 10^{18}$ n / cm^2) is presented in Figure 17.

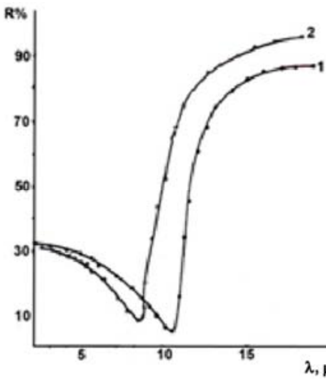

Figure 17. *Dependence of the reflectance on the wavelength for InAs with electrons initial concentration $1.2 \cdot 10^{19}$ cm^{-3} irradiated by fast neutrons; 1 – before and 2 – after irradiation.*

Numerical values of effective mass of the electrons have been identified in InAs, InP and their solid solutions from spectra of the plasma reflection.

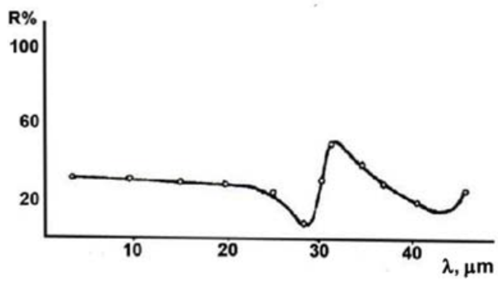

Figure 18. *Dependence of the optical reflection coefficient in the lattice vibration region on the wavelength for irradiated with fast neutrons ($2 \cdot 10^{18}$ n / cm^2) for sample of p-$InP_{0.8}As_{0.2}$ with electrons initial concentration $3 \cdot 10^{16}$ cm^{-3}.*

From the obtained values for effective mass dispersion and the degree of the non-parabolicity of conduction band have been identified. Obtained results allow suggest that the created clusters in materials do not influence sensitively on the dispersion of the conduction band and the nature of the non-parabolicity. Thus nanoscale clusters do not distort the conduction band of the material. Influence of radiation concludes only in the fact that NSC causes a decrease in the mobility of the charge carriers. It is interesting to note that the change of carriers' concentration is not the result of influence of nanoscale clusters. NSC does not play a role of radiation donors and acceptors. Radiation donors and acceptors are the smaller defects.

In the Figure 18, there are presented dependence of optical reflection coefficient in the lattice vibration region for irradiated with fast neutrons ($2 \cdot 10^{12}$ n / cm^2) p-$InP_{0.8}As_{0.2}$

solid solution.

On the base of investigation of electrical, optical, thermoelectrical and structural properties of materials and optical reflection spectra it is possible to conclude that in spate of hard irradiation with fast neutrons and 50 MeV electrons ($2 \cdot 10^{18}$ n / cm^2 and $6 \cdot 10^{17}$ e / cm^2, respectively) created nanosize clusters do not make significant changes in the lattice dynamics. They do not change the crystalline structure of the materials, and do not cause the amortization process in InAs, InP and InP_xAs_{1-x} solid solutions.

4. Conclusion

It is shown that with the aid of hard radiation in the semiconductor compounds InAs, InP and their solid solutions InP_xAs_{1-x}, nanosize clusters and smaller defects may be introduced. They can gain important properties to the materials. Wherein they do not distort the conduction band of material and change tangibly the crystalline structure of compounds and alloys.

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