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Peculiarities of Absorption near the Edge of the Fundamental Band of Irradiated InAs-InP Solid Solutions

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Abstract : The semiconductor devices are irreplaceable elements for investigations in Space (artificial Earth satellite, interplanetary space craft, probes, rockets) and for investigation of elementary particles on accelerators, for atomic power stations, nuclear reactors, robots operating on heavily radiation contaminated territories (Chernobyl, Fukushima). Unfortunately, the most important parameters of semiconductors dramatically worsen under irradiation. So creation of radiation-resistant semiconductor materials for opto and microelectronic devices is actual problem, as well as investigation of complicated processes developed in irradiated solid states. Homogeneous single crystals of InP-InAs solid solutions were grown with zone melting method. There has been studied the dependence of the optical absorption coefficient vs photon energy near fundamental absorption edge. This dependence changes dramatically with irradiation. The experiments were performed on InP, InAs and InP-InAs solid solutions before and after irradiation with electrons and fast neutrons. The investigations of optical properties were carried out on infrared spectrophotometer in temperature range of 10K-300K and 1mkm-50mkm spectral area. Radiation fluencies of fast neutrons was equal to 2·1018neutron/cm2 and electrons with 3MeV, 50MeV up to fluxes of 6·1017electron/cm2. Under irradiation, there has been revealed the exponential type of the dependence of the optical absorption coefficient vs photon energy with energy deficiency. The indicated phenomenon takes place at high and low temperatures as well at impurity different concentration and practically in all cases of irradiation by various energy electrons and fast neutrons. We have developed the common mechanism of this phenomenon for unirradiated materials and implemented the quantitative calculations of distinctive parameter; this is in a satisfactory agreement with experimental data. For the irradiated crystals picture get complicated. In the work, the corresponding analysis is carried out. It has been shown, that in the case of InP, irradiated with electrons (Φ=1·1017el/cm2), the curve of optical absorption is shifted to lower energies. This is caused by appearance of the tails of density of states in forbidden band due to local fluctuations of ionized impurity (defect) concentration. Situation is more complicated in the case of InAs and for solid solutions with composition near to InAs when besides noticeable phenomenon there takes place Burstein effect caused by increase of electrons concentration as a result of irradiation. We have shown, that in certain conditions it is possible the prevalence of Burstein effect. This causes the opposite effect: the shift of the optical absorption edge to higher energies. So in given solid solutions there take place two different opposite directed processes. By selection of solid solutions composition and doping impurity we obtained such InP-InAs, solid solution in which under radiation mutual compensation of optical absorption curves displacement occurs. Obtained result let create on the base of InP-InAs, solid solution radiation-resistant optical materials. Conclusion: It was established the nature of optical absorption near fundamental edge in semiconductor materials and it was created radiation-resistant optical material.

Keywords : InAs-InP, electrons concentration, irradiation, solid solutions
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