PHOTOELECTRIC PROPERTIES OF SINGLE CRYSTALS GaSe DOPED BY DYSPROSIUM

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In this work experimental results of the study of photoconductivity of GaSe single crystals doped by atoms of dysprosium (D_y) of the various concentration are reported. With the increasing of the dysprosium content the negative photoconductivity disappears, the spectrum of the intrinsic photoconductivity broadens, the relative portion if the impurity photoconductivity increases and its maximum shifts to the long wavelengths.

The doping of GaSe crystals by rare-earth element D_y influences on photoelectrical properties and changes the whole character of impurity photoeffects of this material.

Comprehensive development of solid-state electronics stimulates the search and investigation of the physical properties of new materials and also study of the influence of different impurities on the properties of already known semiconductors [1,2].

The aspect A^3B^6 compounds have been investigated sufficiently in detail to the present time. However, the influence of the doping by rare - earth elements on their photoelectrical properties is investigated extremely insufficiently.

In this work experimental results of the study of the photoconductivity of GaSe single crystals doped by atoms of dysprosium D_y of various concentration ($N_{Dy}=10^{-5}$-10^{-1} at.%) are reported. GaSe single crystals are obtained by the method of simultaneous melting of source components (Ga and Se) which are taken in stoichiometric ratio. The doping by addition of fine-grained powder of D_y is carried out before the synthesis process. Single crystals of GaSe and GaSe:D_y are obtained by modified Brigman's method. The installation for measurements is constructed on the basis of KSVU-12 set.

Temperature dependences of dark, photo- and residual conductivity, spectrum, kinetics and quenching of photoconductivity in the λ=0,2-2,0 μm wavelength range under different illumination intensities and temperature in the linear range of the volt-ampere characteristics (VAC) have been investigated experimentally.

In fig. 1 characteristic curves of the spectral distribution of the photoconductivity of samples with $N_{Dy}=10^{-3}$ at.% for different temperature are shown. The photoconductivity spectra of GaSe:D_y with different N_{Dy} at 77 K are presented in fig. 2. It is established that temperature dependence of the photoconductivity of undoped GaSe crystals have the complex character: in the low temperature region the thermal activation of photocurrent (TAP)is observed and in the high temperature region (250-300 K) the process of thermal quenching of photoconductivity progresses.

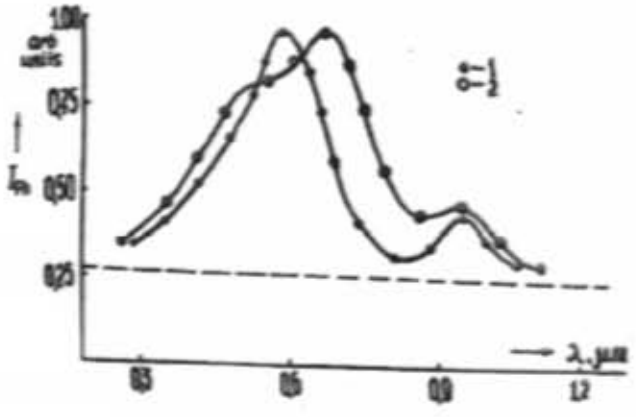

Fig. 1. Spectral distribution of the photoconductivity in samples of $N_{Dy}=10^{-3}$ at.%:
1 - T=77 K, 2 - T=300 K.

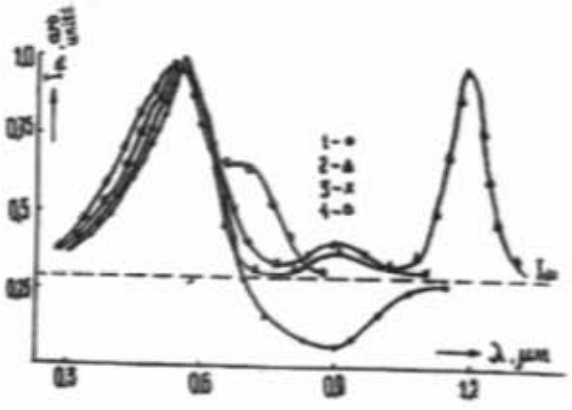

Fig. 2. Spectral photoconductivity of GaSe of different N_{Dy} at 77 K:
1 - GaSe; 2 - GaSe:D_y ($N_{Dy}=10^{-2}$ at.%);
3 - GaSe:D_y ($N_{Dy}=10^{-3}$ at.%);
4 - GaSe:D_y ($N_{Dy}=10^{-4}$ at.%).

The position of negative photoconductivity under impurity excitation (λ=0,7-1,2 μm) is characteristical for this crystals. The doping of GaSe crystals by dysprosium with $N_{Dy}=10^{-5}$-10^{-1} at.% influences considerably not only on detached parameters and characteristics, but dramatically changes the whole of the character of impurity photoeffects.

When the content of D_y increases the maximum of intrinsic photoconductivity of GaSe:D_y samples initially ($N_{Dy}<10^{-3}$ at.%) shifts to the short wavelengths and further - in the opposite direction. In GaSe:D_y samples at T=77 K with the increasing of N_{Dy} up to $N_{Dy}=10^{-3}$ at.% a little step appears in short-wave portion of spectral dependence which disappears with the further increasing of the impurity concentration. The step appears again at the room temperature. The dependence of the intensity and maximum value of im-

purity conductivity on N_{Dy} have monotone character, and dark conductivity and intrinsic photoconductivity has non-monotone dependence on N_{Dy}. At the increasing of dysprosium content the negative photoconductivity disappears, the spectrum of the intrinsic photoconductivity broadens, the relative portion of the impurity photoconductivity increases and its maximum shifts to longer wavelengths.

It must be noted that thermal activation of the impurity photoconductivity in investigated samples more brightly manifests in self in the GaSe when temperature dependence of intrinsic photoconductivity is weak. The photoconductivity band detected can be connected with the presence of r-centers which energetic depth of bedding changes proportionally to the impurity concentration.

Complicated character of the photoelectrical properties of undoped and D_y-doped samples including temperature dependence of intrinsic photoconductivity can be explained by realization of many-center recombination model which includes S-channel of intensive recombination, r-centers of photosensitivity, t-centers of minority charge carrier trapping. In GaSe the role of S-channel are performed by extended defects in sublattice of metalloide. While the compensation of the vacancies of selenium (V_{Se}) as deep donors act as centers of photosensitivity and interstitial Se atoms - as trapping centers. The obtained experimental results of negative photoconductivity in source crystals are adequately explained in the frameworks of partially - unordered crystal model with different local levels (t, r, s) in band gap, irregularly distributed in material volume [3].

High photosensitivity and monopolarity of photoconductivity of GaSe:D_y ($N_{Dy}<10^{-3}$ at.%) crystals are most connected likely with the presence of sufficient quantity of r-levels (N_r) compensating donors concurenting with some recombination levels. Their compensations are accomplished by shallower centers (N_t).

Rebuilding point - defect structure of crystal the doping controls concentration of different types of local levels. In so doping transformation of the shape of $I_{Pc}(T)$ curves for doped samples are due to change of r- and t-level concentrations.

Photosensitivity observed at 300 K in GaSe:D_y ($N_{Dy}<10^{-3}$ at.%) evidences that the concentration of donor r-levels increases at low N_{Dy}. On the other hand the measurements of the magnitude and temperature dependence of the conductivity of GaSe:D_y crystals shows that up to some dopant concentration ($N_{Dy}=10^{-3}$ at.%) the increasing of reciprocally compensating pairs prevails in defect generation mechanism. The further increasing of N_{Dy} is accompanied by prevailed generation of defects, producing S-channel of rapid recombination. The doping of GaSe crystals by rare-earth element D_y even for small quantities influences considerably on photoelectrical properties and changes the whole character of impurity photoeffects in this material.

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DİSPROZİUMLA AŞQARLANMIŞ QALLİUM SELEN MONOKRİSTALLARININ FOTOELEKTRİK XASSƏLƏRİ

Müxtəlif konsentrasiyaya malik nadir torpaq elementi (D_y) ilə aşqarlanmış layh quruluşa malik GaSe monokristallarında qalıq keçiriciliyin, aşqar fotokeçiriciliyin və infraqırmızı işıqla məxsusi fotokeçiriciliyin sönməsi tədqiq olunmuşdur.

Müəyyən olunmuşdur ki, D_y aşqarları GaSe monokristallarının yalnız ayrı-ayrı parametrləri və xarakteristikalarına tə'sir etmir, hətta bəzən bu kristallarda aşqar fotoeffektin bütün xarakteristikalarını dəyişir.

Bu parametrlərin və xarakteristikaların N_{Dy} -dan asılılığı kristalların nizamsızlığı və quruluş defektlərinin dəyişməsi, həmçinin r-mərkəzlərinin enerji dərinliyinin dəyişməsi ilə izah olunur.

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ФОТОЭЛЕКТРИЧЕСКИЕ СВОЙСТВА МОНОКРИСТАЛЛОВ СЕЛЕНИДА ГАЛЛИЯ, ЛЕГИРОВАННЫХ ДИСПРОЗИЕМ

Проведено исследование остаточной проводимости, примесной фотопроводимости и гашения собственного фототока с инфракрасным светом в слоистых монокристаллах GaSe, легированных редкоземельным элементом диспрозия (D_y) с различными концентрациями.

Установлено, что легирование примесью диспрозия значительно влияет не только на отдельные параметры и характеристики, но иногда меняет весь характер примесных фотоэффектов в этих монокристаллах.

Зависимость этих параметров и характеристик от N_{Dy} объясняется изменением структурной дефектности и неупорядоченности кристаллов, а также энергетической глубиной залегания r-центров.

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