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LONG-TERM RELAXATION OF PHOTOCONDUCTIVITY IN CADMIUM DOPED Gd_2S_3 FILMS

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In first time it is experimentally investigated some regularities of long-term relaxation of photoconductivity of gadolinium one-and-halp sulfides thin films doped by cadmium atoms. Was calculated maximum of recombination barrier and found the location of trapping levels in the gap.

Keywords: film, sulfide, photoconductivity, relaxation, acceptor, barrier.

Вперше експериментально досліджені деякі закономірності довгострокової релаксації фотопровідності плівок полуторного сульфіду гадолінія, які леговані атомами кадмію. Розраховано максимальне значення рекомбінаційного бар'єру та встановлено розташування рівнів прилипання в забороненій зоні.

Ключові слова: плівка, сульфід, фотопровідність, релаксація, акцептор, бар'єр.

Впервые экспериментально исследованы некоторые закономерности долговременной релаксации фотопроводимости плёнок полуторного сульфида гадолиния, легированных атомами кадмия. Рассчитано максимальное значение рекомбинационного барьера и установлено расположение уровней прилипания в запрещённой зоне.

Ключевые слова: плёнка, сульфид, фотопроводимость, релаксация, акцептор, барьер.

INTRODUCTION

One-and-a-half sulfides of rare-earth elements (REE) concern to wide-band semiconductors [1]. In these connections are observed variety interesting, small studied effects, which are perspective for practical application for optoelectronis devices [2 – 6]. To such effects concerns so called a long-term relaxation (LTR) of photoconductivity (FC). It is considered that LTR is connected with existence in investigated object potential barrier, which are in turn caused by in homogeneity of material. As it is known, one-and-a-half sulfides REE are characterized by presence in them own statistically distributed structural defects (in caution sublattice every ninth knot is vacancy [7]). It is possible to assume that such imperfections will play a part in process of LTR of photoconductivity.

In the given work some experimental laws of LTR in films of Gd_2S_3 alloyed by atoms of cadmium are presented.

EXPERIMENTAL

Polycrystalline films of Gd_2S_3 0.6 – 4.4 mm in thikness were made by thermal evaporated from two independent sources of Gd and S [8]. Electronographical and X-ray analyze showed that thin films had cubical crystal structure of Th_3p_4 type (γ-form, space group of In_3d) with lattice parameters $a = 8.34$ Å, which is in good agreement with lattice parameters of bulk crystals of Gd_2S_3 [7]. All films had high specific resistivity – $\sim 10^{10}$ Ohm·cm. In order to reduce resistivity the samples are doped with cadmium atoms. Doping was done from gas phase in closed volume by a technique described in [8]. After doping, as have shown X-ray and electronographical analysis all films were single-phase, had *n*-type conductivity and specific resistivity – $\sim 10^2 - 10^3$ Ohm·cm.

Experiments on studying temperature, spectral, time and luxsampere dependences of resistance were spent on installation КСВУ-23 equipped with the micro-computer, which was used for management of experiment and processing of the saved up data.

RESULTS AN DISCUSSION

As have shown experiments on studying of kinetics photoconductivity (fig. 1), long-term processes accompany not only de-energizing but also induction of monochromatic illumination. It is known that the hearth of a LTR lies space division of nonequillibrium carriers of a charge

by electric fields of inhomogeneithy an investigated materials. In this connection, naturally, the recombination in interfaced to necessity of overcoming of a potential barrier E_B, and time of life of nonequellibrium carrier of a charge is calculated by the formula

$$\tau = {}_0\exp(E_B/kT). \qquad (1)$$

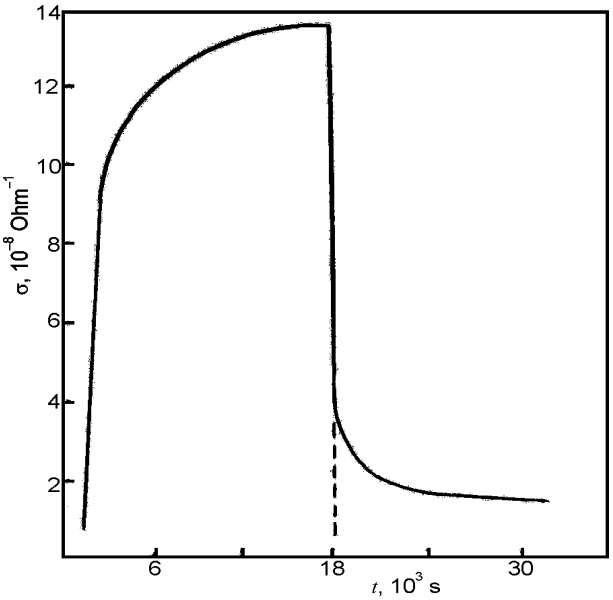


Fig. 1. Cinetics of photoconductivity at 98 K (λ=450 nm, I = Vt/cm^2 by a dotted line accepts the illumination termination).

Stationary concentration is expressed by the formula

$$\Delta n = \Delta\beta\tau J ,$$

where α is coefficient of absorption, β – quantum exit, J – intensity of light. It is natural to admit that division of carriers of a charge creates electric fields inhomogeneity in this connection energy potential barrier with growth of stationary concentration will decreases.

Naturally, instant times of a relaxation should grow linearly with time increase, as it is shown in work [9]. Value of instant times of a relaxation (fig. 2) we have defined on an inclination of tangents to relaxation curves. From fig. 2. it is visible that characterizing these two processes instant times have very close values. The big size of life time (> 10^5 s), of nonequillibrium carriers of a charge, leads to that after a while de-energizing of monochromatic radiation, falling on the sample, conductivity of a film changes and remains essentially above it darking values. The described phenomenon is considered as residual conductivity [9], sometimes it name spectral memory conductivity aspires to saturation.

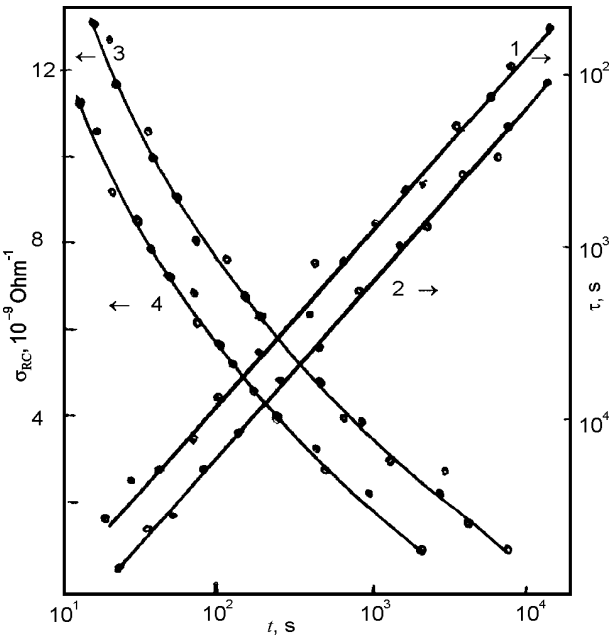


Fig. 2. Characteristis times of a relaxation (1) and an establishment of stationary value of photoconductivity (2), relaxation curves of residual conductivity at T = 104 K (3) and T = 121 K (4).

Luxsampere characteristics of photoconductivity and residual conductivity are shown on fig. 3. It is known [10] that at small intensitys of illumination size of photoconductivity and residual conductivity linearly grow, and at big when stationary concentration nonequillibrium essentially changes size potential barrier, stationary values of photoconductivity show sublinear character, and the size of residual.

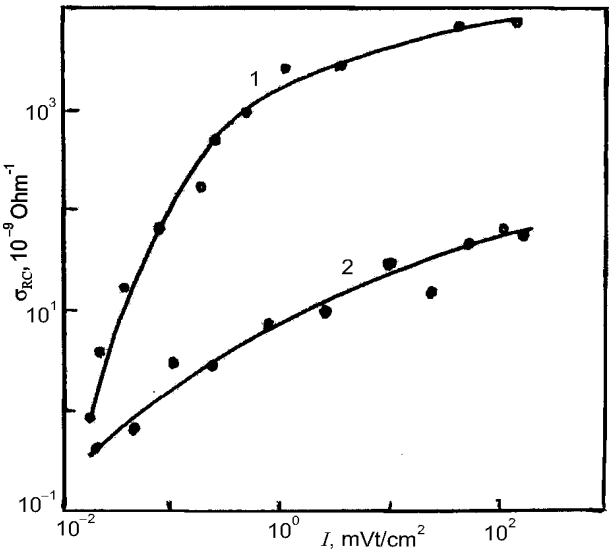


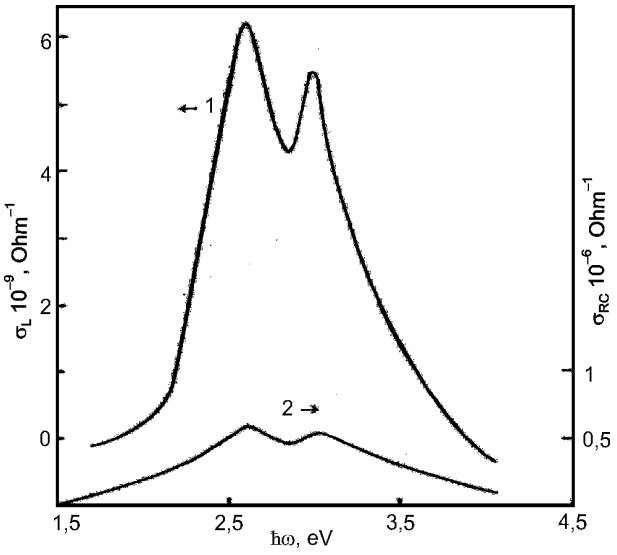
Fig. 3. Dependence of photoconductivity (1) and residual conductivity (2) from intensity of radiation at 112 K (λ = 470 nm).

The analysis of relaxation curves of residual conductivity at various temperatures (fig. 2) has shown that the size potential barrier is expressed by the formula

$$E_B = \left[\frac{T_1 T_2 k \ln T_1}{T_2}\right] \Big/ \left[T_1 - T_2\right].$$

During a relaxation at accepts value 0.13 – 0.27 eV. It is obvious that darking value of E_B it is even more.

Measurement of FC and residual conductivity of Gd_2S_3:Cd film spent to areas of energy of photons 1.5 – 4.2 eV at temperature 98 K (fig. 4). Exceeding background of the photoresponse is marked above energy of illumination 1.6 eV. On all spectrum identical frequency rate of change FC an residual conductivity is observed.



Fg. 4. Spectra of photoconductivity (1) and residual conductivity (2) at $T = 118$ K (photoconductivity is normalizaed on equal number of photons corresponding $I = 0.065$ mVt/cm^2).

The long-wave edge of FC most likely is connected with acceptor levels in impurity zone. The peak of FC at energy 2.63 eV, is obviously caused with excitation of a charge carrier from a valency zone in donor zone. Carrying outh that analysis of position of this transition and red border of FC, it is possible to estimate energy of ionization of acceptor the level formed by vacancies Gd – 0.85 eV. The structure of energy 2.93 eV, possibly is caused by interzone transition of electrons and will well be coordinated by power position with the data optical research.

CONCLUSION

In films of Gd_2S_3 alloyed by atoms of cadmium, are studied kinetics of photoconductivity and processes of a long-term relaxation. It is shown that the long-wave edge of photoconductivity is connected with transitions of electrons from compensated deep acceptor levels in impurity zone. Energy of ionization of the acceptor levels, formed by vacancies of the gadolinium atoms, are estimated.

The received experimental data say that thin films of one-and-a-half sulfide of a gadolinium alloyed by atoms of cadmium can be perspective materials for creation of photosensitive devices.

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