THE INFLUENCE OF THE THERMAL TREATMENT ON THE AIR ON THE DRIFT AND RECOMBINATION BARRIERS IN THE FILMS $Cd_{1-x}Zn_xS$ (x=0÷0,6)

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The values of the drift and recombination barriers for the main carriers have been calculated in the films $Cd_{1-x}Zn_xS$ (x=0-0,6), obtained by the deposition from the solution. It has been established, that the height of the recombination barrier is higher, than drift, and it leads to the charge accumulation and remanent conductivity. The role of these barriers reduces effectively as a result of the thermal treatment on the air and the light sensitivity increases.

The films CdS, obtained by the method of the chemical deposition, distinction by the high technological reproduction of parameters and are applicable for the formation on their base a large number of devices. Therefore they are actively investigated for the recent years [1-5]. It is possible to observe the heterogeneities (defects) by the structure and local fluctuation in the impurity spreading with the internal electric fields, taking the part of the potential barriers in the polycrystal films, obtained by the deposition from the solution. Therefore the research of the heterogeneous barrier relief in these films has the practical and scientific interest. The temperature dependence of the dark current, photoconductivity, thermostimulated current and remnant conductivity of films $Cd_{1-x}Zn_xS$, obtained on the sitall substrate by the method of the chemical deposition from the aqueous solution, containing salt of Cd, Zn and thiourea has been investigated. The samples with the remanent conductivity (RC), anomaly conductivity and high photosensitivity have been obtained by the parameters change (such as the deposition time, the film thickness, the reaction mixture content, the thermal treatment (TT) regime). The conditions: the concentration is 0,05m $CdCl_2$, 5÷10ml - NH_4OH, 0,05m $(NH_2)_2CS$, the temperature is 90° C, the deposition time is 20÷30 min. are the optimal to receive the stable film of the highest thickness (8÷12mcm), achieved at the single deposition, adhesion to the substrate and heterogeneities.

The specific dark conductivity of the initial samples makes $10^{-9}÷10^{-10}$ $(Ohm\cdot cm)^{-1}$, the ratio of the photocurrent to dark is $\gamma = \frac{I_{ph}}{I_d} = 10^2$. RC has been observed both at room and nitrogen temperatures. In the range 90÷140K the anomalies of the activation energy 0,147eV have been observed at the temperature dependence of the dark current (fig.1).

After cut-off the photocurrent reduces to the fixed value (RC) and then it remains practically invariable. The remanent conductivity occurs, when the relaxation time of non-equilibrium carriers τ exceeds the observation interval τ_0. The relaxation time of RC is $\tau=10^3÷10^6$s for the various samples and depends on the duration and intensity of the preliminary illumination.

The sudden maximum has been observed on the curves of the thermostimulated currents (TSC) at the temperature range 240÷270K [5].

Samples, subjected to TT on the air at 500°C during 15min. have high specific resistivity ($\rho\approx5÷7\cdot10^{-9}$Ohm·cm) and are photosensitive with the multiplicity $\gamma=10^7÷10^8$. After TT the peak intensity on TSC at 240÷270 K have reduced and anomalies in the temperature dependence of the dark current and RC at the nitrogen temperature have disappeared.

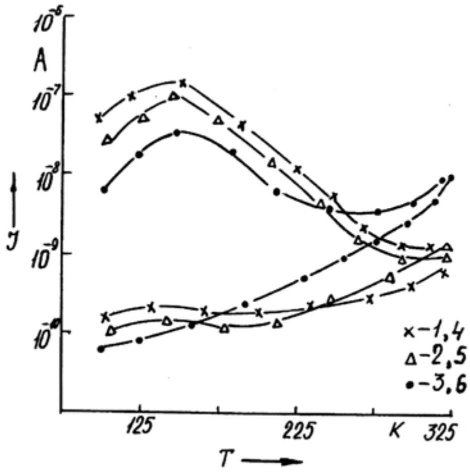

Fig.1. The temperature dependence of the current of the initial films $Cd_{1-x}Zn_xS$ in the darkness (1, 2, 3) and in the state of RC (4, 5, 6) (1,4-x=0; 2,5-x=0,1; 3,6-x=0,6)

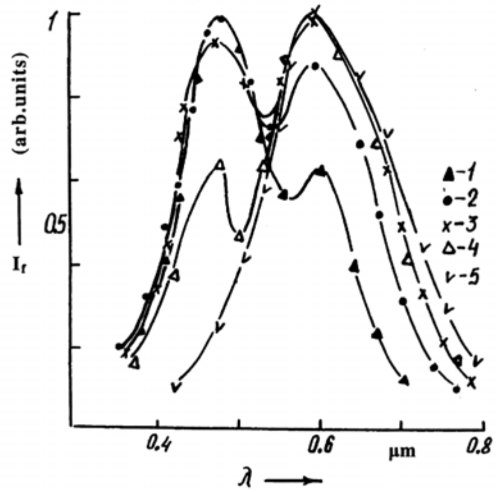

Fig.2. The spectral dependence of the films photoconductivity $Cd_{1-x}Zn_xS$ (x=0,2) versus the thermal treatment time on the air at 500°C (I - t=3 min, 2 - t=5 min, 3 - t=7 min, 4 - t=10 min, 5 - t=15 min.)

The maximum of the spectral characteristic of the samples photocurrent, subjected to TT on the air is in the range 0,47÷0,048mcm (fig.2). It should be noticed, that the maximum bias of the spectral sensitivity of the films $Cd_{1-x}Zn_xS$

to the short-wave side has been observed by the x increase. The samples has the sensitivity in the ultrasound region of the spectrum (0,32÷0,4mcm). One more peak has been observed on the spectral curves at λ=0,57mcm. The appearance of the extra maximum on the spectral curves of the photoconductivity, obviously, is connected with the formation of the cubic phase [6]. The spectrum dependence of the photoconductivity on TT time testifies the statement. The recrystallization of films occurs during the thermal treatment on the air at the temperature 500°C and it leads to the formation on the substrate more perfect by the structure films. In spite of the fact, the specific resistivity reduces, the relative intensity of the extra maximum increases.

The obtained results have the explanation in the framework of the barrier model, connected with the recombination and drift barriers for the main charge carriers. The macroscopic barriers of such type may occur, for example, in consequence of the density fluctuation of the surface state [7]. In framework of the observed model the current ratio through the drift barriers in the RC state (I_{RC}) and in the darkness (I_d) have been determined by the formula:

$$\frac{I_{RC}}{I_d} = exp\left(\frac{\varphi_{ST}}{kT}\right) \quad (1)$$

Hence it follows, that the height of the dark drift barrier at 80 K makes φ_{ST} = 0,045÷0,06 eV. The typical relaxation time of RC depends on the height of the recombination barrier in the form:

$$\tau = \tau_0 \, exp\frac{\varphi}{kT} \quad (2)$$

The barrier height, calculated on the base of the formula (2) and experimental data φ=0,11÷0,14eV coincides with the activation energy value of the optimal temperature dependence, i.e the recombination barrier is higher, than drift and therefore the charge accumulation occurs and the anomaly conductivity phenomenon with the following RC at the nitrogen temperature has been observed. The potential barriers reduce the section of the main carriers capture of the recombination center, and it leads to the sudden delay of the relaxation time.

The presence of the peaks on the curves of TSC predicts that there exist traps, surrounded by the powerful potential barriers in the samples. The role of these barriers reduces effectively in the process of TT. It is testified by the increase of the light sensitivity and peak reduction at 240÷270K on the curves of TSC after TT on the air at 500°C.

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$Cd_{1-x}Zn_xS$ TƏBƏQƏLƏRİNDƏKİ REKOMBİNASİYA VƏ DREYF BARYERLƏRİNƏ HAVADA TERMOEMALIN TƏSİRİ

Məhluldan çökülmə üsulu ilə alınmış $Cd_{1-x}Zn_xS$ (x=0÷0,6) təbəqələrində əsas yükdaşıyıcılar üçün dreyf və rekombinasiya baryerləri hesablanıb. Təyin olunub ki, rekombinasiya baryerlərinin hündürlüyü dreyfdən yüksəkdir, bu da yüklərin toplanmasına və qalıq keçiriciliyinin yaranmasına səbəb olur. Təbəqələrin havada termoemalı baryerlərin rolunu zəiflədir, işığa həssaslığı artırır.

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ВЛИЯНИЕ ТЕРМООБРАБОТКИ НА ВОЗДУХЕ НА РЕКОМБИНАЦИОННЫЕ И ДРЕЙФОВЫЕ БАРЬЕРЫ В ПЛЕНКАХ $Cd_{1-x}Zn_xS$ (x=0-0,6)

В пленках $Cd_{1-x}Zn_xS$ (x=0-0,6), полученных осаждением из раствора, вычислены значения дрейфового и рекомбинационного барьера для основных носителей. Установлено, что высота рекомбинационного барьера выше, чем дрейфового, что приводит к накоплению зарядов и остаточной проводимости. В результате термообработки на воздухе роль этих барьеров эффективно снижается, светочувствительность увеличивается.

Received: 12.04.03