THE DOPING INFLUENCE OF NEAR-SURFACE REGIONS OF PHOTOSEMICONDUCTOR MICROPARTICLES BY ANNEALING IN CHLORINE ATMOSPHERE ON THE ELECTROPHOTOGRAPHICAL (EF) PARAMETERS OF TRIGONAL Se LAYERS IN THE BONDING SOLUTION

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The introduction of chlorine impurity in the near-surface region of microparticles (≃15mcm) of trigonal Se by diffusion annealing increases the integral photosensitivity of EF layers.

The electrophotography (EPh), for the development of which the perfection necessity of existing and the search of new materials, useful for the photoreceptor formation appears, is the one of operative methods of information recording and duplication. Moreover, the change possibility of their properties purposefulnessly is considered of no small importance one.

Nowadays, the amorphous Se and its alloys, chalcogenides and organic semiconductors, multi-layer composition structures and etc are widely used. The use of amorphous Se is caused by correspondence of its photoelectric properties to demands of Eph process. Besides, Se is manufacturable, comparatively easily comes to purification, doping and it is relatively inexpensive one.

EPh layers on the base of amorphous Se have the high photosensitivity (S_{int}≃0,8(Lk·s)$^{-1}$) in the visible region of spectrum, well charge up to initial potential U_0≃600 V, have the long duration of dark half-decay of surface potential $\tau_{1/2}$. However, they have the significant disadvantage: they crystallize under the influence of many factors and fail in the result of exploitation and storage. Moreover, the technology of their manufacture is complex, requires the vacuum equipment, high temperatures, big power imputs. EPh layers on the base of trigonal Se in the bonding solution are stable on the structure, have enough high photosensitivity (S_{int}≃0,4(Lk·s)$^{-1}$), the complex and power-consuming equipment isn't required for their manufacture.

Se by SF-17 type, which is treated by thermal processing in the extracted quartz ampoules at 700 during 3 hours with the further quick cooling up to 250°C in the flowing water, is the initial material. At such thermal processing in Se the initial molecular and submolecular structure (thermal prehistory) destroys and the stabilized new one, which corresponds to the given conditions of thermal processing forms [1]. Moreover, at such thermal processing the chemical oxygen fixation and other impurities and their transition into electro-inactive state take place [2].

Se, obtained by such way, crystallizes at 210°C during 40 hours. The measurements show, that trigonal Se has the dark conductivity ≃10^{-7}(Om·cm)$^{-1}$. This trigonal Se is crushed in a ball mill up to average size of particles ≃15 mcm, is filled up into quartz ampoules, in which the gaseous chlorine is filled with the help of a la carte tap after degassing (ρ≃10^{-2}Pa).

The pure chlorine is obtained by the way of interaction of MnO_2 with HCl [3]. The chlorine pressure in ampoules varies in the interval $5\cdot10^3 \div 10^5$ Pa. After chlorine filling the trigonal Se is treated to diffusion annealing at T_{tr}=90÷170°C during 0,5÷5 hours. In the result of such thermal processing the chlorine molecules diffuse in the near-surface region of trigonal Se particles up to depth ≃1mcm, i.e. in fact that region of photosemiconductor dopes, where the light quantum can penetrate at exposure of EPh layer.

The solvent (ETOH)and the bonding solution (polivinilbutiral of ПШ type) are added to obtained by such way powder of trigonal Se with chlorine impurity and after combined dispersion the emulsion is marked on the aluminum substrate (foil by width 150 mcm) by method of swimming roll. The substrate preliminary is degreased, dipped in 10% solution of KOH, thoroughly washed and conserved in acetone up to emulsion marking.

The width of manufactured EPh layers is 20÷30 mcm in the dependence on the relation trigonal Se – bonding solution. Further, EPh layers are dried in the common conditions during the day.

Their main EPh parameters are measured on the ectrometric installation with vibrating electrode near layer surface. The charging of EPh layers is carried out in the corona discharge. The light characteristics are measured by exposure through shutter with the use of lamp glowing and neutral color filters after dark adaptation of EPh layers during 15 minutes.

The newly-made EPh layers from the trigonal Se, annealed in chlorine atmosphere in bonding solution charge only up to initial potential U_0≃ 100 V, have the duration of dark half-decay of surface potential $\tau_{1/2}$≃15c and integral photosensitivity S_{int}≃0,04(Lk·s)$^{-1}$. The essential improvement of all parameters of the same layers after drying at T_d=70÷150°C with further slow cooling is observed. Thus, S_{int} increases almost in 10 times at T_d≃120÷150°C. The improvement of other parameters is observed. The obtained results are tabulated in the table, from which it is seen, that powder annealing of trigonal Se in chlorine atmosphere (P_{Cl}=$5\cdot10^3 \div 10^5$Pa) essentially influences on the parameters of EPh layers.

The further growth T_d>150°C leads to the parameter degradation and thus, the drying at T_d≃120÷150°C is necessary for the formation of optimal sizes. The parameter degradation of EPh layers at T_d>150°C is probably caused both by penetration of chlorine impurity deep into particles of trigonal Se and beginning of thermo-destruction process of bonding solution.

The introduction of chlorine impurity into trigonal Se is caused by the fact, that chlorine increases the dark conductivity of photosemiconductor on several orders. Situating on the edges of Se chains, the chlorine molecules decrease the height of potential barriers and promote to mobility of current carriers. Simultaneously with it both acceptor impurity and the chlorine increase the carrier concentrations. The photosensitivity of trigonal Se increases because of the given reasons. However, the growth of dark conductivity of photosemiconductor strongly decreases the charge quantity of EPh layer. The chlorine impurity makes degradation the dark characteristics, improving the light ones. Thus, it is necessary to introduce the impurity so, that it can wrap up the surface layer of particles of trigonal Se up to the depth of light penetration at exposure ($\simeq$1 mcm at $\lambda \lesssim 0{,}7$ mcm). The impurity shouldn't penetrate into internal regions of powder particles in order the conductivity of main mass of trigonal Se stays low one. Only at that case the slow relaxation of surface charge in the darkness will be promoted. The diffusion annealing of powder of trigonal Se in chlorine atmosphere is carried out especially with realization aim of such situation.

From the table it is seen, that the parameter improvement of EPh layers is observed with the increase of annealing time t_{tr} up to 1 hour. At the further increase t_{tr} their degradation is observed, i.e. the annealing during $t_{tr}\simeq$ during 1 hour is optimal one.

The result analysis (see table) allows us to confirm that annealing of photosemiconductor microparticles in chlorine atmosphere at the given T_{tr} and t_{tr} promotes the increase of integral photosensitivity of EPh layers of trigonal Se in bonding solution.

Table

	T_{tr}, h	S_{int}, $(Lk \cdot s)^{-1}$					U_0, V					$\tau_{1/2}$, s				
PCl_2, Pa	t_{tr}, h / T_{tr}, °C	0,5	1	2	3	5	0,5	1	2	3	5	0,5	1	2	3	5
$5 \cdot 10^3$	90	0,23	0,21	0,24	0,26	0,27	293	288	282	262	251	41	40	38	37	36
	120	0,23	0,25	0,31	0,34	0,37	290	286	272	254	244	39	38	37	36	34
	135	0,24	0,28	0,33	0,35	0,38	284	274	266	248	235	38	36	35	34	33
	150	0,25	0,31	0,34	0,37	0,39	275	265	262	242	232	36	34	32	29	28
	170	0,25	0,30	0,33	0,35	0,38	270	262	258	240	228	34	31	28	26	25
10^4	90	0,24	0,24	0,27	0,29	0,31	292	288	278	256	246	41	39	37	36	36
	120	0,25	0,30	0,37	0,40	0,41	285	280	272	250	238	39	37	36	34	33
	135	0,26	0,32	0,38	0,41	0,42	280	272	265	244	232	37	35	34	33	32
	150	0,27	0,37	0,40	0,42	0,43	275	264	258	240	228	36	34	32	30	30
	170	0,28	0,35	0,38	0,43	0,43	268	260	255	235	224	33	30	28	26	25
$5 \cdot 10^4$	90	0,25	0,28	0,28	0,31	0,32	290	285	274	250	236	40	38	37	36	36
	120	0,26	0,32	0,38	0,40	0,44	282	278	265	242	230	38	37	35	33	32
	135	0,28	0,34	0,40	0,42	0,45	276	270	258	235	224	36	35	34	32	32
	150	0,32	0,43	0,50	0,50	0,49	270	264	254	231	220	35	34	33	31	30
	170	0,33	0,44	0,48	0,47	0,47	260	258	250	226	216	32	28	26	25	24
10^5	90	0,26	0,27	0,27	0,30	0,30	288	280	270	246	230	39	37	34	31	28
	120	0,27	0,31	0,36	0,40	0,42	282	274	263	238	225	37	35	31	29	28
	135	0,28	0,34	0,40	0,41	0,44	275	266	256	232	217	35	32	29	27	26
	150	0,34	0,45	0,47	0,44	0,47	265	253	248	228	213	32	30	26	22	21
	170	0,35	0,42	0,45	0,41	0,40	258	256	246	224	210	30	28	24	20	19

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FOTOYARIMKEÇİRİCİNİN MİKROZƏRRƏCİKLƏRİNİN SƏTHƏ YAXIN OBLASTININ XLOR ATMOSFERİNDƏ TERMİK İŞLƏMƏKLƏ LEQİRƏ EDİLMƏSİNİN TRİQONAL Se-NİN ƏLAQƏLƏNDİRİCİDƏ EF LAYLARININ PARAMETRLƏRİNƏ TƏSİRİ

Triqonal Se-nin mikrozərrəciklərinin ($\simeq$15 mkm) səthə yaxın oblastının xlorla aşqarlanması EF layların inteqral fotohəssaslığını artırır.

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ВЛИЯНИЕ ЛЕГИРОВАНИЯ ПРИПОВЕРХНОСТНЫХ ОБЛАСТЕЙ МИКРОЧАСТИЧЕК ФОТОПОЛУПРОВОДНИКА ОТЖИГОМ В АТМОСФЕРЕ ХЛОРА НА ЭЛЕКТРОФОТОГРАФИЧЕСКИЕ (EF) ПАРАМЕТРЫ СЛОЁВ ТРИГОНАЛЬНОГО Se В СВЯЗУЮЩЕМ

Введение примеси хлора в приповерхностную область микрочастичек ($\simeq$ 15 мкм) тригонального Se диффузионным отжигом увеличивает интеграль-ную светочувствительность EF слоёв.

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