# ELECTROGRAPHIC LAYERS FROM TRIGONAL SELENIUM CHEMICALLY REFINED AND DOPED BY SODIUM IN BINDING

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The electrographic layers on the base of trigonal selenium chemically refined and doped by sodium in binding with intepal photosensitivity $\simeq$ 0,8 (lux-s)$^{-1}$ and extended photosensitivity region up to $\lambda \simeq$ 700 nm.

Nowadays the chemical method of refining and doping of photosensitive materials by the way of photosemiconductor dissolution, its reconstruction and chemical treatment in the solution of doping substance is widely used. The use of the given method for refining and doping of selenium is caused by following circumstances. As it is known the impurities of alkali metals (for example, sodium)decrease the conductivity of trigonal selenium on several orders and so this should led to increase of initial potential $U_N$ of electrographic layers (EP) on its base and to rate decrease of its dark relaxation. The advantage of this method in comparison with traditional high-temperature doping is that final product is obtained in the form of fine-dispersed powder the particle near-surface region of which is reached by impurity.

EP layers from amorphous selenium [1] obtained by vacuum evaporation have high EP parameters, but they are treated by degradation because of crystallization and their spectral region is limited by blue-green spectrum region, i.e. up to $\lambda \leq$ 520nm. EP layers on the base of trigonal selenium in binding [2,3] have the definite advantages in the comparison with first ones. Thus the investigations show that thin layer of trigonal selenium covered by nano-layer of electro-active organic material (binding) forms the photosensitive layer which has the extended spectral photosensitive region in the comparison with layers from amorphous selenium. It is also important that they are crystalline ones and don't degrade.

The amorphous selenium by brand SF 17-4 from which the trigonal selenium chemically refined and doped by sodium is used in the capacity of initial material. The main principle of such selenium obtaining is in dissolution of amorphous selenium in NaOH solution. The definite quantity of powder-like amorphous selenium is put in the bottle with 2,5N of NaOH solution. The solution is supported at 80°C and continuously mixed by magnetic stirrer during 5 hours. At this the following reaction with polyselenide formation is carried out:

$$(2n+1)\,\underset{\text{amorphous}}{Se} + 6\,NaOH \rightleftarrows 2\,Na_2\,\underset{\substack{n=3\text{-}4\\ \text{polyselenide}}}{[Se_n^{2-}]} + Na_2\,SeO_3 + 3\,H_2O$$

The obtained solution of red color is diluted by distilled water up to required volume, mixed and stayed for stabilization during 18 hours. Further the solution filtration is carried out and distilled water in relation 1:3 is added to bottle with solution. The diluted solution is mixed during 5 minutes and the 30% solution of pereoxide $H_2O_2$ is added by drip feed in it. Moreover, the selenium reconstruction and its settling-out on reaction take place:

$$Na_2\,[Se_n^{2-}] + 2\,H_2O_2 \rightarrow \downarrow \overset{n}{\underset{\text{trig}}{Se}} + 2\,NaOH$$

The liquid obtaining after sedimentation is drained and this procedure is multiple repeated while the resistance of this settled liquid doesn't become close to value of distilled water resistance ($pH \simeq 7$) on order. Further the trigonal selenium is filtered. The trigonal selenium obtained by such way is dried at 60°C in dry air (during 18 hours).

The advantage of the given refining and doping method is that all sparingly soluble impurities are excluded from solution and first refining stage is carried out at its filtration. The second refining stage is carried out in the process of selenium reconstruction and residue scrubbing.

The rentgenodifractometric investigations show that selenium obtained by that way presents itself the powder of trigonal selenium (average particle size $d \lesssim$ 0,7 mcm).

EP layers are prepared from usual trigonal selenium (thermal crystallization at 210°C during 40 hours) and selenium chemically refined and doped by sodium. The layers from these materials are firstly prepared by dispersion in ball mill and later the solvent (ethyl alcohol) and binding polyvinilbutiral are added and the layers after mutual dispersion are marked on aluminum substrate (fil by thickness 150 mcm) by the method ? The substrate is previously degreased by solvents, dipped in KOH 10% solution, thoroughly washed by distilled water and conserved in acetone up to establishing in water distribution vehicle. The thickness of prepared layers is $\simeq$ 20 mcm.

The layer main EP parameters are studied on electrometric installation with vibrating electrode near layer surface after layer drying in usual conditions during the day and after annealing at 160°C during 30 min. The layer charge is carried out in corona discharge. The layer light characteristics are measured by exposure through shutter with use of filament lamp and neutral filters. The spectral distribution of photosensitivity of EP layers is measured in interval 400-1000nm (monochromator VSU2 – P). The measurements are carried out after layer dark adaptation during 15 minutes. The latest increase of layer adaptation time doesn't reflect on their parameters.

The character curves of dark potential fall from initial trigonal selenium chemically refined and doped by sodium in binding in the dependence on weighting relation which is photosensitivity-binding $N = 0,25 \div 5$ are given on the fig.1. As it is seen from the figure the initial potential $U_N$ decreases with increase of photosemiconductor-binding relation and value $U_N$ is higher than one for layers of selenium doped by natrium.

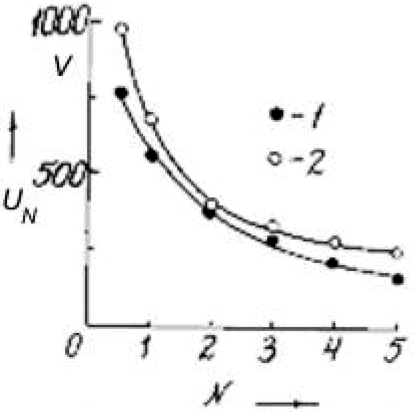

*Fig. 1.* The dependence of initial potential ($U_N$) on relation trigonal selenium - binding ($N$):
1 - initial trigonal selenium;
2 - trigonal selenium chemically refined and doped by sodium.
At $N = 0,25$ $U_N \geq 1500$ B isn't marked on the plot.

The time of dark half-fall $\tau_{1/2}$ of these layers decreases with increase of of semiconductor-binding relation.

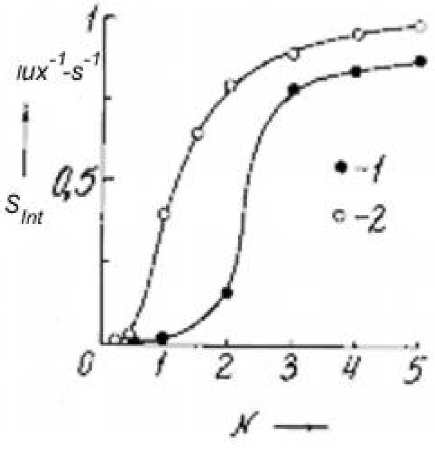

*Fig. 2.* The dependence of intepal photosensitivity ($S_{Int}$) on relation trigonal selenium - binding (N).
1 - initial trigonal selenium;
2 - trigonal selenium chemically refined and doped by sodium.

The measurements of integral photosensitivity $S_{Int}$ on half-fall criteria of initial potential reveal its monotonous increase with N increase with tendency to saturation at $N = 4 \div 5$ (fig.2). As it is seen from the figure the layers of trigonal selenium from chemically refined and doped by sodium have the bigger quantity of $S_{Int}$ than layers from initial trigonal selenium at all photosemiconductor-binding relations considered by us. According to residual potential, its value decreases with increase of N relation and establishes on the level 25-30V that is order 10% from initial potential value for both layers from selenium doped by natrium and for ones from initial selenium.

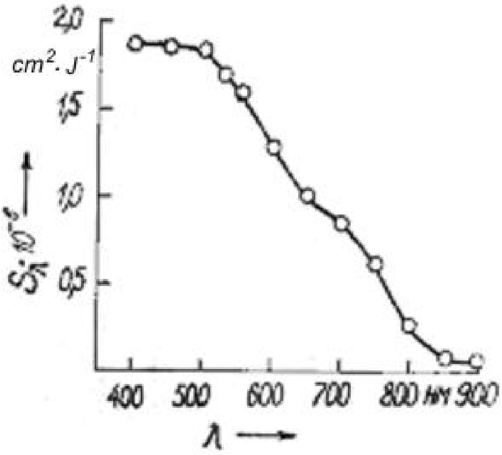

*Fig. 3.* Photosensitivity spectral distribution of EP layers of trigonal selenium cleaned chemically and doped by natrium.

The comparison of EP layer parameters from selenium doped by natrium and initial one shows that the first layers are better on all parameters. This proves that the chemical refining and doping by sodium essentially improves the main EP layer parameters from trigonal selenium in binding. The analysis of investigation results shows that photoreceptors with photosemiconductor-binding $N = 2 \div 3$ have optimal parameters in method of EP layer preparation used by us.

The meaning of chemical refining and doping is that sodium impurities are on both surface of trigonal selenium microparticles and enter in their near-surface region (in the result of diffusion at annealing), i.e. in that region where light quantum penetrates at exposure and where the origing of charge carriers takes place. The main part of selenium particles stays undopped and origin couples shift in particle volumes with big mobility than in the case of equilibrium selenium doping. Indeed, the obtained results prove the above mentioned: $S_{Int}$ is bigger in layers from selenium $U_N$ doped by sodium than in layers from initial one.

The plot of photosensitivity spectral distribution of EP layers from selenium doped by sodium from which it is seen that region of photosensitivity spectral distribution extends up to $\lambda \simeq$ 700nm is shown on Fig. 3.

Thus the EP layers on the base of trigonal selenium chemically refined and doped by sodium in binding with integral photosensitivity $\simeq$ 0,8 $(\text{lux-s})^{-1}$ and extended up to $\lambda \simeq$ 700nm of photosensitivity region, have been formed.

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## KİMYƏVİ ÜSULLA TƏMİZLƏNMİŞ VƏ NATRİUMLA AŞQARLANMIŞ TRİQONAL SELEN ƏSASLI ELEKTROFOTOQRAFİK LAYLAR

Kimyəvi təmizlənmiş və natriumla aşqarlanmış triqonal selen əsasında fotohəssaslığı $\simeq$ 0,8 $(\mathrm{Lk} \cdot \mathrm{s})^{-1}$ və spektral oblastı $\lambda \simeq 700$ nm olan elektro-fotoqrafik laylar yaradılmışdır.

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## ЭЛЕКТРОФОТОГРАФИЧЕСКИЕ СЛОИ ИЗ ХИМИЧЕСКИ ОЧИЩЕННОГО И ЛЕГИРОВАННОГО НАТРИЕМ ТРИГОНАЛЬНОГО СЕЛЕНА В СВЯЗУЮЩЕМ

Созданы электрофотографические слои на основе химически очищенного и легированного натрием тригонального селена в связующем с интегральной светочувствительностью $\simeq$ 0,8 $(\text{Лк} \cdot \text{с})^{-1}$ и расширенной до $\lambda \simeq 700$ нм областью фоточувствительности.

*Received: 03.10.08*