THE INFLUENCE OF PHOTOVOLTAIC AND PHOTORESISTIVE EFFECTS ON THE FORMATION OF THE PHOTOELECTRET EFFECT IN CdS AND ZnS POLYMER COMPOSITES

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It was shown that like in orqanic and inorqanic photosensitive materials photoelectric properties (photoconductivity, photovoltaic, photogeneration and stabilization of electricity charge carries) of the polymer – CdS and polymer – ZnS composities are of great importance as the decisive factor in forming of photoelectret effect.

Keywords: photoelectret, photovoltaic, photorezistivity, photosensitive semiconductor.
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INTRODUCTION

The mechanism of photoelectret state formation in the polymer composites with photosensitive phase was widely studied in the recent years [1, 3]. It is known, that it is necessary to have two types of relaxers (homo and hetero) for the formation of both electrets and photoelectret effects in any solid material. The electrons injected into composite during photopolarization process and electric charge carrier generated as a result of internal photoeffect belong to the first type of relaxers. There are different kinds of the second relaxer types, including:

- low molecular positive and negative ions having electric load in the polymer matrix;
- colloidal fractions having electric load in the polymer matrix;
- compounds having certain dipole moment in inorganic (CdS, ZnS) and organic (polymer groups, domains, conjugant combination) phases.

The formation of photoelectret effect is possible in the polymer CdS (ZnS) systems having this kind of structure. Certain requirements are set before photoelectrets to meet the growing demand of technique, including electronics. For example, the photoelectrets with different relaxation period are required for photolithography system development. In general, considering photoelectret, photoresistive and photovoltaic effects in materials, for the formation of the above mentioned effects the following common factor comes to the fore:

- creation of charged particles in photopolyarization process and their isolation from one another.

The main goal of our work is to study and define the mechanism of photoelectrete effect formation in polymer - CdS (ZnS) heterogeneous systems. Taking into consideration this goal, the parallel investigation of the mentioned three photoelectret effects in the studied composites is of great importance [1, 3-5].

MATERIALS AND METHODS

The initial phase of the technology of composite obtaining includes: the obtaining of press – crumbs of the components, separating of fractions according to their sizes, blow out from the magnetic separators, cleaning the surface of particles and thermal treatment [6]. The constituents of photocomposities are chosen according to the requirements for them. Thermoplastic polymers such as polyolefine and fluorine-containing polymers were used as polymer phase. CdS, ZnS were used as semiconductor light-sensitive phase.

The working principle of the installations and the blocking scheme used to study photoresistive and photovoltaic effects in polymer-based composites is presented in the work [2]. Generally, photosensitivity is characterized by the ratio of photo current to the dark current. The device used in the study of photoelectret, photovoltaic and photoresistive effects in the composites are extensively considered in the works [1-3, 5, 6] .

The intensity of the light falling on the sample varied between 100 - 600 mWt/sm^2 [2].

RESULTS AND THEIR DISCUSSION

In accordance with the main goal of this work, in order to reveal the formation mechanism of photoelectret effect the main factor in our research was the use and compare of the dependence of composites photoelectrical properties on the share volume of photosensitive phase like all the available composites. Fig. 1, a presents the $I_{ph}/I_d = f(\Phi)$ dependence for F42 – ZnS and F42 – CdS composities. The experimental results show that the maximum photosensitive semiconductor observed in $I_{ph}/I_d = f(\Phi)$ dependences are very dependent on phases: if the maximum share is 30% of phase volume for ZnS semiconductor phase composites, the same result for the CdS phase composite is equal to 40%. In the fist approach, this interesting effect should be explained by the interactions with different features occurring in interphase. It should be noted that the maximum observed in $I_{ph}/I_d = f(\Phi)$ dependence is defferent for F42 - CdS and F42 - ZnS composites. In the first approach, it can be assumed that in the F42 - ZnS compositie the value of the potential interphase barrier is small. This factor is also confirmend by the value of I_{ph}/I_d ratio.

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In fig. 1, b the dependence of photo electromotive force of polar and non - polar polymers and CdS, ZnS compositions on lightsensitive semiconductor phase is shown. F42- ZnS is the best composite as photovoltaic element. This experimental result is an important factor for clarifying the mechanism of photelectrete effect formation in our work.

a) in the given composites photovoltaic effect depends on the light-sensitive semiconductor phase;

b) photovoltaic effect depends on the polarity, dielectric permittivity and the specific volume resistance of the polymer matrix.

The analysis of the result of studies on photoelectrete effect allows defining the following regularities:

1) in photoelectrete composites consisting of polymer - lightsensitive (CdS, ZnS) semiconductors the photoelectret potential difference U_{phe} first increases according to the increase of the share volume of CdS and ZnS and then decreases after reaching a maximum, increases share volume increases, that is the dependence of $U_{phe} = f(\Phi)$ is of extreme character. On the other hand, a definite relationship between fig.1,a and fig.2 is observed. So, $I_{ph}/I_d=f(\Phi)$ (photoresistive effect) and $U_{phe}=f(\Phi)$ (photoelectrete effect) is of extreme character.

2) there are some difference between various polymers and the composites having light - sensitive semiconductor phases in terms of maximal values of the dependence of photoelectret potential difference U_{phe} on the light - sensitive semiconductor phase share volume; maximum potential difference of polar polymer matrix photocompposities $U_{phe}=f(\Phi)$ dependences are greater than those of non - polar matrix photocomposities (Fig. 2).

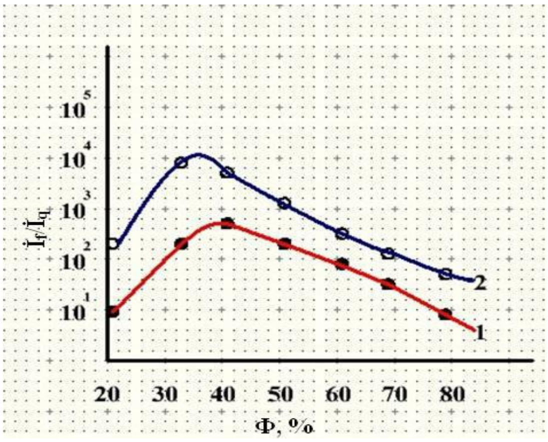

Fig. 1,a. Dependence of F42 – ZnS and F42 – CdS composities on $I_{ph}/I_d=f(\Phi)$. U=100V,E_l=400 Wt/sm^2.1. F42–CdS; 2. F42–ZnS.

3) the share volume of semiconductor phase corresponding to the maximal value of U_{phe} is smaller for polar polymer matrix composites (Fig. 2).

The extreme character of the obtained dependences caused by the following reasons.

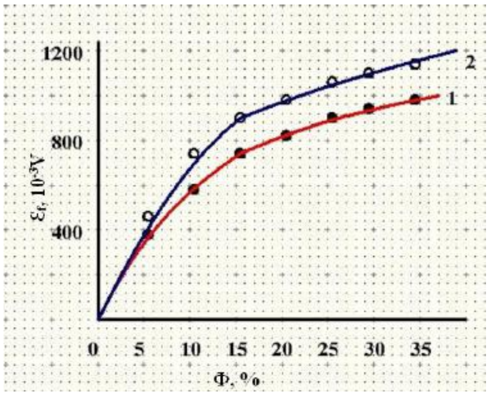

Fig. 1,b. Dependence of photoelectric move force on on the share volume of light- sensitive phase for polar and non- polar polymers, CdS and ZnS based composities. 1.F42 – CdS; 2. F42 – ZnS. Diameter of particles of the semiconductor phase is 6 microns and the sample thickness is 15 microns.

First, oxidation of the polymer matrix and creation of the polar groups forming photoelectrical charge during mechanical mixing of the components under combined effect of temperature and pressure (mechanical termodestruction and termooxidation). Second, change of quasineutral systems forming probability created by homocharges and heterocharges stabilized in interphase border during photoinjection and reduction of $\Delta Q_e=Q_r-Q_{het}$ electrete charge or electrete potential difference defined as homo - and heterocharge superposition. Third, the rise of the composites specific photoconductivity according to the increase of light sensitive phase share volume and the increase of homoelectrical charge relaxation. Fourth, when the share volumes of CdS and ZnS in composite increases, the mass of the polymer phase playing a key role in the electrets formation. Indeed, as a result of the interaction (polymer - light-sensitive CdS and ZnS) between phases, both polymers crystalline structure and CdS and ZnS electronic structure change in the studied composites phase and these effects increase when the share volume of light-sensitive phase rises.

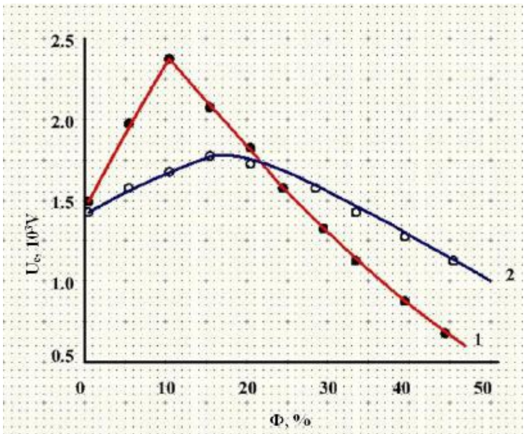

Fig. 2. Dependence of the composites photoelectrete potential difference (Ue) on light-sensitive phase share volume. 1.F42 – ZnS; 2.F42 – CdS. $E_p=0{,}4\cdot10^4$ V/m; t_p=0,25 hour; E_l=400 mWt/cm^2; T_p=393K..

Thus, in the first approach it can be considered that, the photoelectron prosseses occurring in the interphase boundary play more important role in forming of an photoeletret effect in the composites consisting of polymer photosensitive inorqanic semiconductor materials. We think, that the formation of a new polymer on its nature phase under the influence of polymer – $A^{II}B^{VI}$ photosensitive semiconductor phase are the photoelectret effects. Firs of all, this approach determines the connection between the electret effect and the effects of photoconductivity, photovoltaic and electrical photoquenching. It is known, that free charge carriers, which determine the conductivity owing to internal photoeffect, are forming under the light effect. At the same time, the holes are forming. Now, a possible mechanism of the formation of homo and hetero charges from the abovementioned charges should be clarified. A similar approach should be used for photovoltaic effect. So, the formation of free electrons and holes under the light effect and their subsequent isolation from each other is an essential condition for photoelectret effect forming in the high heterogenic polymer – various inorganic photosensitive phase materials. Electrons are stabilized in traps as deep as possible and certain potential difference is formed during the isolation process. It was determined experimentally that there is no direct connection among photorezistive, photovoltaic and photoelectret effects. So that, the maximums observed in the dependence of I_f/I_q, ε, U_e parameters on the volume share of the composite's photosensitive phase don't fall with each other.

CONCLUSION

The main reason of photoelectret effect formation under the action of light and electricity in the composites based on polymer and CdS, ZnS components is the establishment of homo and hetero charges, which determine the electrets potential difference in electrophotopolyarization proses interphase in the border of composites.

Based on the results of the studies it is concluded, that the major reason of polymer - CdS and polymer - ZnS composites extreme character of $I_{ph}/I_d = f(\Phi)$ and $U_{phe} = f(\Phi)$ dependence is explained with the change of the potential barrier formed in the switch polymer layer between the particles of light-sensitive phase according to the increase of their share volume.

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