

BOUNDARY EFFECTS IN POLYMER COMPOSITES - POWERED CERAMICS

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The paper presents the results of studies of the piezoelectric properties of composites based on multicomponent piezoceramics and fluorine-containing polar polymers. In this regard, the role of interfacial charges in the formation of the piezoelectric effect is considered.

**Keywords:** polymer composites, injection, multicomponent ceramic, boundary effects  
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1. INTRODUCTION

Analysis of numerous works on piezoelectric and pyroelectric materials shows that the polymer matrix of these disperse systems is the active phase and determines the magnitude of the macroscopic parameters of the marked composites. The piezo-, pyroelectric properties of these heterogeneous systems are due to the combined action of the boundary, interfacial, injection, and electret properties of individual phases, in particular, the polymer [1-4].

The aim of the work is to study the interphase phenomena and boundary polarization effects under the conditions of simultaneous exposure to a strong electric field ( $E_p$ ) and temperature ( $T_n$ ) in polymer composites.

2. EXPERIMENTAL TECHNIQUE

As a research method, we used spectra of thermally activated spectroscopy (TSD).

Multicomponent ceramics of the lead zirconate titanate (PZT-19) family were used as the piezoelectric phase. Composite samples were obtained by hot pressing in the melting range of the polymer matrix [1]. The dielectric parameters of the composites are measured using an E7-20 voltmeter.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The energy diagram of the polymer – piezoceramics boundary before (fig. 1a) and after contacting (fig. 1b) of the phases is shown in fig. 1. After contact between the polymer and piezoceramics is established, the Fermi levels  $E_f$  are equalized due to the movement of electrons from polymer. The formation of layers of space charges near the interface is accompanied by the bending of zones and is the initial stage of the formation of the Schottky barrier.

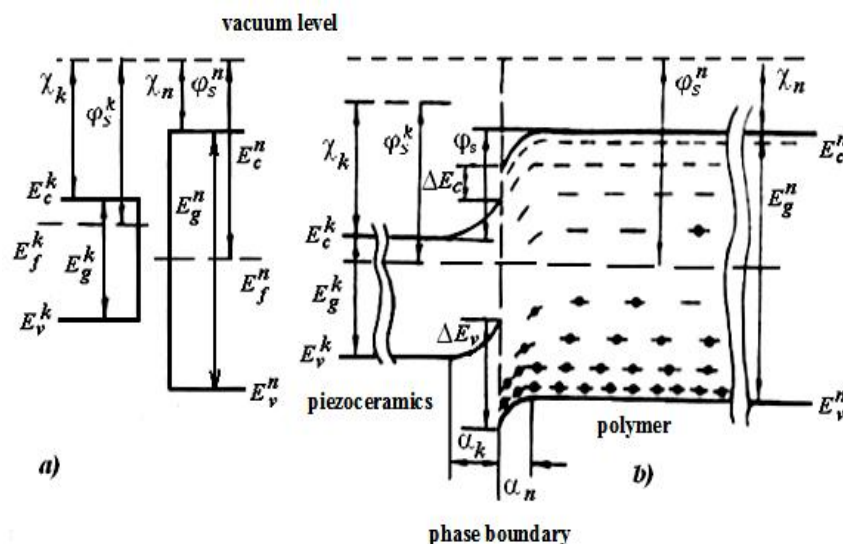


Fig.1. Energy diagram of the polymer - piezoceramics boundary before (a) and after contacting (b) phases

With the ratio of the work function of the electrons indicated in fig. 1, in the case of contact of a polymer - piezoelectric ceramics the interface passes from piezoceramics to a polymer, resulting in an excess charge on the surface of the polymer phase and, therefore, a potential barrier height

$$\varphi = \frac{e^2 n_D \alpha^2}{2 \epsilon_{nc}}$$

and the Fermi level by the formula

$$E_F = kT \ln \frac{n_D}{N_S}$$

where  $N_S$  is the density of the filled boundary states;

$\epsilon_{ps}$  is the dielectric constant of the transition layer;  $n_D$  is the density of donors.

It can be concluded that for  $d_{33}$  in composites it is not the electrode that is responsible  $\varphi$ , but  $\varphi$ , which is formed at the interface [4] (fig.2).

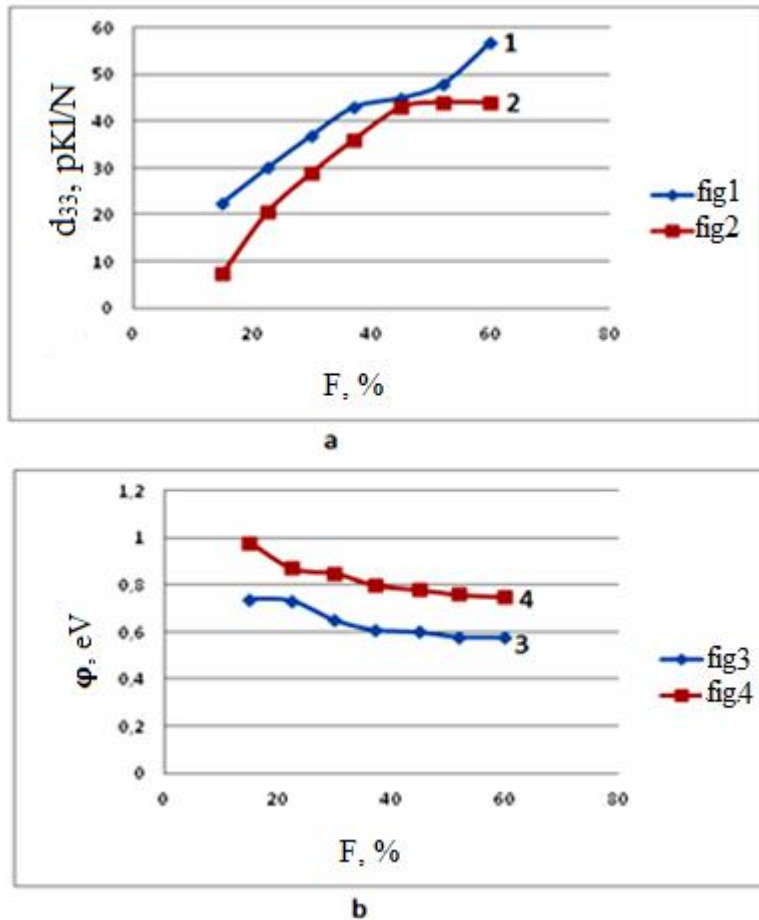


Fig.2. Dependencies of the piezomodule  $d_{33}$  (1, 2) and the potential barrier  $\varphi$  (3, 4) at the interface between the phases and the volume content ( $F$ ) of the piezophase. 1 is  $d_{33}$  for PVDF –Pb (TiZr) O<sub>3</sub> composite; 2 is  $d_{33}$  for PVDF – Pb (TiZr) O<sub>3</sub> composite; 3 is  $\varphi$  for composite PVDF –Pb (TiZr) O<sub>3</sub>; 4 is  $\varphi$  for PVDF – Pb (TiZr) O<sub>3</sub> composite. The size of piezoparticles is 60 microns;  $E_n = 4.5$  MV / m;  $T_n = 393$  K;  $t_n = 0.5$  hour

#### 4. CONCLUSION

Dispersion of the polymer matrix by multicomponent ferroelectric particles leads to a noticeable increase in the piezomodule depending on

the volume content of the piezophase in the composite.

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