# FEATURES OF ELECTROPHYSICAL CHARACTERISTICS OF ZINC OXIDE AND POLYMER BASED COMPOSITE VARISTORS

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**ABSTRACT**

In the work the results researches of volt-ampere characteristics, specific resistance, electric and mechanical durability of composite varistors on the basis of high density not polar polythene (PE) and zinc oxide based ceramics (C) are presented. Influence of components contents of a composite on volt-ampere characteristics, on specific resistance value, electric and mechanical durability is revealed.

**Keywords:** composite, varistor, zinc oxide, polymer, conductivity, resistance.

## I. INTRODUCTION

Next to on-going turn-over to nanotechnology [1], the conditions for protection of electronic devices are becoming more rigid, causing big demands for low-voltage limiters of overvoltages. Particularly, low-voltage non-linear varistors, or varistors based on various combinations of composite materials are now of increased interest [3,4].

The present work is devoted to studying influence of volume content of ceramic filler on the values of specific resistance, mechanical and electric durability of composite varistors on the basis of zinc oxide with impurities and polymer.

## II. EXPERIMENTAL DATA

The zinc oxide based varistor ceramics and not polar high pressure polythene have been used as components of composite varistor. Varistors are received from a homogeneous mix of powders components by the hot pressing method. The contents of composite components were varied in a wide range of 10-70 % (C) and 90-30 % (PE) accordingly. The samples thickness made up 150 microns.

For all samples the dependences of specific resistance, mechanical and electric durability from volume content of ceramic filler and volt-ampere characteristics have been investigated. Measurements of investigated parameters are carried out at a room temperature (T=293K).

On fig.1-4 the volt-ampere characteristic, dependences of specific resistance, mechanical and electric durability from volume content of ceramic component (C%) accordingly are brought.

The ceramic content (C,%) dependence of composite specific resistance conditionally can be divided on three areas:

1) area 1 – value(fig.1) of specific resistance (ρ) strongly decreases with growth of ceramic content up to C = 30-40 %;

2) area 2 - value of specific resistance (ρ) remains almost constant with growth of ceramic content within the limits of C=40-60 %;

3) area 3 - value of specific resistance (ρ) sharply increases at further growth of ceramic content C>60 %.

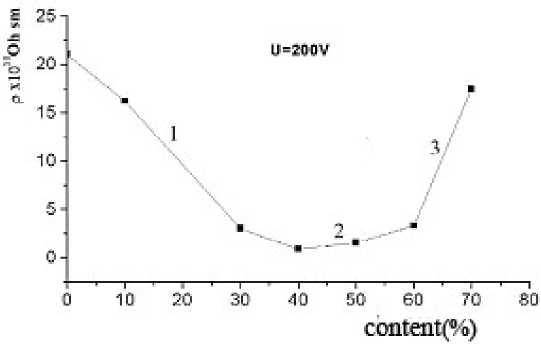


Fig.1. Dependence of specific resistance on ceramics content

From figures 2(a,b)-4 following features of investigated paran

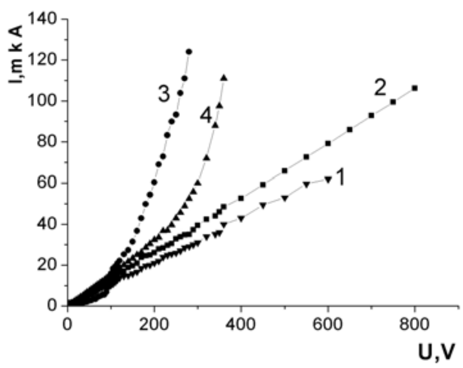

Fig.2a. Volt-ampere characteristic of the composite varistor
1-0%(C), 2-10%(C), 3-30%(C), 4-60%(C)

1) volt-ampere characteristics for all samples have nonlinear character, namely, with growth of the supplied voltage the value of a current through the varistor changes on 2-3 orders;

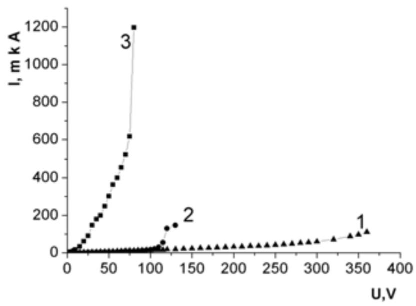


Fig.2b. Volt-ampere characteristic of the composite varistor
1-60%(C), 2-50%(C), 3)-40%(C)

2) with growth of filler volume content the values of electrical and mechanical durability decreases.

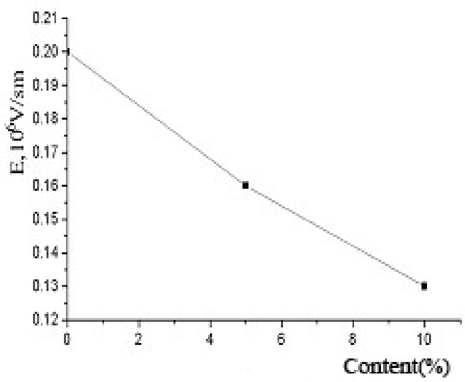


Fig.3. Dependence of electric durability on ceramics content

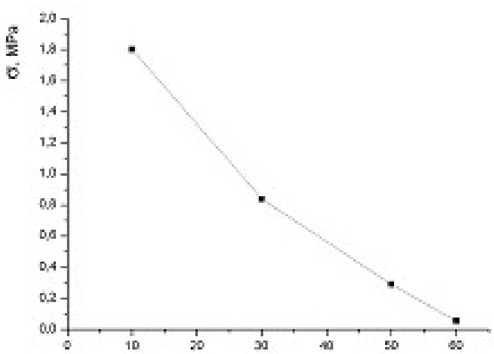


Fig.4. Dependence of mechanical durability on ceramics content

## III. DISCUSSION OF EXPERIMENTAL RESULTS

The obtained experimental results are discussed from the point of view of charge carriers transfer in the polycrystalline structures, namely: a) tunneling of charge carriers through the intercrystalline and interphase potential barriers arising between the filler particles because of presence between them thin polymeric isolating layers; b) emission of charge carriers through barriers between the filler particles; c) charge carriers transfer through direct contacts between ceramic filler particles which forms the conductive chains in a composition.

According to work [5] conductivity of a composition represents function of an average contacts number to one particle. Besides according to the theory of electric contacts the electric current between two conductors can to flow not only at their direct contact but also then between them there is a thin layer of dielectric. In that case conductivity can be carried out by tunneling of charge carriers through potential barriers. The fact is that at the tunnel effect the charge carrier with energy smaller, than the height of a potential barrier, has non-zero probability to overcome it, keeping thus the own energy. According to the same work the tunnel resistance depends exponential from thickness of a potential barrier.

Under the above stated it is possible to explain dependence of a specific resistance from the filler content(C%) as follows. At the small contents of filler the average number of contacts to one particle is not enough and conductivity has the hopping mechanism connected by overcoming of a potential barrier between the filler particles. In other words because of the big thickness of polymeric layers the tunneling probability of charge carriers through a thick barrier is small and the contribution of tunnel conductivity on area 1 will be insignificant. Hence, resistance of a composition will be determined, basically, by the polymer resistance. With increasing of ceramics content on the one hand the average number of contacts between the particles increases, on the other hand the width of a potential barrier decreases and thus the probability of carriers tunneling through a barrier increases exponentially. As a result of all this conductivity of a composite increases and accordingly its specific resistance (area 2) decreases. At the further increase of the filler content наполнителя its particles start to form the continuous chains and due to the conductivity of a composite basically will be determined by the conductivity of the filler particles (area 3). The mechanism of varistors conductivity are detail considered in the our works [4,6].

Reduction of electric durability, apparently, is connected by that at low contents of filler the thickness of a polymeric layer between the filler particles is great therefore the electric durability of a composite will be determined basically by the polymeric layer durability. This is confirmed by the experimental data. With increasing of ceramics content the thickness of a polymeric layer between the filler particles decreases and by that the contribution of a polymeric layer decreases and as a result the electric durability of composite decreases.

Before explaining the reduction of mechanical durability of researched composites it is established by us that mechanical rupture of a pure polymeric film has a viscous character. At the same time with growth of filler content the rupture of a composite has almost fragile character. The received results can be explained as follows: at composite manufacturing there is destruction of composite continuity, namely, due to filler particles the chemical connection between the polymer molecules collapses and the composite becomes fragile. In view of this, it is possible to explain reduction of polymer mechanical durability of as follows: at low values of the filler content connection between the polymer molecules strong and the value of mechanical durability with greater probability is determined by the polymer film durability, and it high enough, with growth of the filler content the connection between the polymer molecules sharply decreases, connection between the composite particles becomes fragile, that reduces the mechanical durability.

The analysis of the received experimental results shows, that the mix of polymer and ceramics in a composite is not mechanical, evidently, between them there is an interphase interaction.

## IV. CONCLUSION

Thus, the technology reception of composite varistors on the basis of ceramics from the zinc oxide with impurities and a polymeric material is developed**.**

Influence of the composite components content on varistors volt-ampere characteristics, its specific resistance, electric and mechanical durability is revealed.

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