DEPENDENCE OF THE NANOCOMPOSITE SYSTEMS RESISTANCE ON THE INITIAL MATERIALS DISPERSITY

Ya.I. Lepikh*, V.A. Borshchak, N.N. Sadova, N.P. Zatovskaya

*Odesa I.I. Mechnikov National University, 2 Dvoryanska str., 65082, Odesa, Ukraine, *E-mail: ndl_lepikh@onu.edu.ua*

Introduction

Nanodispersed composites based on "glass - metal compounds" are widely used in microelectronics, in particular, as nanocomposite thick-film elements of multilevel hybrid integrated circuits. These composites are formed by annealing. The resulting pastes are a multiphase heterogeneous system consisting of functional material powders, glass bonds, and organic fertilizer. In the element annealing process glass powders are melted and sintered into a glass matrix, in which the functional phase particles are fixed, forming current-carrying chains. The composite system formation is accompanied by complex physicochemical processes that, at the selected annealing temperature conditions, determine nanocomposites phase composition, microstructure, and electrophysical properties.

With the development of nanophysics and nanoelectronics, at present, widespread use is made of composite materials, which are a multiphase heterogeneous system consisting of components with various physical and chemical properties. The analysis of the studies showed that the formation of the composite systems is accompanied by complex physicochemical processes between the conductive phase, on the one hand, and glass and organic bonds, on the other. Factors that control the rate of the chemical interaction (such as the starting material particle size, their acid-reducing properties) at the selected annealing temperature conditions determine the phase composition, microstructure and electrophysical properties of nanocomposites. That is, by providing for starting materials high level of stability, it is possible to solve the problems associated with the degradation processes that occur in the materials over time and often serve as causes of equipment failures.

Methods

It was found that a significant role in the reproduction and stability of the nanocomposites electrophysical parameters is played by the dispersion of the functional material and glass frit powders. At present, the dispersion of powders is not regulated; according to the design documentation, powders with particle sizes less than 25 microns are used.

Results and discussion

Our studies on samples made by standard technology showed a low level of the nanocomposites parameters reproducibility, which can be associated with a large glass particles spread in their geometric dimensions [1-2]. Studies of samples obtained from powders of lead-borosilicate glass (PbO, SiO_2, B_2O_3, Al_2O_3) with fixed particle sizes (0.5 μm, 1 μm, 3 μm, 5 μm) and a functional material RuO2 with a particle size of 3 μm at a fixed annealing temperature (870^0C) showed the nanocomposites resistance dependence on the ratio of the glass and conductive phases concentration. It has been determined that for samples with a low content of ruthenium dioxide, the influence of the glass-frit particle sizes on the resistance is the largest. The resistance of the samples increases with increasing of the glass content, and the highest growth rate is observed for glass fiber with particle sizes of 0.5 μm.

With an increase in the RuO_2 concentration, the resistance approaches a constant value and does not depend on the glass fiber particle sizes. The resistance dependence on the particle sizes for high-resistance nanocomposites can be associated with the processes of sintering and the effect of the components dispersion on the conductive chains geometric dimensions. With a decrease in the glass particle sizes, the length increases and the cross-sectional area of the chains of the conducting phase decreases.

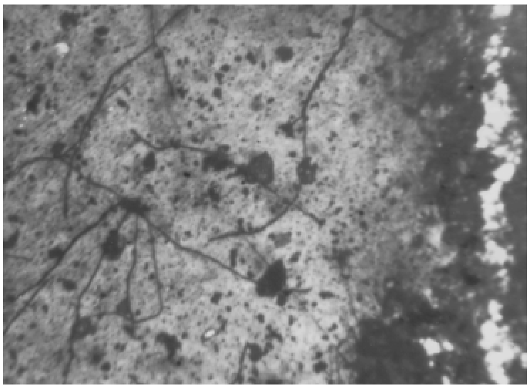

Fig. 1 Microcracks in thick films. Scanning microscopy. Secondary electron mode. Magnification 500

In RuO_2 – glass systems, a mixed character of conductivity is observed, which is a combination of processes occurring in the conductive and glass phases. In high-resistance nanocomposites, the main contribution to the conductivity is made by glass fiber, so the properties of this phase play a significant role in the process of current transfer.

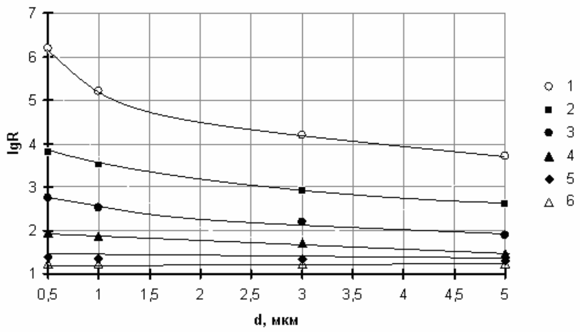

Fig. 2 R(Ohm/cm^2) dependence on the glass particles geometric sizes for different concentration ratios glass: RuO_2 (1 - 90:10; 2 - 80:20; 3 - 70:30;4 - 60:40; 5 - 50:50 ; 6 - 45 - 55)

Conclusions

It was found that with an increase in the conductive phase - glass ratio, the surface resistance decreases. The greatest influence on the nanocomposite resistance is the glass frit particle size for samples with a low content of ruthenium dioxide. With an increase in the glass content, the resistance rate growth increases, and the highest rate is observed when the glass particle size is about 0.5 μm. As the RuO_2 content increases, the resistance tends to a constant value and does not depend on the glass particle size.

References

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