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C4-P-P023801 **Properties of electrical insulation coatings from yttrium-stabilized zirconia and alumina**

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INTRODUCTION

There are a large number of methods for creating electrical insulating coatings using organic and ceramic materials.

Organic materials, in particular plastics, due to their low heat resistance, have a limited temperature range of functioning as electrical insulation.

Ceramic insulating materials with the appropriate choice of composition and application technology have high mechanical strength, high relative permittivity and a small dielectric loss tangent.

Compared with organic materials, ceramics, as a rule, have greater resistance to electrical and thermal aging, and do not give permanent deformation when a mechanical load is applied to it.

The results of a study of the electrical characteristics of zirconia films stabilized by yttrium oxide with the addition of alumina obtained by electron beam evaporation in the forevacuum pressure range is present.

TECHNIQUE AND EXPERIMENTAL TECHNIQUE

The creation of dielectric coatings was carried out on a vacuum installation pumped out only by a mechanical fore-vacuum pump. A plasma source based on a glow discharge with a hollow cathode was used as an electron source. Working gas - residual atmosphere - air at a pressure of 5 - 6 Pa.

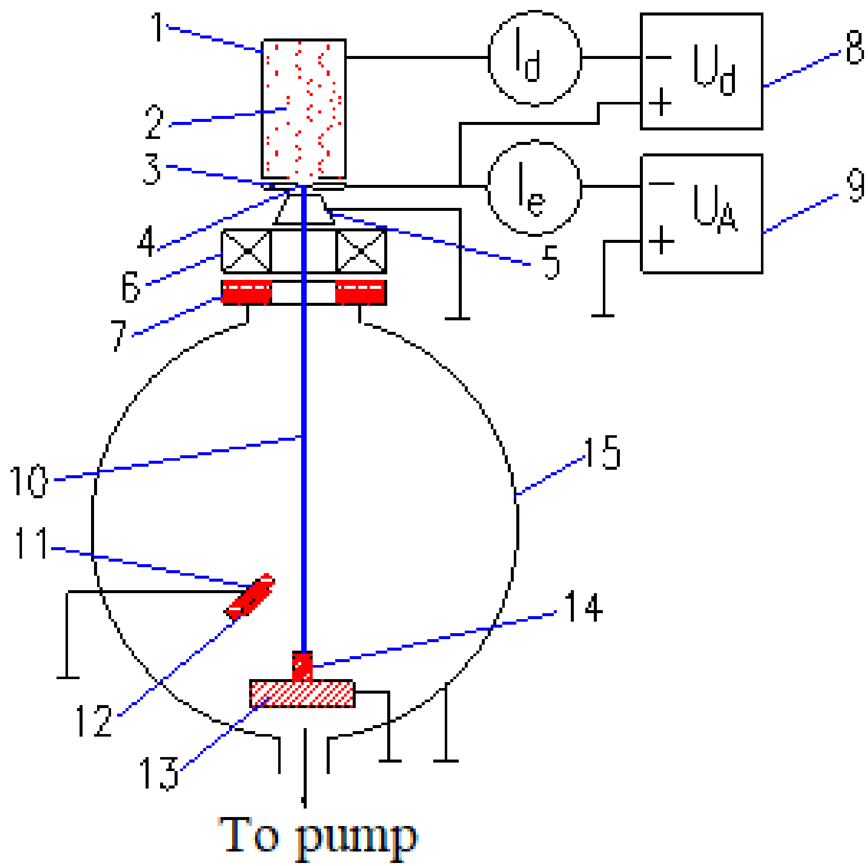

Fig.1. The experimental setup.
1 - hollow cathode; 2 - plasma of a hollow cathode; 3 - anode; 4 - emission electrode with an emission hole;
5 - accelerating electrode (extractor);
6 - magnetic focusing coil; 7 - magnetic deflection system; 8 - discharge power supply; 9 - power supply accelerating voltage;
10 - electron beam; 11 - sample holder;
12 - sample; 13 - graphite crucible;
14 - sprayed dielectric target;
15 – vacuum chamber.

Samples obtained by hot pressing from the following powders were used as sputtering targets:

1) pure aluminum oxide Al_2O_3 (grain size ~ 100 μm);
2) pure ZrO_2 oxide (grain size ~ 30 - 50 microns);
3) zirconium oxide stabilized with yttrium ZrO_2 + 8% Y_2O_3 (grain size ~ 50 μm);
4) corundum-zirconium ceramics - CCC, (ZrO_2 + 8% Y_2O_3) + Al_2O_3 (grain size ~ 100 μm).

Alumina additives were 20, 50, and 80 weight percent. The sprayed targets had a cylindrical shape with a diameter of 10 mm and a length of 8 - 10 mm.

The power of the electron beam was ~ 500 W (accelerating voltage of 20 kV, beam current ~ 25 mA). The temperature of the substrate was ~ 850 °C. Spraying time 1 hour.

EXPERIMENTAL RESULTS

Dielectric coatings with a thickness of 6 to 9.3 μm were obtained on a stainless steel substrate.

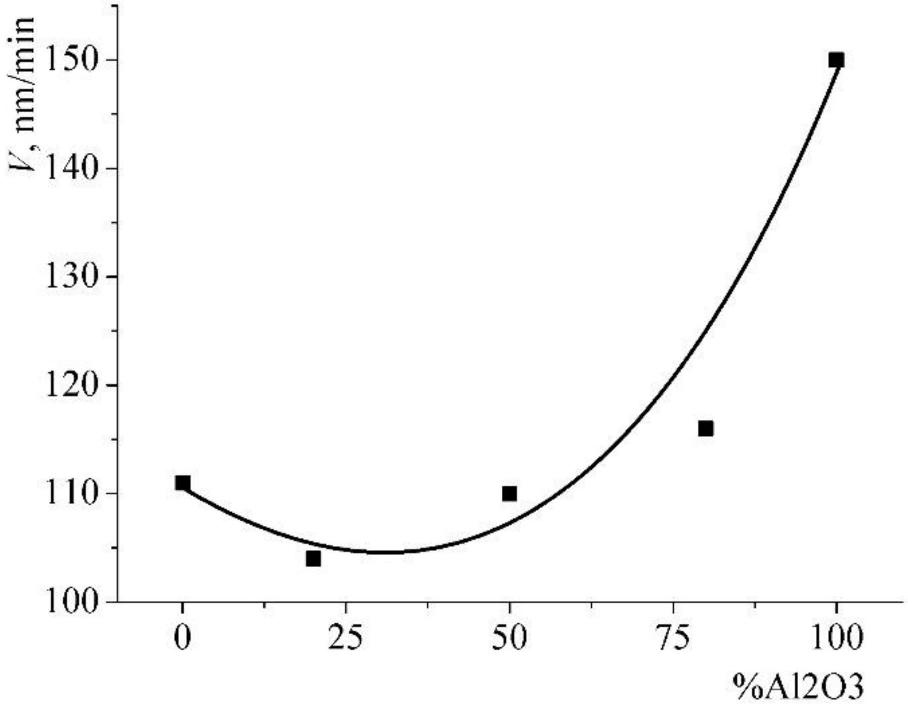

Fig. 2. Dependence of the deposition rate V of a dielectric coating on a stainless steel substrate on the percentage of alumina in the sprayed target from yttrium-stabilized zirconia

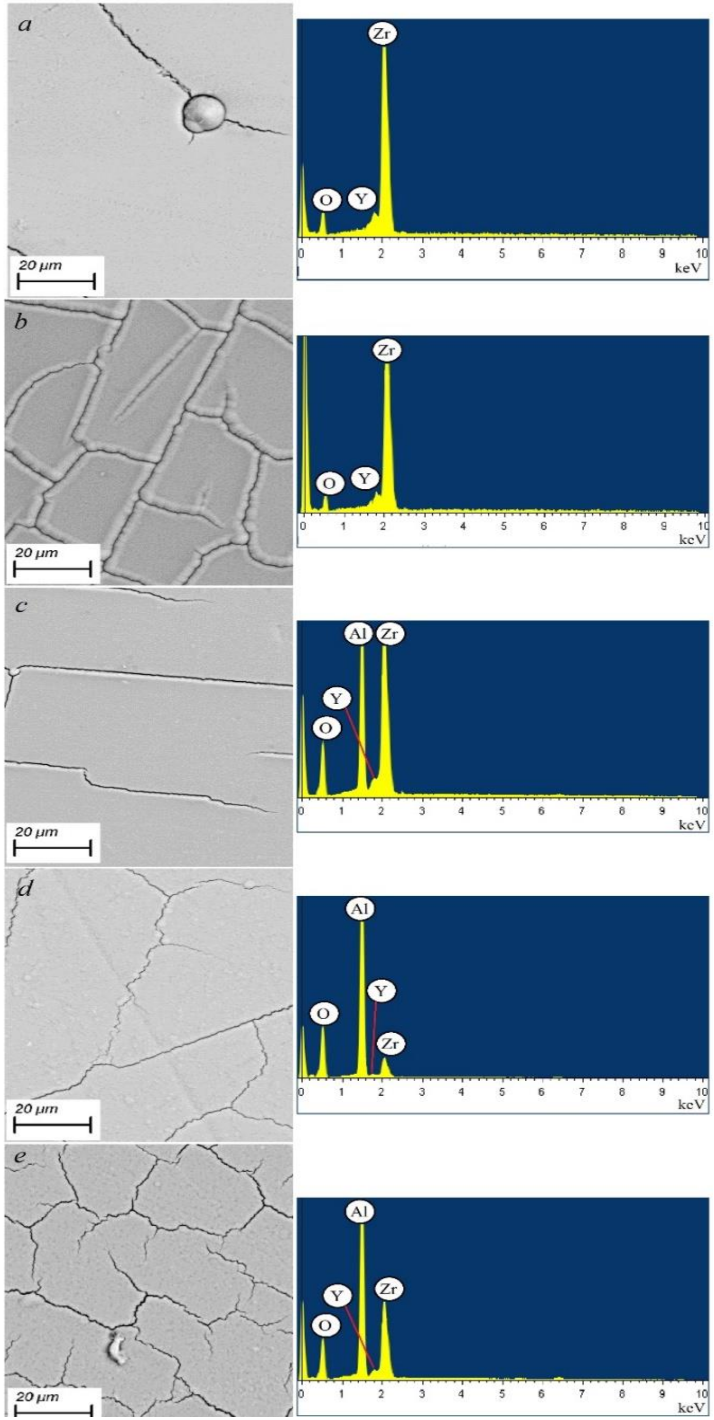

Fig. 3. Surface morphology and composition of the applied coatings. a is pure zirconium oxide; b - yttrium stabilized zirconia; c - yttrium stabilized zirconia with the addition of 20 weight percent alumina; d - yttrium stabilized zirconia with the addition of 50 weight percent alumina; e - yttrium stabilized zirconium oxide with the addition of 80 weight percent alumina.

The surface is homogeneous and has not continuous cracks and block structure, and an increase in the content of alumina in the coating leads to a decrease in block sizes. The deposition of aluminum electrodes did not lead to the appearance of shorts. As inclusions, droplets of the substance of the sputtered target are observed

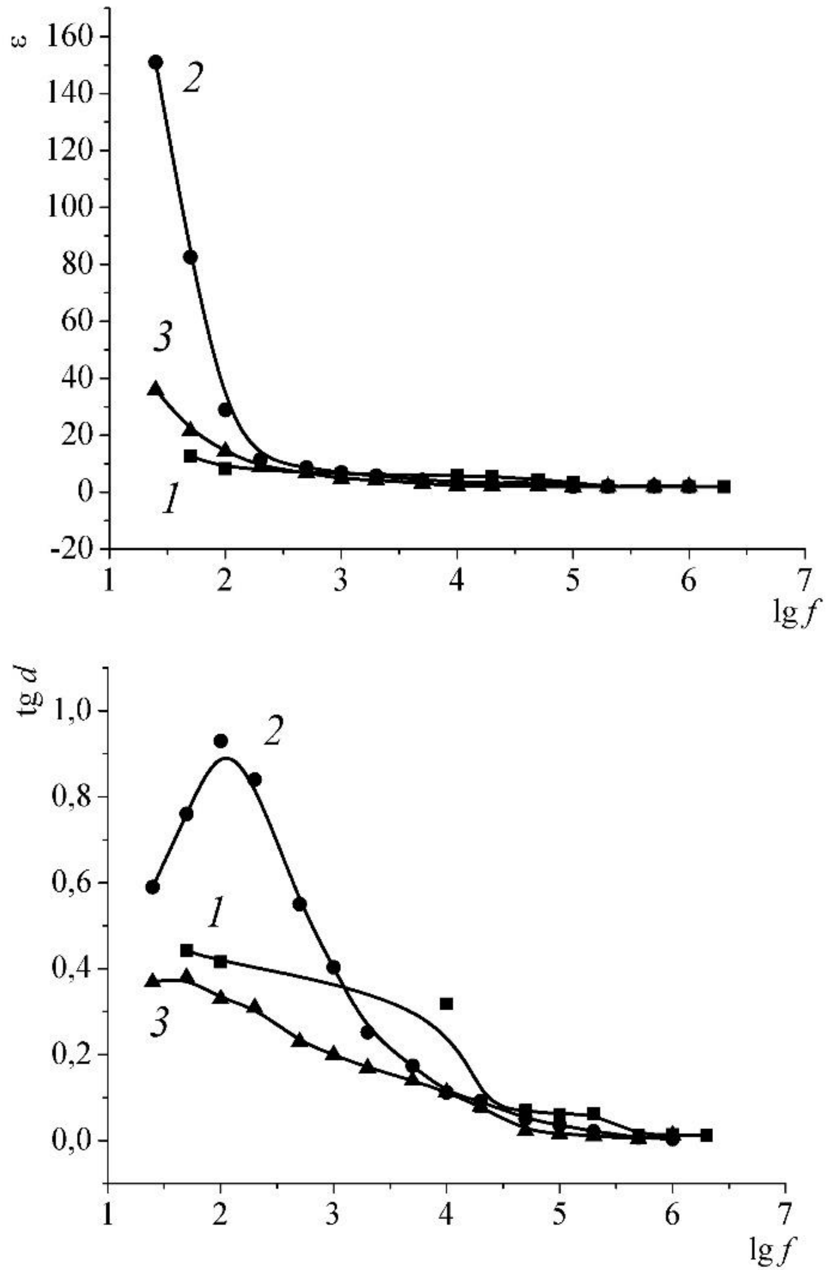

Fig. 4. The dependences of the relative permittivity ε and the dielectric loss tangent tg d on frequency f: 1 – Al_2O_3; 2 – ZrO_2; ZrO_2st + 20%Al_2O_3.

At low frequencies (up to 1 kHz) the main losses are due to losses due to through conductivity. At frequencies of ~ 100 kHz, the losses are due to relaxation losses characteristic of solid dielectrics, in particular ceramic materials containing defects, boundaries, and impurity ions that can capture electrons.

Conclusion

- The results of the studies show the possibility of creating ceramic coatings on conductive metal surfaces by electron beam evaporation using a plasma electron source that reliably functions in the fore-vacuum pressure range.
- Coatings made of zirconium oxide stabilized with yttrium with the addition of alumina possessing good adhesion.
- At a frequency of 1 MHz, their relative permittivity is 8–9, and the dielectric loss tangent is 0.05–0.07. This allows you to use them as electrical insulating coatings.