TECHNOLOGY OF APPLYING Ni_3B – METAL-CERAMIC TRACKS BY MULTILAYER SCREEN PRINTING METHOD

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Conduction tracks based on Ni_3B - metal-ceramic pastes were synthesized in different modes and their properties were investigated. It was found that with increasing thickness, the resistance of the conduction track decreases, and the synthesis of conductive tracks with 3-stage application allows to obtain maximum power with minimal resource costs for multi-stage heat treatment. The topography of the synthesized coatings was investigated by infrared interferometry. The microstructure of the conduction tracks was investigated on polished transverse microsections.

Keywords: conduction tracks, Ni_3B - metal-ceramic paste, properties, resistance, topography, microstructure

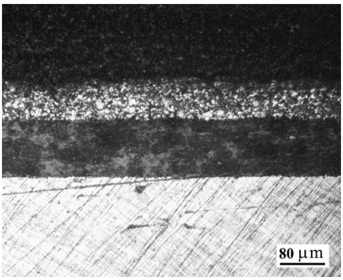
Introduction. Due to its high chemical and thermal stability, PRN paste (Paste Resistive Nitride) is used as the material for the resistive coating. These pastes are produced by incorporating nickel borides (Ni_3B) into a glass-ceramic composition based on the $BaO–SiO_2–ZnO$ system. The resistive coating is applied to a glass-ceramic surface formed from steel. Annealed steel maintains its structural and phase stability during cyclic heating and cooling within the temperature range of 25–450 °C and is resistant to atmospheric corrosion. The coefficient of thermal expansion for 430-grade steel is 10.4×10^{-7} K^{-1}, which closely matches that of the $BaO–SiO_2–ZnO$-based glass-ceramic material (10×10^{-7} K^{-1}), thereby preventing delamination of the coating from the substrate [1]. Through multi-stage deposition and heat treatments, conductive tracks with different resistivity and thickness parameters were obtained by screen printing method.

Materials and Method of Investigation. The microstructure of the composite reinforcement was studied on transverse and longitudinal sections using metallographic analysis. Quantitative analysis of the microstructure was performed using the ImageJ software. The thickness was measured with an ultrasonic thickness gauge. The topography of the insulating coating and the synthesized conductive paths was examined using the infrared interferometry method on the Micron-alpha device.

Results and Discussion. With an increase in thickness, the resistance of the conductive track decreases from 43.5 Ω to 11.7 Ω. At the same time, samples produced using three-stage deposition process exhibit resistances of 11.7 Ω and 15.4 Ω, respectively. Thus, the synthesis of conductive tracks through a three-stage deposition allows for achieving maximum power output with minimal resource consumption for multi-stage heat treatment.

The topography of the insulating coating and the synthesized conductive tracks was studied using the infrared interferometry method. Inhomogeneities in the coating of the conductive tracks were detected in all four investigated samples. Their surface roughness (R_z) varies in the range from 8.647 to 16.94 µm. The obtained roughness values enable the synthesis of multilayer conductive tracks with a good level of adhesion.

The microstructure of the conductive tracks was examined on polished transverse microsections. It was found that the structure consists of light regions corresponding to the conductive phase based on nickel boride and dark regions representing the amorphous–crystalline glass-ceramic matrix (fig. 1). No visible signs of adhesion between the conductive track and the ceramic layer were observed. However, good bonding between these coatings is achieved due to the fusion effect between the insulating ceramic layer and the ceramic component in the PRN paste during heat treatment.



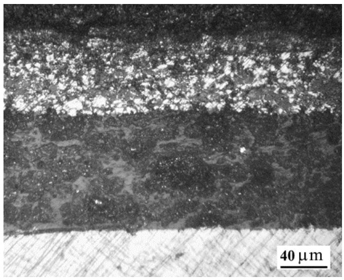


Fig.1. Microstructure of the conduction tracks synthesized by 3-stage deposition

The microhardness of the conductive tracks was measured using the Vickers method. Considering the relatively small variation in microhardness, ranging from 205 to 260 HV.

Conclusions. The structure of the track consists of light areas of the conduction phase and dark areas of glass-ceramic. It was established that good grafting of these coatings is obtained due to the effect of fusion of the glass-ceramic phase. Considering the small spread of microhardness (205…260 HV), the conduction tracks synthesized by 3-stage deposition have a more homogeneous structure than the tracks obtained by the standard method. And these tracks allow to obtain maximum power with minimal resource costs for multi-stage heat treatment.

1. *Kovbasiuk T., Duriagina Z., Kulyk V., Pleshakov E., Kushpir V. Influence of heat treatment modes on the performance characteristics of resistive cermet coatings // Ukrainian Journal of Mechanical Engineering and Materials Science. – 2020. – 6, № 3/4. – P.35–40. https://doi.org/10.23939/ujmems2020.03-04.035*