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THERMALLY CONNECTED SHS PROCESSES IN A LAYERED POWDER SYSTEM $Ni + Al/PbO_2 + B$ + INERT

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Thermally coupled SHS processes make it possible to expand the range of materials produced by the SHS method. So, for example, the use of external heating of a low-exothermic or endothermic mixture with the help of a highly exothermic mixture makes it possible to obtain such valuable materials as WC, CrAlC, TiNi, etc. The method does not require sophisticated equipment, energy costs are negligible. Another advantage of the method is the possibility of obtaining functionally gradient materials, such as layers of metals and ceramics with high heat resistance and resistance to thermal shocks.

The same method can be used to obtain multilayer coatings with different electrical conductivity in the layers. For example, if the lower layer is made dielectric and the upper layer is electrically conductive, then it will be possible to obtain flat electric heaters in one stage. Now this technology requires 6-8 stages with firing in high-temperature furnaces.

The work is devoted to the study of processes occurring in a two-layer powder system $Ni + Al/PbO_2 + B$ + inert (glass + Al_2O_3). In which the Ni + Al mixture is a heat donor and serves to create an electrically conductive layer. A mixture of PbO_2 + B + inert (glass + Al_2O_3) serves as both an acceptor and a heat donor. By changing the content of the inert component, one can control the temperature in the layer and set the chemical composition of the glass obtained during the reactions, which serves as an insulator. The temperature can also be controlled by changing the thickness of the Ni + Al layer. Thus, it is possible to choose the conditions for obtaining a reliable coating with a minimum thickness.

To prepare the initial mixture (Ni + 31 wt. % Al), nickel PNK-L5 and aluminum ASD 4 were used. To obtain a dielectric coating, a mixture of PbO_2 , boron, Al_2O_3, and glass powders was used. In this case, a mixture of PbO_2 + B was prepared separately. The ratio of components was calculated in accordance with the reaction equation $PbO_2 + 2B = PbO + B_2O_3$. As well as a mixture of 50 wt. % Al_2O_3 and 50 wt. % glass powder. A mixture of powders in the form of a suspension in isopropanol was applied to ceramic (VK 1, 98 wt % Al_2O_3) or steel (St3) substrates through a stencil 0.5 thick; 1.1 and 1.6 mm.

The temperature and propagation velocity of the reaction front were determined by the tarmocouple method, using multichannel optical sensors, and a high-speed video camera. X-ray phase analysis was carried out on a portable RIKOR diffractometer provided by the Tomsk Common Use Center of the Siberian Branch of the Russian Academy of Sciences. The coating microstructure was studied using an Axiovert optical microscope (Karl Zeiss, Germany).

It has been established that an increase in the thickness of the Ni + Al layer leads to an increase in the temperature and velocity of the combustion wave front. A similar regularity is also observed with an increase in the content of the PbO_2 + B mixture in the lower layer. In addition, an increase in the content of the PbO_2 + B mixture in the lower layer leads to the expansion of the wave front in the Ni + Al layer due to heating from the exothermic reaction in the lower layer. An increase in the content of the PbO_2 + B mixture leads not only to the melting of glass particles and the formation of a glass-ceramic coating, but also to the chemcal interaction between the components of the mixture with the formation of a homogeneous glass coating. The microstructure of the fracture of the coating indicates the formation of two layers: the upper NiAl and the lower glass-ceramic, firmly bonded to each other.

Thus, in the course of the study, the possibility of obtaining a two-layer electrically conductive and dielectric coating by the SHS method was shown. The optimal ratios of the layer thicknesses and the composition of the powder mixture of the layers have been established. The addition of a PbO_2 + B mixture to the lower layer makes it possible to reduce the thickness of the NiAl layer and ensure the formation of a uniform dielectric coating.