ISMAN: NEW RESULTS AND ACHIEVEMENTS

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Merzhanov Institute of Structural Macrokinetics and Materials Science, Russian Academy of Sciences (Russian acronym ISMAN) was founded in 1987. The purpose and scope of Institute activities are to carry out fundamental, research, and applied scientific studies in the field of physics and chemistry of combustion and explosion processes, including self-propagating high-temperature synthesis, physicochemical transformations of substances under high temperatures and pressures, and materials science.

The following are some important results obtained at the Institute in recent years.

In the framework of the macrokinetic approach, analytical and numerical methods were used to study the thermal conditions of passivation of pyrophoric nanopowders at lower initial temperature of layer. It was shown that a decrease in initial temperature of nanopowder leads to a transition from layer-by-layer to volume passivation. It made it possible to control the permissible level of heating during passivation even at high concentration of oxidizing agent in the gas. Analytical expressions for determining the conditions for layer-by-layer and volume passivation, which were confirmed by numerical calculations, were obtained [1].

Experimental and theoretical method for the calculation of gas flow parameters at which a slow conductive mode of combustion of granular mixtures transforms into a fast convective one was developed. Dependence of the burning velocity on the gas flow in the convective mode was determined. The results can be used to explain and predict the occurrence of fast-moving forest fires [2].

Propagation of solid flame over a combustible wire placed at the axis of cylindrical mirror was studied by mathematical modeling. The use of mirror for return of radiant losses was found to significantly expand the limits of combustion in linear systems. Even in case of non-ideal reflection, the combustion temperature and burning velocity can be expected to attain their superadiabatic values. [3].

$(Zr_xTi_{1-x})_3AlC_2$ MAX phase was prepared by SHS method. X-ray diffraction analysis of the $(Zr_xTi_{1-x})_3AlC_2$ ($0 < x < 1$) crystals made it possible to more accurately determine the composition of a new MAX phase prepared by SHS: $(Ti_{0.67}Zr_{0.33})_3AlC_2$. Density functional theory calculation results suggested that the formation of crystals with this composition is energetically favorable. The arrangement of the Zr and Ti atoms in the metal–carbon layer was shown to be disordered [4].

Ta_4ZrC_5 и WC–W_2C composites with melting point above 4000°C were first synthesized by electro thermal explosion (ETE) under pressure. WC–W_2C composite has a density of 12.5 g/cm³ and microhardness of 16–21 GPa. High physical and mechanical characteristics were explained by the presence of needle-like W_2C particles in WC–W_2C composite [5].

The influence of additives of sodium halides on the structure formation in the system Si + Si_3N_4 during nitriding in the combustion mode was studied. It was found that the use of sodium halide additives makes it possible to form the α silicon nitride phase of different morphology. Combustion mode for obtaining the equiaxed α silicon nitride phase was developed. Silicon nitride samples prepared with mean diameter of particles of 1.2–1.5 μm possess specific surface area of 5–6 m^2/g [6].

Electrically conducting composite ceramic materials based on Al–AlN–TiB_2, BN–TiN–AlN–TiB_2, and MAX phases Cr_2AlC and Ti_2AlN prepared by SHS were investigated. [7].

The gravity-assisted combustion synthesis of γ-TiAl from TiO_2 as a raw material in the presence of mixed Al–Ca reductant was explored. The use of Al–Ca reductant was found to markedly increase the yield of TiAl and decrease the amount of residual contaminants (such as oxygen, nitrogen, carbon) in target product [8].

Mn, Co, and Ni/ZSM-5 catalysts were first produced by low-temperature combustion synthesis. The physicochemical and catalytic properties of the catalysts were studied during deep oxidation and hydrogenation of CO_2 [9].

SHS technology was developed for nitriding a vanadium–aluminum alloy containing 15–20 mass % nitrogen. Successful tests of nitrided vanadium–aluminum alloy as a nitriding component for the production of vanadium–aluminum–nitrogen master alloy were carried out. The method of obtaining the master alloy has already been implemented at Uralredmet Ltd. [10].

These results offer important opportunities for further basic research in the field of SHS, materials science, and novel industrial developments.

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