RESEARCH AND SYNTESIS OF ALUMINUM NITRIDE BY BURNING OF ALUMINUM NANOPOWDER WITH ADDITIVES OF GALLIUM OXIDE

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Even in the end of the XX century people actively studied the physics and chemistry of burning metal nanopowders for further usage of the results in modern technologies. Today more and more problems appears in the area of production due to technological progress. Necessity to application refractories arises from the fact of use of modern high-temperature furnaces to create products from infusible materials. However, most modern methods of creating thermostable compounds are laborious and not economically feasible. Since then, engineers and scientists have conducted a lot of research to create new materials. A special feature of nanopowders burning in the air is the formation of nitrides [2]. Aluminum nitride is a unique material, which has a low electrical conductivity and high thermal conductivity. This is material used to create ceramic refractory materials, and materials, used in electronics [3]. Among the large number of experiments on combustion of aluminum nanopowder the additives effect on the combustion process have been studies. At present, using chemical high-temperature bonding of nitrogen, powder with aluminum nitride content of 40–80 % obtained. Gallium nitride is also widely used, promising material. It is heavy, mechanically stable material. Gallium nitride used to create light-emitting diodes, semiconductor lasers, and diode in electronics. In addition, it used to build massive solar panels on satellites because it has a low sensitivity to ionizing radiation. Synthesis of burning is energy-intensive and cost-effective because no special conditions is required. During the burning of aluminum nanopowder the temperature inside the sample achieved about 2000 °C.

The aim of the work was to determine the yield of aluminum nitride, and the final phase composition of products of aluminum nanopowder combustion in air with the addition of gallium oxide.

We used aluminum nanopowder produced by electrical explosion wire in argon atmosphere [4]. Gallium oxide powder obtained by thermal decomposition of gallium (III) nitrate chemically pure (white crystalline powder) in a muffle furnace at 800 °C. Mixtures of aluminum and gallium oxide nanopowder was prepared by mechanical mixing in a dry form, observing the rules of the pyrotechnic mixing. Three mixtures were prepared with different ratios of moles Al / Ga_2O_3 : in the first sample as 1:1, in the second sample as 3:2, in the third sample as 4:2. Each sample strewed in the form of a cone on the metal plate. After cauterization samples anomalous bright glow observed. None of the samples observed with first combustion stage (smoldering). There was a small amount of liquid phase in each sample, which can be explained by the fact that gallium is recovered and melted. After burning, the products were grind in a mortar and were investigated by X-ray diffraction (XRD) (Scientific Analytical Center of TPU)). Estimation of the content of aluminum nitride phase (of AlN) showed (according to XRD), that in the first sample AlN phase characterized by the maximum reflections on radiographs, the first and second samples have maximum gallium nitride reflexes. It was also found that in addition to aluminum nitride phase combustion products are aluminum oxide, recovered gallium, gallium nitride (samples 1, 2). Analysis of the reflection intensity ratio of aluminum nitride and oxide ($\alpha - Al_2O_3$) showed that in the first sample the aluminum nitrate refers to aluminum oxide as 1.1:1.

After the experiment, we can conclude, that the most optimal for obtaining aluminum nitride is a mixture of aluminum oxide nanopowder with gallium oxide, which is equal to 1:1 (mol.). Content of aluminum nitride in the final product is equal 24 %. Content of gallium nitride in the final product is equal 24 %. 22 % and 30 % for Al_2o_3 and Ga respectively. The addition of gallium oxide had a catalytic effect, it observed by bright quick combustion without the first step (smoldering), as in the case by combustion of pure aluminum nanopowder. Nitrogen is less electronegative than oxygen in the air. Therefore, to obtain nitrides due to the fall in oxygen activity. The fall of the activity can be related to transition triplet oxygen to chemically inactive singlet state because of increased emission of heat and light from the samples. Recycled gallium prevent the formation of intermetallic compounds, which appeared in experiments with other additives [5], thereby increasing the yield of aluminum nitride. Gallium Recovering can be avoided by carrying out the

reaction in a nitrogen atmosphere. This procedure is relevant and applicable in the preparation of metal nitrides.

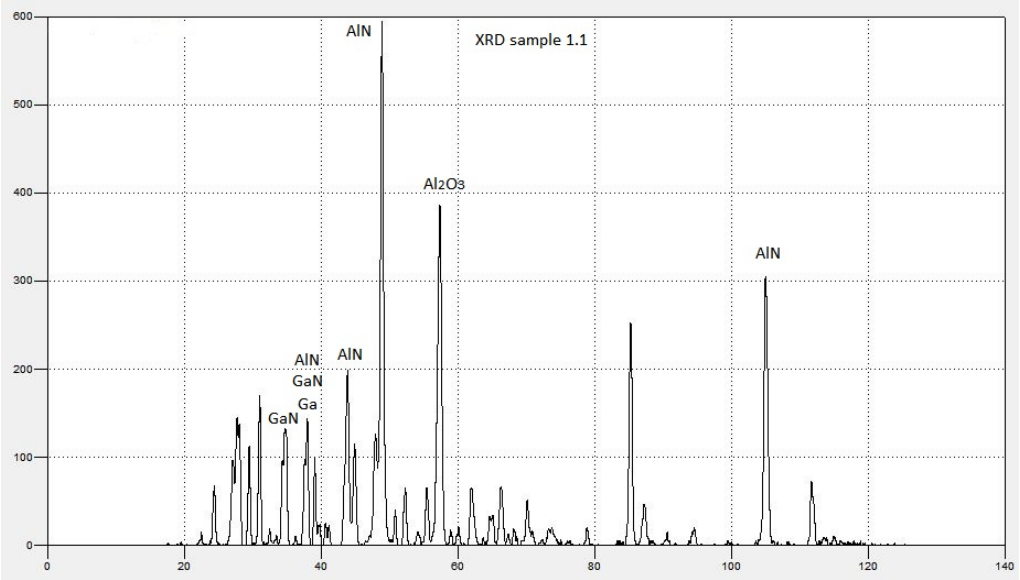

Figure 1. X-ray of the combustion products of mixture of aluminum nanopowder and gallium oxide in a ratio of 1:1(mol.)

References

1. Koizumi M. Burning synthesis chemistry. Translation from Japanese. – M: Mir, 1998. – p. 247.
2. Ilin A.P., Gromov A.A. Combustion of aluminum and boron in the hyperfine state. – M: publishing outfit of Tomsk Polytechnic University, 2002. – p. 154.
3. Ivanov S.N., Popov P.A., Egorov G.V. Thermal properties of the ceramic aluminum nitride //physics of solids, v. 39, № 1. p. 93–96, (1997).
4. Ilin A.P., Nazarenko O.B., Tikhonov D.V. Peculiarities of obtaining nanopowders in conditions of electrical explosion of conductors.-M: publishing outfit of Tomsk Polytechnic University, 2013. – p. 223.
5. Soboleva D.R., Kornilov S.V., Root L.O. Abstracts of the International Conference «VII Staver reading», Krasnoyarsk, Russia, 2015. – p. 76.