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# Structure and Properties of Intermetallic NiAl-Based Coatings Produced by Magnetron Sputtering Technique

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**Abstract :** Aluminum and nickel-based intermetallic compounds have attracted the attention of scientific community as promising materials for heat-resistant and wear-resistant coatings in such manufacturing areas as microelectronics, aircraft and rocket building and chemical industries. Magnetron sputtering makes possible to coat materials without formation of liquid phase and improves the mechanical and functional properties of nickel aluminides due to the possibility of nanoscale structure formation. The purpose of the study is the investigation of structure and properties of intermetallic coatings produced by magnetron sputtering technique. The feature of this work is the using of composite targets for sputtering, which were consisted of two semicircular sectors of cp-Ni and cp-Al. Plates of alumina, silicon, titanium and steel alloys were used as substrates. To estimate sputtering conditions on structure of intermetallic coatings, a series of samples were produced and studied in detail using scanning and transition electron microcopy and X-Ray diffraction. Besides, nanohardness and scratching tests were carried out. The varying parameters were the distance from the substrate to the target, the duration and the power of the sputtering. The thickness of the obtained intermetallic coatings varied from 0.05 to 0.5 mm depending on the sputtering conditions. The X-ray diffraction data indicated that the formation of intermetallic compounds occurred after sputtering without additional heat treatment. Sputtering at a distance not closer than 120 mm led to the formation of NiAl phase. Increase in the power of magnetron from 300 to 900 W promoted the increase of heterogeneity of the phase composition and the appearance of intermetallic phases NiAl, $Ni_2Al_3$, $NiAl_3$, and Al under the aluminum side, and NiAl, $Ni_3Al$, and Ni under the nickel side of the target. A similar trend is observed with increasing the distance of sputtering from 100 to 60 mm. The change in the phase composition correlates with the changing of the atomic composition of the coatings. Scanning electron microscopy revealed that the coatings have a nanoscale grain structure. In this case, the substrate material and the distance from the substrate to the magnetron have a significant effect on the structure formation process. The size of nanograins differs from 10 to 83 nm and depends not only on the sputtering modes but also on material of a substrate. Nanostructure of the material influences the level of mechanical properties. The highest level of nanohardness of the coatings deposited during 30 minutes on metallic substrates at a distance of 100 mm reached 12 GPa. It was shown that nanohardness depends on the grain size of the intermetallic compound. Scratching tests of the coatings showed a high level of adhesion of the coating to substrate without any delamination and cracking. The results of the study showed that magnetron sputtering of composite targets consisting of nickel and aluminum semicircles makes it possible to form intermetallic coatings with good mechanical properties directly in the process of sputtering without additional heat treatment.

**Keywords :** intermetallic coatings, magnetron sputtering, mechanical properties, structure
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