World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:13, No:06, 2019

Adhesion Enhancement of Boron Carbide Coatings on Aluminum Substrates Utilizing an Intermediate Adhesive Layer

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Abstract : Boron carbide is a ceramic material with superior properties such as high chemical and thermal stability, high hardness and high wear resistance. Moreover, it has a big cross section for neutron absorption and therefore can be employed in nuclear based applications. However, an efficient attachment of boron carbide to a metal such as aluminum can be very challenging, mainly because of the formation of aluminum-carbon bonds that are unstable in humid environment, the affinity of oxygen to the metal and the different thermal expansion coefficients of the two materials that may cause internal stresses and a subsequent failure of the bond. Here, we aimed to achieving a strong and a durable attachment between the boron carbide coating and the aluminum substrate. For this purpose, we applied Ti as a thin intermediate layer that provides a gradual change in the thermal expansion coefficients of the configured layers. This layer is continuous and therefore prevents the formation of aluminum-carbon bonds. Boron carbide coatings with a thickness of 1-5 µm were deposited on the aluminum substrate by pulse-DC magnetron sputtering. Prior to the deposition of the boron carbide layer, the surface was pretreated by energetic ion plasma followed by deposition of the Ti intermediate adhesive layer in a continuous process. The properties of the Ti intermediate layer were adjusted by the bias applied to the substrate. The boron carbide/aluminum bond was evaluated by various methods and complementary techniques, such as SEM/EDS, XRD, XPS, FTIR spectroscopy and Glow Discharge Spectroscopy (GDS), in order to explore the structure, composition and the properties of the layers and to study the adherence mechanism of the boron carbide/aluminum contact. Based on the interfacial bond characteristics, we propose a desirable solution for improved adhesion of boron carbide to aluminum using a highly efficient intermediate adhesive layer.

Keywords : adhesion, boron carbide coatings, ceramic/metal bond, intermediate layer, pulsed-DC magnetron sputtering
Conference Title : ICTFTA 2019 : International Conference on Thin Film Technology and Applications
Conference Location : Copenhagen, Denmark
Conference Dates : June 11-12, 2019