World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:17, No:09, 2023

Microstructure and Mechanical Properties of Nb: Si: (a-C) Thin Films Prepared Using Balanced Magnetron Sputtering System

Authors : Sara Khamseh, Elahe Sharifi

Abstract : 321 alloy steel is austenitic stainless steel with high oxidation resistance and is commonly used to fabricate heat exchangers and steam generators. However, the low hardness and weak tribological performance can cause dangerous failures during industrial operations. The well-designed protective coatings on 321 alloy steel surfaces with high hardness and good tribological performance can guarantee their safe applications. The surface protection of metal substrates using protective coatings showed high efficiency in prevailing these problems. Carbon-based multicomponent coatings, such as metal-added amorphous carbon coatings, are crucially necessary because of their remarkable mechanical and tribological performances. In the current study, (Nb: Si: a-C) multicomponent coatings (a-C: amorphous carbon) were coated on 321 alloys using a balanced magnetron (BM) sputtering system at room temperature. The effects of the Si/Nb ratio on microstructure, mechanical and tribological characteristics of (Nb: Si: a-C) composite coatings were investigated. The XRD and Raman analysis results showed that the coatings formed a composite structure of cubic diamond (C-D), NbC, and graphite-like carbon (GLC). The NbC phase's abundance decreased when the C-D phase's affluence increased with an increasing Si/Nb ratio. The coatings' indentation hardness and plasticity index (H^3/E^2 ratio) increased with an increasing Si/Nb ratio. The better mechanical properties of the coatings with higher Si content can be attributed to the higher cubic diamond (C-D) content. The cubic diamond (C-D) is a challenging phase and can positively affect the mechanical performance of the coatings. It is well documented that in hard protective coatings, Si encourages amorphization. In addition, THE studies showed that Nb and Mo can act as a catalyst for nucleation and growth of hard cubic (C-D) and hexagonal (H-D) diamond phases in a-C coatings. In the current study, it seems that fully arranged nanocomposite coatings contain hard C-D and NbC phases that embedded in the amorphous carbon (GLC) phase is formed. This unique structure decreased grain boundary density and defects and resulted in high hardness and H^3/E^2 ratio. Moreover, the COF and wear rate of the coatings decreased with increasing Si/Nb ratio. This can be attributed to the good mechanical properties of the coatings and the formation of graphite-like carbon (GLC) structure with lamellae arrangement in the coatings. The complex and self-lubricant coatings are successfully formed on the surface of 321 alloys. The results of the present study clarified that Si addition to (Nb: a-C) coatings improve the mechanical and tribological performance of the coatings on 321 alloy.

Keywords : COF, mechanical properties, microstructure, (Nb: Si: a-C) coatings, Wear rate
Conference Title : ICMMSE 2023 : International Conference on Metallurgy, Materials Science and Engineering
Conference Location : Zurich, Switzerland
Conference Dates : September 11-12, 2023