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Mechanical and Tribological Performances of (Nb: H-D: a-C) Thin Films for Biomedical Applications

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Abstract : Plenty of metallic materials are used for biomedical applications like hip joints and screws. Besides, it is reported that metal platforms such as stainless steel show significant deterioration because of wear and friction. The surface of metal substrates has been coated with a variety of multicomponent coatings to prevail these problems. The carbon-based multicomponent coatings such as metal-added amorphous carbon and diamond coatings are crucially important because of their remarkable tribological performance and chemical stability. In the current study, H-D contained Nb: (a-C) multicomponent coatings (H-D: hexagonal diamond, a-C: amorphous carbon) coated on A 304 steel substrates using an unbalanced magnetron (UBM) sputtering system. The effects of Nb and H-D content and ID/IG ratio on microstructure, mechanical and tribological characteristics of (Nb: H-D: a-C) composite coatings were investigated. The results of Raman spectroscopy represented that a-C phase with a Graphite-like structure (GLC with high value of sp2 carbon bonding) is formed, and its domain size increased with increasing Nb content of the coatings. Moreover, the Nb played a catalyst for the formation of the H-D phase. The nanoindentation hardness value of the coatings ranged between ~17 to ~35 GPa and (Nb: H-D: a-C) composite coatings with more H-D content represented higher hardness and plasticity index. It seems that the existence of extra-hard H-D particles straightly increased hardness. The tribological performance of the coatings was evaluated using the pin-on-disc method under the wet environment of SBF (Simulated Body Fluid). The COF value of the (Nb: H-D: a-C) coatings decreased with an increasing ID/IG ratio. The lower coefficient of friction is a result of the lamelliform array of graphitic domains. Also, the wear rate of the coatings decreased with increasing H-D content of the coatings. Based on the literature, a-C coatings with high hardness and H3/E2 ratio represent lower wear rates and better tribological performance. According to the nanoindentation analysis, hardness and H3/E2 ratio of (Nb: H-D: a-C) multicomponent coatings increased with increasing H-D content, which in turn decreased the wear rate of the coatings. The mechanical and tribological potency of (Nb: H-D: a-C) composite coatings on A 304 steel substrates paved the way for the development of innovative advanced coatings to ameliorate the performance of A 304 steel for biomedical applications.

Keywords : COF, mechanical properties, (Nb: H-D: a-C) coatings, wear rate
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