

Coaxial Arc Plasma Deposition of Ultrananocrystalline Diamond/ Amorphous Carbon Composite Film at Different Substrate Parameters for Hard Coating Applications

アリ, モハメッド, アリ, エブラヒモ, アブデルガワッド

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By

Ali Abdelgawad

KYUSHU

UNIVERSITY

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ABSTRACT

Coaxial arc plasma deposition (CAPD) has been recently employed as a promising physical vapor deposition technique to fabricate artificially structured nanomaterials specially ultrananocrystalline diamond for hard coating applications. CAPD offers many pros over chemical vapor deposition growth techniques, which has essentially employed for nanodiamond films deposition. Like lower deposition temperature, higher growth rate, and enhanced control of morphology and thickness, as well as its applicability to versatile substrates without surface pretreatments or seeding process, are the main advantages of CAPD to mention.

To improve the deposition ability of the CAPD system and enhance the mechanical and structural properties of the deposited films a development of coating systems was driven by controlling the substrate parameters during the deposition. Substrate temperature and the energy of deposited species are two major factors in CAPD, which controlling the adhesion strength and film properties. Whereas the substrate temperature controlled the mobility of substrate surface atoms and caused a high diffusion rate at the interface. Also, the energy of the deposited species, which controlled by negative substrate bias, is necessary to compensate for the deeper penetration of the arriving species as their energies increase. Investigate the influence of these parameters on the deposition process, structural, and mechanical properties of the deposited ultrananocrystalline diamond/ amorphous carbon (UNCD/a-C) composite films, are the aim of this study.

The influences of bipolar and unipolar substrate pulsed bias voltage on the deposition processes and properties of the obtained films have investigated. The negative bias can attract more positive ions to bombard the substrate surface, leaving behind a much denser structure. At appropriated selective bias frequency, the accelerated positive carbon ions have shown prudent plasma energy favorable for nanocrystalline diamond growth. Hard films of 62 GPa were performed at a bias frequency of 10 kHz. In addition, regarding the optimization of substrate temperature, the adhesion strength of UNCD/a-C films on a silicon substrate has comprehensively enhanced by adopting an adhesion intermediate layer to reduce the internal stress and increase the adhesion. Finally, the structural properties of the deposited films have newly obtained by Tip-enhanced Raman spectroscopy. Where tip-enhanced Raman spectroscopy clearly detects diamond peaks specific to UNCD/a-C film for the first time. This study demonstrates the considerable potential of substrate parameters like negative bias and temperature as promising deposition parameters that leads to a super mechanical property of nano-carbon based materials for a wide range of applications.