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Abdul Wasy Zia, Zhifeng Zhou, Po Wan Shum, Lawrence Kwok Yan Li

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The effect of two-step heat treatment on hardness, fracture toughness, and wear of different biased diamond-like carbon coatings

Abdul Wasy ZIA*, Zhifeng ZHOU, Po Wan SHUM, Lawrence Kwok Yan LI

Advanced Coatings Applied Research Laboratory (ACARL), Department of Mechanical and Biomedical Engineering, City University of Hong Kong, Hong Kong

* E-mail: awzia3-c@my.cityu.edu.hk; Tel: (852) 3442-2033

Abstract

A conventional furnace heat treatment critically reduces hardness and fracture toughness after a certain temperature. This study reports the effects of two-step heat treatment on hardness, fracture toughness, and wear of bias varied diamond-like carbon (DLC) coatings deposited without buffer layer on silicon substrates using unbalanced magnetron sputtering system. Pristine specimens were directly heated (1-step) at 300^{o}C in a tube furnace for 30min and took out after 20hr furnace cooling. For 2-step 300^{o}C, pristine specimens were heated at 150^{o}C for 30min and furnace cooled for 20hr and then re-heated at 300^{o}C followed by the same procedure. The residual stresses in pristine DLC specimens were calculated with Stoney equation. Raman spectroscopy was performed to understand atomic disorder and clustering under bias and heat treatment effects. The reciprocating wear test was performed to understand the effect of bias voltage and heat treatment on wear volume of DLC coatings. Indentation studies were performed to analyze hardness, cracking behavior, and fracture toughness of bias varied pristine to re-heated specimens. 1-step 300^{o}C heat treatment decreases hardness and fracture toughness up to 20% in general, whereas, the 2-step 300^{o}C heat treatment process generally retained pristine values along with the prominent increase of 43% hardness and 9% fracture toughness for specimens which are deposited at a bias of -60V and -140V respectively.

Keywords: Sputtering; Heat Treatment; Indentation; Fracture Toughness; Hardness, Wear

1. Introduction

Fracture toughness is an important mechanical property and it plays an important role in product life. In general, materials with high hardness have low fracture toughness due to poor crack arrest capability. The high hardness of diamond-like carbon (DLC) coatings is desirous and several strategies are adopted to achieve this purpose including heat treatment. Heat treatment refines grain boundaries [1], reduces defects and flaws by thermal migration of atoms which increases hardness.

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