Graphite-like carbon films by high power impulse and direct-current magnetron sputtering

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Abstract

Both direct-current magnetron sputtering (dcMS) and high-power impulse magnetron sputtering (HiPMS) were employed to fabricate graphite-like amorphous carbon (GLC) films. The structure and mechanical properties of the GLC films deposited by the HiPMS were investigated in contrast to the dcMS. The microstructure of the films was measured by X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy. The atomic force microscopy (AFM) and the nano-indenter were used to characterize the surface quality and micro-hardness, respectively. Internal stress of the films was calculated using the curvature measured by a laser tester. Tribological behaviors of the GLC films are contrastively studied by a ball-on-disc tribo-meter in ambient condition. The results show that the deposition rate and the internal stress, increasing with impulse voltage, are enhanced by HiMPS with respect to dc-MS. All the as-deposited films are considered as graphite-like carbon due to the dominating sp2 bonds. Compared with dcMS, HiPIMS produces a relatively high fraction of sp2 bonds. The fraction of sp2 bonds decreases as the impulse voltage increases from 750 V to 900 V, and it then increases if the voltage further increases to 1000 V. The percentage of sp3 bonds has a reverse variation, that is, a maximum fraction of sp3 bonds is found at 900 V. In spite of the monotonous increment of internal stress, the maximum hardness is obtained at 900 V. It indicates that hardness of the GLC films is dominated by the sp3 bonds within the films. AFM illustrates that the GLC films deposited by HiPMS have lower roughness than dcMS. Surface roughness of the films by HiPMS decreases with increasing impulse voltage. Although the HiPMS films deposited at 900 V have the maximum hardness and a small roughness, their friction coefficient is higher than those at 750 V and 1000 V. It is thought that the fraction of sp2 is responsible for the tribological properties of the GLC films. The results are analyzed and discussed.

Keywords: Graphite, like carbon film, High power impulse magnetron sputtering, Microstructure, Hardness, Friction coefficient

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