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Characterization of the mixed-mode carbon HiPIMS process

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'Mixed-mode' deposition uses a HiPIMS (High Power Impulse Magnetron Sputtering) discharge to repeatedly trigger the ignition of a short-lived cathodic arc on the surface of a conventional circular magnetron target. This process can be used to generate a highly ionized carbon plasma, suitable for the deposition of sp^3-bonded carbon films. The first studies of carbon mixed-mode operation identified nanometre-scale particles in the deposited films, and we are also investigating the mixed-mode process with the aim of optimizing the formation of these particles as precursors for the synthesis of nanodiamond.
We have studied the mixed-mode regime by analysis of the discharge current and voltage, still photography, time-resolved spectroscopy, and AFM, SEM and cross-sectional TEM of deposited films. Mixed-mode operation significantly increases the ionized fraction of the carbon flux at the substrate compared to HIPIMS deposition without arcs. The short-lived arcs present in mixed-mode operation behave in the manner of cathodic arc discharges, moving rapidly around the target due to the retrograde E×B steering effect of the magnetron's magnetic field. The velocity of the arc spots was found to increase with operation at lower Ar pressure.
The condition of the target surface is critical in determining the characteristics of the arc discharge. For much of the target lifetime, the mixed-mode process erodes the target surface in a manner similar to sputtering target erosion. Slight changes in the target condition caused by varying the maximum arc current affect the likelihood of arc ignition. Eventually, a different erosion mode commences where nodules appear in the target racetrack, causing dramatic changes in the behaviour of the arc discharge.

Keywords
HiPIMS
Carbon
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