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Effect of HiPIMS impulse shape on DLC films deposition: process and mechanical properties

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The deposition of hard diamond like carbon (DLC) films, such as tetragonal amorphous films (ta-C), relies on the subplantation of C ions into the subsurface region of the growing film and subsequent formation sp^3 sites. In HiPIMS the sputtered species are ionized in their path towards the substrate. Thus, ionized C species can be used to bombard the growing film allowing for a more efficient formation of sp^3 than in dcMS, as bombardment with energetic ions from the background gas (Ar) causes additional compressive stresses without significantly contributing to sp^3 site formation. However, the ionization fraction of C in HiPIMS is rather low compared to metallic species. The ionization fraction can be improved by adding Ne to the discharge gas as previously shown by the authors. In this work, the effect of the shape of the HiPIMS pulses is investigated in order to increase the ionization fraction of the C sputtered species. DLC films were deposited using long pulses (up to 140 µs), with a HiPIMS Hipster power supply, and packets of oscillating pulses with less than ≈20 µs, using a Cyprium power supply in deep oscillation magnetron sputtering (DOMS) mode.
The effect of substrate biasing has been studies for both power supplies. Time resolved substrate current density measurements, carried out in pure Ar plasma using a specifically designed flat probe, clearly show an increase of ionic current for DOMS. Denser DLC films are deposited with increasing bias, resulting in an increased hardness, although with a decreasing deposition rate. However, for the same bias, harder and denser films are obtained when using packets of short oscillating pulses. The harder films are obtained with a bias of -100 V for short pulses while similar films are only deposited at a bias of - 160 V when using long pulses. However, in the latter case, lower maximum compressive stresses are obtained (- 1.5 GPa against - 2.5 GPa)

Keywords
HiPIMS
DOMS
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Current density Probe