Nanomechanical characteristics of pulsed-laser deposited DLC films with metallic (Ag, Mo) nanoinclusions

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Abstract: We here report on the systematic synthesis and characterization of diamond like carbon (DLC) films with metallic (Me) nanoinclusions and explore their potential for mechanical (protective coatings or solid lubricants) or other functional (solar harvesting films) applications. The objective of this experimental study is to investigate and analyze DLC:Me nanocomposite films with silver (Ag) or molybdenum (Mo) as reinforcing material, such as to develop structure-property relations for material optimization purposes. DLC:Ag film is optically efficient, mechanically tough, has low residual stress and its design methodology differs from the one adopted for single phase amorphous carbon film, as it has to take into consideration the metallic inclusions' influence for tailoring purposes. Similar attention is placed on the mechanism at which molybdenum influences the chemical, physical and mechanical properties of DLC films. A single deposition method, Pulsed Excimer Laser Deposition (PELD) of sector targets, is used for the growth of DLC:Me amorphous carbon films with varying compositions of Ag or Mo. A range of characterization techniques is used for the in-depth study of materials in terms of their density, thickness, surface roughness, atomic bonding, crystallinity and phase compositions. Particular emphasis is placed on the nanomechanical and nanotribological characteristics of the nanocomposite films using an instrumented indentation platform and testing protocols based on the classical nanoindentation or nanoscratch modes. Scanning electron microscopy is used for visualizing residual plastic, fracture or delamination phenomena while atomic force microscopy is applied for morphological measurements. The increase of both metal amounts within the host amorphous carbon matrix is found to be beneficial as it increases the ductility of the material system and reduces film deterioration and film fracturing during scratching.