ABSTRACT
Synergetic Effect of DLC/TM (TM = Ag, Cr, Ti & Ni) Films on Mechanical and Tribological Properties through Various Film Architectures
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A large variety of structural and functional properties can be optimized separately for the bulk material and the surface by applying an appropriate coating. Therefore, coated parts usually show a superior performance compared to uncoated work pieces. Protective coatings such as titanium nitride (TiN), chromium nitride (CrN), titanium carbide (TiC), tungsten carbide (WC), molybdenum sulphide (MoS2), Aluminum oxide (Al2O3), etc. are commercially used for cutting tools, for machining and for engine components. But a protective hard coating does not only mean mechanically hard, but it also has to be tribologically, thermally hard and chemically inert. Therefore, in this respect diamond-like carbon (DLC) films have an edge over all the other materials. This thesis encompasses with the principal objective to deposit DLC films over AISI SS304 substrates with a) reduced internal stress b) improved adhesion c) low coefficient of friction and d) better hardness by using different film architecture. The earlier work done on DLC film addresses these problems using hybrid techniques and complicated film architectures such as gradient multilayers with multiple dopants and complicated procedures in order to obtain better mechanical and tribological properties of DLC film. These proposed methods were economically costly, tedious and time consuming. Therefore, the present work has employed simple film architectures by using transition metals (TM) as dopant and as interlayer in order to enhance the mechanical and
tribological property of the film and also the adhesion strength by reducing the internal stress. The first specific aim of the work involves deposition of DLC film with high $sp^3$ content using PLD. The $sp^3$ content in the film controls the mechanical and tribological behavior of the DLC film which in turn is controlled by the deposition parameters. The PLD parameters were optimized and DLC film with 68 % of $sp^3$ fraction was obtained for a laser power density of 9 GW/cm$^2$. The second specific aim was to deposit nanocomposite DLC/TM (TM = Ag, Cr, Ti & Ni) films by using PLD and to study their mechanical and tribological properties. The metal concentration was varied from 5 to 20 at %. The hardness of the DLC film decreased with the addition of the metal dopant. Formation of TiC and CrC nanoclusters in the DLC film were confirmed by XPS, XRD and TEM studies which improved the adhesion of the nanocomposite films. Stable and low friction coefficient was obtained for DLC/TM nanocomposite film with low (5-15 at %) metal concentration. The third specific aim involved the deposition of DLC/TM bilayer architecture. DLC/Ti film showed high hardness of 15 GPa and the formation of tribo film resulted in low friction of 0.2 for DLC/Cr bilayer film. The fourth aim was the deposition of DLC/TM multilayer films which resulted in the enhancement of hardness and adhesion strength. High adhesion strength of 150 N was achieved for DLC/Ni multilayer film. Very low friction coefficient of 0.06-0.08 was achieved for the multilayer architecture. It was concluded that the DLC/TM multilayer film architecture exhibited better mechanical and tribological properties along with good adhesion. Thus, the objective of the work was met by forming a simple architecture of the DLC film using nanosecond PLD which resulted in high hardness, low friction coefficient and high adhesion strength.