Hard thin film coatings deposited by Cathodic Arc Physical Vapor Deposition technique

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ABSTRACT – Physical vapor deposition technique is used to deposit hard and wear resistant thin film of coating material into the substrate surface without changing the substrate properties; commonly referred as thin films. Hard thin film coatings are employed to enhance the surface characteristics of the substrates such as hardness, surface roughness, wear resistance and corrosion resistance without changing the bulk properties of the substrates. Demands for transition metal nitrides such as TiCN, TiCrN, TiAlN, CrAlN synthesized by physical vapor deposition (PVD) as hard film coatings are increasing rapidly due to their superior mechanical, tribological, and corrosion characteristics, thus increasing the components life and productivity of the production. These metal nitride coatings are used to improve friction, wear and life of cutting tools, mould and dies, machine elements, automotive components. Type of coating applied on the substrate depends on the applications of that component.

Physical vapor deposition uses physical forces to deposit a pure source material which is gasified via evaporation. Physical vapor deposition is performed at relatively low temperature (300° to 600°C) as compared to chemical vapor deposition operating at a temperature of 1000°C. The stoichoimetric composition of the film arises from reactive gas absorption by growing films, reactive collision between gas molecules and vapour species emitted from the evaporation source, and surface reaction between gas molecules and condensed films.

Quality of thin film coating produced on the substrate depends on; (i) surface preparation such as degreasing and polishing, surface pre-cleaning such as ultra-sonic and plasma sputtered etching, (ii), deposition parameters such as substrate temperature, chamber pressure, current, reactive and working gas flow rate, negative bias voltage, and (iii) target shape, geometry of the chamber, and the position of the substrate relative to the target. Though the physical vapor deposition has been used widely and many researches have been conducted, there are some opportunities in developing high quality in hard thin film coating. These include (i) optimizing the coating process parameters using Taguchi or Design expert method, (ii) determining significant effect of coating process parameter on the mechanical and tribological properties, (iii) determining residual stress in thin film coating, (iv) establishing failure mechanism on different type of coating materials, (v) developing life predicting model.

In this keynote lecture, results of some works in depositing hard thin film of TiN, TiZrN, TiCN, TiAlN on high speed steel and tungsten carbide substrates will be presented and discussed. The tool life and wear mechanism of coated-drill during drilling and coated-cutting tool insert during turning will also be presented and discussed. The characterization tools employed in this study include (i) x-ray photo electron spectroscope, (ii) x-ray diffraction, (iii) pin-on-disc tribometer, (iv) glow discharge optical emission spectroscope, (v) field emission scanning electron microscope, (vi) scratch tester, and (vii) microhardness tester.

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