Chapter 3
Nano Indentation Response of Various Thin Films Used for Tribological Applications

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ABSTRACT
Various thin films used for tribological applications are classified under four heads. Based on their load vs. displacement curves, which have some characteristics features, the ratio of nanohardness to elastic modulus and the ratio of cube of nanohardness to square of elastic modulus are evaluated in this chapter. It is demonstrated that depending on the type of film used, these ratios vary within a certain range. For soft self-lubricating films, these ratios are very low; whereas for hard self-lubricating film, these ratios are quite high.

INTRODUCTION
Tribology deals with the study of friction, wear and lubrication of interacting surfaces in relative motion. The word tribology is derived from the Greek word “Tribos” which means rubbing. Until lately, this study was considered as a branch of mechanical engineering, and due to its ever increasing presence in almost every branch of science, it has now turned into an interdisciplinary field. Rapid growth of science and technology has created increased demand for materials with improved performances operated in demanding environment. This has resulted in development of several varieties of materials and more importantly modification of surfaces with different surface and bulk properties.

Surface engineering is one of the most effective ways of enhancing the performance of industrial components to make them suitable for functions that are different from the primary function of the bulk substrate. Although surface engineering has been practiced from the dawn of civilisation, the science and technology of surface modification has been explored only in recent past. Major progress in this direction has been achieved only when a significant gain in performance along with financial benefit is realised by practicing surface modification techniques. Even though surface modification is practiced for several reasons
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for protection against degradation such as wear, corrosion, fatigue etc. surface engineering for enhanced wear performances is most widely used tools for performance enhancement. Deposition of thin film for monitoring the tribology related surface response has received increased attention in recent days.

Various tribological thin films can be broadly classified under four different heads. The first variety films are hard film with high friction coefficient. These films are used where the wear should be low and high friction coefficient is required. Second variety consists of films with very high nanohardness and low friction coefficient with excellent inertness. These films are used for tribological application under circumstances where corrosion or oxidation resistances plays crucial role. When these films are used as protective coating, wear of mating surface is an important problem. Third varieties films known as self-lubricating film have low nanohardness along with low friction coefficient. Although wear rate of these films are not important from application point of view, the friction coefficients of these films are very low. Finally forth variety is films with reasonable nanohardness but low friction coefficient. These films are used as self-lubricating film where wear is also a concern.

The objective of the present chapter is to critically examine the nano indentation response of selected films pertaining to each variety of films mentioned above. In order to achieve the aforementioned objective, one example of each variety of films is taken. The load vs. displacement curves of each film is analysed. Their nanohardness, elastic modulus, ratio of nanohardness to elastic modulus and elasticity are evaluated. The characteristics features of these properties of each variety of films are ascertained.

VARIABLES FILMS

Four different films pertaining to four varieties referred in earlier section are selected for present chapter. Nitrides of hard coatings are used for wear reduction on cutting and die tools for long time. More recently ZrN has received increased attention due to its better corrosion resistance improved mechanical properties and warm golden colour (Chou, YU, & Huang, 2003; Kolesoguru, Miterrer, & Urgen, 2002). ZrN is considered to be an example of first variety of film. Although the nanohardness of the investigated film is not as high as reported for other ZrN film, this is a film with high nanohardness and high friction coefficient. Nanocrystalline diamond film is second variety film having high nanohardness and low friction coefficient. Nano crystalline and ultra nano crystalline diamond (NCD/UNCD) films can be produced using a modified hot-filament technique (Braza & Sundarshan, 1992). These films can be deposited on a broad spectrum of substrate materials such as tungsten carbides, titanium and titanium alloys, refractory metals, ceramics, glass, silicon, quartz, sapphire, graphite and steel using a passive interlayer. Depending on deposition parameters, i.e. gas mixture, temperature, pressure and substrate seeding, CVD growth of diamond results in different types of films. These are generally classified according to the crystal grain size as micro crystalline (grain size 5 μm), nano crystalline (NCD) (grain size about 50 nm) and ultra nano crystalline (UNCD) (grain size < 5 nm). Crystallites with sizes down to 3 nm display special advantages. Due to the small dimensions of nano crystallites, the relation of volume-to-surface increases dramatically, leading to an exceptionally high amount of surface atoms and this results in distinct physical and chemical properties (Braza & Sundarshan, 1992; Tasi & Bogy, 1987).