Tribological Properties of Titanium Nitride-Based Coatings with Respect to Environment

Youn-Hoo Hwang, Kuk-Jin Seo, You Jin Min, Yuzhen Liu, Tae-Hyeong Kim and Dae-Eun Kim*

Tribology Research Laboratory, Department of Mechanical Engineering, Yonsei University, Republic of Korea
*Corresponding author: kimde@yonsei.ac.kr

In this study the tribological properties of TiN-based coatings were investigated with respect to environment. Sliding tests were performed using a pin-on-reciprocating type of a tribometer in both ambient air and vacuum environments. Friction force was monitored during the sliding test and wear characteristics of the coatings were also assessed using surface characterization tools. Significant differences in the tribological properties of the TiN-based coatings between the ambient air and vacuum environments were observed. It is expected that the results of this work will aid in the use of TiN-based coatings for friction and wear minimization in vacuum equipment applications.

Keywords: vacuum, titanium nitride, coating, friction, wear

1. Introduction

Over the past decade demand for specialized precision mechanical components has been steadily increasing. Particularly, there has been an increasing need for advanced processing equipment that must be operated in vacuum environment to manufacture ultra-precision devices and systems. It has been generally known that adhesion between contacting parts increases in a vacuum environment due to the absence of contamination on the surface, such as gas molecules or impurities [1]. The increase in adhesion can cause fatal damage to the machine and shorten the life of the mechanical component [2]. Since lubricating oil cannot be utilized in a vacuum environment, functional coatings need to be used to overcome the tribological problems in vacuum. In this regard, selection of a proper coating material for tribological applications in vacuum is an important issue. In this work, TiN-based coatings, that have been widely used in various industries such as aerospace and cutting tool, were investigated with respect to their friction and wear behaviors in both ambient air and vacuum environments. It is expected that this work will lead to development of a viable coating to protect the mechanical components used in vacuum environment.

2. Methods

2.1 Specimens and tribological tests
The TiN-based coatings were deposited on stainless steel substrates. The substrates were cleaned using acetone, ethanol and deionized water in an ultrasonicator to remove contamination on the surface prior to deposition of the coatings. The coatings were deposited using the PVD technique.
Friction tests of the coatings were carried out using a pin-on-reciprocating type of a tribometer in an environmental chamber for a given set of load, speed, stroke and sliding cycles. The tests were repeated three times for each experimental condition to attain reliability of the data.

2.2 Experimental analysis
The friction force was monitored in real time during the sliding tests. Following the tests, the wear tracks formed on the specimens were characterized using a laser confocal microcope and scanning electron microscope (SEM). The chemical compositions of the wear tracks were anlayzed by Energy dispersive X-ray spectroscopy (EDS) and Raman spectroscopy.

3. Discussion

It was found that the friction signal had a relatively large fluctuation in the vacuum environment compared to the ambient air environment. In addition, the difference in the average friction coefficients between ambient air and vacuum environments varied depending on the type of coating. In general, the TiN-based coatings showed less friction compared to the stainless steel substrate in vacuum environment. As for the wear behavior, it was found that in general the wear rate was higher in vacuum compared to that in ambient air. One important factor that led to the difference in the tribological behavior of the specimens in vacuum and ambient air was attributed to the degree of surface layer formed on the specimens during the sliding tests.

4. References

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