Understanding the tribochemical mechanism between DLC and MoDTC: Combination of built-in Raman sensing layer and topographic analysis

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Surface analysis techniques of lubricated interfaces are crucial for investigating the tribochemical mechanims between lubricant additives and the contact surface and their effect on the tribological performance. In view of this fact, a novel approach, based on a bilayer structure with top layer of DLC as light attenuating layer and bottom layer of silicon as Raman signal provider, was employed to investigate the mechanisms of tribofilm formation and evolution for DLC lubricated by MoDTC in conjunction with micro-Raman and profilometry. The results provide useful information about the tribofilm evolution process and new insight into the wear acceleration mechanism of MoDTC on the DLC/steel contacts.

Keywords: tribofilm, wear acceleration, diamond-like carbon, MoDTC, Raman

1. Introduction

Material lightweight design in the automotive, aerospace, power plants, etc. has attracted intensive research interest due to its critical role in reduction of energy consumption and emission [1]. It is well-known that lightweight materials, like aluminum and magnesium alloys and polymer composites, have been applied in the key lubricated components, like gear, bearing and piston [2,3]. However, the inherent drawbacks of these materials, like low mechanical strength and poor wear resistance, represent a serious barrier to their wider application. The application of DLC coating is becoming a promise way to overcome these challenges due its outstanding physical and chemical properties. A better understanding of the tribochemical mechanism between lubricating additives and DLC is essential for development and optimization of effective lubricating additive solutions. This study aims to develop a surface analysis method based on built-in Raman sensing layer to reveal the interaction mechanism between DLC and MoDTC in conjunction with Raman and profilometry.

2. Methods

2.1. Synthesis of hydrogenated amorphous carbon films
The a-C:H films were deposited by PECVD with acetylene as gas feed. The a-C:H films deposited on silicon wafers were used for tribo-test, thickness quantification, and the characterization of structure and composition, while that on glass plates was for the optical studies of a-C:H films.

2.2. Tribological experiments
Tribological experiments were conducted via a UMT ball-on-disc tribometer at room temperature under both dry and oil-lubricated condition.

2.3. Materials Characterisation
Raman spectroscopy was used to characterize the sliding interface on a-C:H films in a line-scanning mode. Profilometers were employed to evaluate the wear condition. UV-vis-NIR spectroscopy was employed to study the optical properties of the samples. A focused ion beam (FIB) was used to prepare thin cross-sectional lamellar specimens of friction contact area for the investigations of TEM.

2.4. Results
Through employing the measured results from profilometry as standard reference, the wear depth difference between Raman and profilometry could be obtained and provide new insight into the wear acceleration mechanism in the friction process (Figure 1).

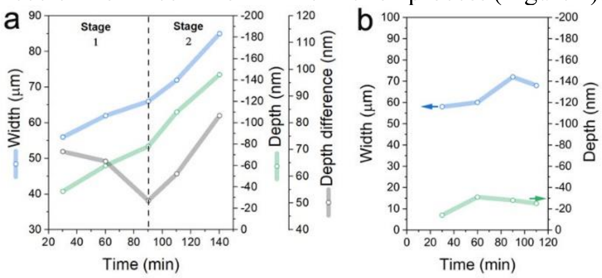

Figure 1: Evolution of width and depth of wear scars with test time under oil-lubricated condition (a, PAO+MoDTC; b, PAO).

3. Discussion

In this study, a surface analysis approach has been developed by combining built-in Raman sensing layer and topographic analysis. Through comparing the measured results of wear depth values from profilometry and Raman signal, useful information about the formation and evolution of tribofilms was obtained. The results provide new insight into wear acceleration mechanism of MoDTC on the DLC/steel contacts.

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