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Investigation of Wear Characteristics of Tetrahedral Amorphous Carbon Thin Film by Nitrogen gas doping

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In this study, the nitrogen gas doping method was used to reduce the ta-C:N film's stiffness, and the effect of the nitrogen gas doping on the friction and wear behavior of ta-C:N film was investigated. The friction test was conducted by sliding a silicon nitride ball (Si_3N_4) on the ta-C:N film under the constant normal force. As the experimental result, the friction force increased as increasing nitrogen gas flowing, while wear amount decreased for the condition. This result suggested the decreased stiffness of the ta-C:N film, and the formation of the transfer film at the interface could improve wear resistance of the ta-C:N film.

Keywords : Nitrogen-doped tetrahedral amorphous carbon (ta-C:N), friction, wear

1. Introduction

Diamond-like carbon (DLC) have been widely exploited as protective coatings for various applications. Particularly, tetrahedral amorphous carbon (ta-C) which is a kind of the DLC, has attracted researchers' interest because of its outstanding mechanical properties such as high density, high hardness, high young's modulus and good thermal resistance. Although the ta-C has been studied because of its good wear resistance, its disadvantage is promoting wear of counter material by its high stiffness. Therefore, nitrogen gas doping method was exploited to reduce stiffness of the ta-C film. In this work, tribological characteristics of ta-C:N thin film was examined and influence of reduced mechanical characteristics of the thin films was investigated.

2. Methods

2.1. Experiment conditions

The ta-C:N thin film was deposited on Si wafer through filtered cathode vacuum arc (FCVA) method. For fabrication of DLC thin film with reduced mechanical strength, nitrogen gas was introduced during the FCVA process. Various conditions of nitrogen flow rate from 0 to 50 sccm were applied for the process. Then, mechanical properties such as hardness and elastic modulus of the ta-C:N thin film were measured using nano-indenter and it was revealed that the mechanical properties decreased as increasing gas flow rate [1]. Tribotests were conducted to examine wear and frictional characteristics of the ta-C:N thin film. For the test, ball-on-reciprocating type tribometer was exploited and Si_3N_4 was chosen as material of the ball. Constant normal force (~hundreds mN) was applied during tribotest for tens of thousands of cycles.

2.2. Results

It was found that frictional force increased as increasing nitrogen gas flow rate from 0 to 30 sccm. DLC thin film fabricated with 40 and 50 sccm gas flow rate condition exhibited smaller frictional force than 30 sccm case. However, it was observed that wear decreased with gas flow rate, and the DLC thin film with 30 sccm condition exhibited the smallest amount of wear. In addition, wear of the Si_3N_4, the counter material for tribotest was examined to be the smallest at the condition of 30 sccm. This result suggests that combination of contacting materials with sufficient mechanical strength rather than hard materials, may lead to suppressed wear behavior because of the distributed contact stress [2]. Moreover, it was evaluated that fraction of sp^2 bonding increased as increasing gas flow rate from the measurement of Raman spectrum [3]. Thus, it was believed that transfer film at the interface was readily formed when the DLC with higher sp^2 bonding fraction was examined and it was regarded as one of the factor that affected wear resistance of the ta-C:N film.

3. Discussion

The effect of nitrogen gas doping on the friction and wear behavior of ta-C:N film was investigated. The friction force increased as increasing nitrogen gas flow rate, while amount of wear changed with opposed trend. The result implies that mechanical strength of contacting materials is critical for wear resistance. In addition, it was revealed that increased sp^2 bonding fraction was attributed to the lower wear amount.

4. References

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