Friction properties of thick tetrahedral amorphous carbon coating with different surface defects under dry contact conditions

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Defects of ta-C coatings are defined as spikes, droplets, and pores. In this study, a hybrid filtering method with duct bias voltage (10-30V) in FCVA. The results revealed that as the duct bias increased up to 30V, the spikes and droplets were almost completely removed on the surface and only the pores remained. The pores could not create a rough surface between interface due to which the CoF increased as the duct bias increased up to 30V. It was concluded that the spike, droplet were positive elements and were required to introduce a carbon transfer and maintain a stable CoF.

Keywords: duct bias voltage, FCVA, surface defects, ta-C coatings

1. Introduction

In this study, a defect control technique for the ta-C coating surface was established by introducing an electrical filter method that uses the application of a positive bias voltage to the duct, which is the carbon plasma transport tube, without changing the mechanical filter in the FCVA system. Additionally, the friction and wear behaviors of the ta-C coated films were investigated according to the type of surface defect.

2. Methods

2.1. Sample preparations

The ta-C coating was fabricated using the 45°-type filter in an FCVA. For the ta-C coating, the positive duct bias voltages were set at 10, 15, 20, and 30 V in the carbon plasma transport tube to reduce surface defects.

2.2. Results

Fig. 1 (a) depicts the reduction of defects on the ta-C-coated surface according to the duct bias. A positive duct bias application method was used to remove the surface defects. As the duct bias increased, the spike and droplet defects on the ta-C coated surface decreased, but left a majority of pores.

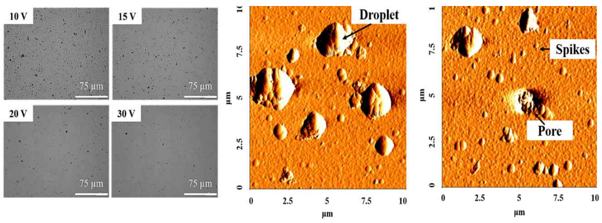

Figure 1: Reduction of surface defects in 1 μm ta-C coatings as a function of duct bias voltage.

Fig. 2 depicts the frictional behavior as a function of the duct bias voltage. The running-in cycle was divided into period (1) (up to 1800 cycles) and period (2) (from 1800 cycles to 10000 cycles) and the friction characteristics were analyzed.

In period (1), the average coefficient of friction (CoF) decreased from 0.17 to 0.08 as the voltage increased from 10 V to 30 V in the duct bias, respectively. This was consistent with the reduced number of surface defects (spikes, droplets, and pores) and surface roughness. However, the friction behavior of the ta-C coating in the steady-state cycle period (2) stabilized after 6500 cycles and showed a CoF of approximately 0.18 and 0.14 at a duct bias voltage of 10 and 15 V, respectively. In contrast, the CoF of the ta-C coating with a duct bias voltage of 20 and 30 V was not stable and it increased continuously.

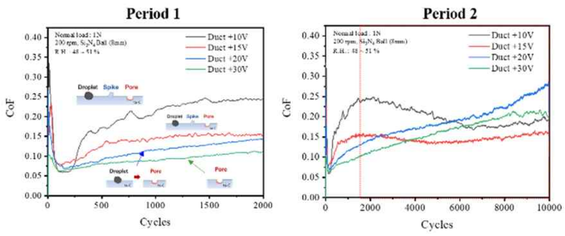

Figure 2: Frictional behavior as a function of duct bias.

3. Discussion

When verifying tribological characteristics under a vertical 1 N load environment, the ta-C coating fabricated by increasing the duct bias reduced the friction in the initial friction section (~ 1800 cycles) and running-in cycle section due to a reduction in surface defects.

It was found that the method in this study is effective, however, the defects on the ta-C coated surface fabricated with a duct bias of 15 V or less had a positive effect on shortening the time to enter the steady-state section and had low friction. The CoF increased linearly as the duct bias voltage increased up to 30 V. This phenomenon occurred because the pore defects could not generate a rough surface for the relative motion between interfaces. It was experimentally confirmed that the pore defects increased the size of the agglomeration of the wear debris behind the wear surface and increased the contact area at three body contacts at the interface.

Therefore, it was concluded that among the surface defects on the ta-C coating, the spikes and droplets were positive elements and they were required to introduce a carbon-based transfer layer for low friction in dry contact conditions and to maintain a stable CoF behavior.