EFFECT OF RESIDUAL WATER DURING DEPOSITION ON THE FRICTION PROPERTIES OF Si-CONTAINING a-C:H FILMS

Hotaka Shibasawa, Hiroyuki Kousaka(*), Noritsugu Umehara, Deng Xingrui
Department of Mechanical Science and Engineering, Nagoya University, Nagoya, Japan
(*Email: kousaka@mech.nagoya-u.ac.jp

ABSTRACT

We investigated the effect of residual water during deposition on the chemical structure and friction property of Si containing a-C:H film (Si-DLC). 6 types of Si-DLC were deposited by either conventional PECVD employing DC plasma or ultra-high-speed PECVD employing MVP method under different 2 conditions of residual water content. Friction coefficients at RH 10 % of all the 4 specimens slid against a mating steel (SUJ2, JIS) ball showed almost the same level of 0.04∼0.08, while friction coefficient at RH 50 % of the Si-DLC deposited by DC plasma in the highest content of residual water showed an unstable friction behaviour, where frequent spikes of friction coefficient appears due to repeated peeling of transferred film on the mating steel ball (SUJ2, JIS).

Keywords: Si-DLC, PECVD, residual water, friction property.

INTRODUCTION

DLC (Diamond-Like Carbon) have excellent characteristics such as high hardness, low friction and high wear resistance. PECVD (Plasma Enhanced Chemical Vapor Deposition) is one of the popular deposition methods for DLC. MVP (Microwave sheath-Voltage combination Plasma), where high density plasma is made by microwave propagation along plasma-sheath interface on metal surface (KOUSAKA 2005, 2006), is one of the plasma generation method employed for PECVD. It has been reported that PECVD with MVP can achieve an ultra-high deposition rate of 157 µm/h in the coating of Si-DLC with a nano-indentation hardness of 20.8 GPa (Kousaka 2013). Such a high deposition rate can drastically decrease the coating time to obtain a required film thickness, typically 1∼5 um. However, for further increase of the throughput as an industrial coating instrument, not only coating time but also evacuation time before deposition should be decreased. Note that this requirement is essential for achieving 1-by-1 processing line of DLC with MVP. Therefore, rough pumping only with rotary pump is desirable for ultra-high-speed DLC coating with MVP, however, the effect of degraded vacuum quality, or increased residual water during deposition on the properties of Si-DLC is not clear. In this work, we investigated the effect of residual gases, especially water, on Si-DLC property. We made 4 specimens, A and A’ by DC plasma CVD, and B and B’ by PECVD with MVP, on stainless steel substrate (SUS304, JIS). Table 1 shows the deposition conditions of these 4 specimens. For A’ and B’, water vapor was flown during deposition. Si/C and O/C ratios in Si-DLC film were determined by XPS (X-ray Photoelectron Spectroscopy). Hardness of specimens was measured by nano-indentation; the hardness values of specimen A, B, A’ and B’ were 18.6, 10.4, 20.9 and 18.9 GPa, respectively. Bball-on-disk type friction test was conducted for the 4 specimens against 8 mm diameter SUJ2 (JIS) ball at 0.5 N load in different two humidity levels, RH10 % and 50 %.
RESULTS AND CONCLUSIONS

Figure 1 shows the Si/C and O/C ratios measured with XPS for the 4 specimens. Si/C ratio of Specimen B increased than that of specimen A. O/C ratios of specimen B and B’ are larger than those of specimen A and A’, respectively. The reason of increased O/C ratio in specimen B and B’ is ascribed to be the oxygen incorporated from residual H$_2$O. As shown in Fig. 2, friction coefficients at RH 10% of all the 4 specimens slid against a mating steel (SUJ2, JIS) ball showed almost the same level of 0.04–0.08, while friction coefficient at RH 50% of the Si-DLC deposited by DC plasma in the highest content of residual water showed an unstable friction behaviour, where frequent spikes of friction coefficient were accompanied; these spikes are ascribed to repeated peeling of transferred film from the mating steel ball (SUJ2, JIS).

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REFERENCES

