TRIBOCHEMISTRY FOR SELF-FORMATION OF CARBONACEOUS TRIBO-LAYER IN SLIDING OF CARBON NITRIDE COATINGS

N. Yamada [a*], S. Mori [a, b], T. Takeno [a], K. Adachi [a]
*yamada@tribo.mech.tohoku.ac.jp
[a] Tohoku University,
6-6-01, Aramaki-Aza-Aoba, Aoba-ku, Sendai, Japan
[b] Iwate University,
4-3-5, Ueda, Morioka, Japan

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ABSTRACT
Carbon nitride (denoted as CN_X) is an expected coating material which shows high hardness and relatively low friction under a nitrogen atmosphere [1]. Our previous paper [2] reported that carbon and hydrogen derived from coating transfer to opposite surface, which contributes the formation of low-frictional carbon tribo-layer. However, the process of transformation at the interface is not clarified in detail. Thus, with an effort to elucidate the tribochemical reactions of CN_X coatings during low friction, the gaseous tribochemical products are detected in vacuum during friction tests in this study.

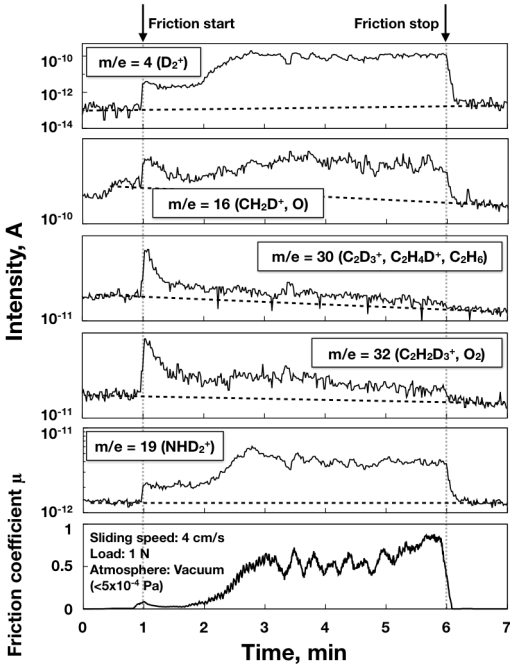

Fig.1. Friction property of CN_X/CN_X:D in vacuum and variation in the ion intensities of gaseous products

The CN_X coating is produced on the surface of Si_3N_4 ball using an ion-beam-assisted deposition system at room temperature. The coating thickness is set at 400 nm. In addition, the deuterated-CN_X (CN_X:D) coating is produced on the surface of Si wafer by plasma-enhanced chemical vapor deposition using a mixture of deuterated-methane (CD_4) and N_2 gas with N_2/CD_4 flow ratio of 0.05 as precursor in this study. Due to introduction of the deuterium in CN_X coating, gaseous products derived from the coating can be distinguished from that derived from organic contaminants on the surface. The ball-on-disk friction tests are conducted in vacuum chamber with a quadrupole mass spectrometer [3]. The chamber is subsequently evacuated to a stable pressure of less than $5x10^{-4}$ Pa. The rotation speed and applied load are 60 rpm and 1.0 N, respectively.

Fig. 1 shows friction property of CN_X/CN_X:D in vacuum and the ion intensities of gaseous products (m/e=4 (D_2^+), 16 (CH_2D^+), 30 ($C_2D_3^+$ or $C_2H_4D^+$ or $C_2H_6^+$), 32 ($C_2H_2D_3^+$), 19 (NHD_2^+)) generated from the frictional interface. As is clear from Fig. 1, deuterium, deuterated-carbons, and deuterated-ammonia are generated when CN_X/CN_X:D shows relatively low friction coefficient. On the other hand, when the friction coefficient of CN_X/CN_X:D increases, the ion intensities of deuterium (m/e=4), deuterated-methane (m/e=16) and deuterated-ammonia (m/e=19) increase although the ion intensities of deuterated-ethane (m/e=30, 32) decrease. These data indicate that the deuterium inside the CN_X:D coating tribochemically reacts with carbon and nitrogen atoms, which desorb from the interface when they show relatively low friction.

ACKNOWLEDGMENTS
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