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EFFECT OF SURFACE ROUGHNESS OF MATING SURFACE AND TRANSFER LAYER ON FRICTION BETWEEN a-CNx AND Si_3N_4 IN NITROGEN

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During the sliding between a-CNx and Si_3N_4, applying nitrogen as environmental gas provided very low friction as the level of 0.01 in friction coefficient. In order to know the effect of the running-in process on the reduction of the friction, the effect of surface roughness of mating surface on friction was investigated. It was shown that smooth surface in wear scar of ball provided low friction coefficient. Friction coefficient after running-in was proportional to the Ry value of wear scar of ball. Also smooth thin transferred layer was observed on the wear scar of balls with an AFM after sliding test. Those results showed the smoothing of wear scar of ball, the generating of the transferred layer from CNx was necessary for low friction.

Keywords : CNx, Ceramics, Surface roughness, Nitrogen, Transfer layer, Sliding

1. INTRODUCTION

Carbon nitride (CNx) coatings was basically expected as new coating with high hardness and wear resistance. However, recently, ball in N_2 gas indicated very low friction coefficient as 0.007 under dry condition, namely N_2 gas played a role of lubrication [1]. We believed that super low friction in nitrogen was specific interesting tribological properties of CNx. After the surface analysis with SEM, Raman spectroscopy and ESCA, we found the there are few wear particles on the contact surfaces and an increase of sp^2 bonding in the case of low friction coefficient in nitrogen. One of the lubrication effects of nitrogen is the decrease of wear particles on the sliding surfaces. A sp^2 rich structures which have low shear strength bonds was considered to cause low friction [2].

Running-in process is important for low friction of CNx in Nitrogen. However, effect of surface roughness and trabnsfer layer on friction is not observed.

In the present work, in order to know the necessary running-in process of CNx for low friction in nitrogen, the effects of

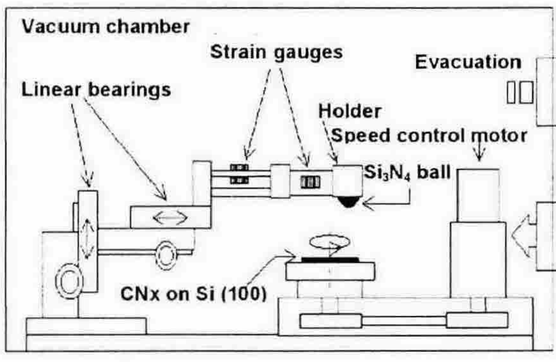

Fig.1 Schematics of Pin-on-disk type friction tester in Nitrogen

2. EXPERIMENTAL APPARATUS AND PROCEDURE

2.1 Coating

Amorphous carbon nitride (a-CNx) thin coatings were coated on Si (111) wafer by Ion Beam Assisted Deposition (IBAD) method, which consisted of sputtered coating of carbon by argon-ion beam and simultaneous irradiation of nitrogen-ion. Substrate material was Si (111) and thickness of coating was 100 nm.

2.2 Friction test

The friction properties were evaluated by ball-on-disk tests in Nitrogen. Figure 1 shows the schematics of pin- on-disk type friction tester.

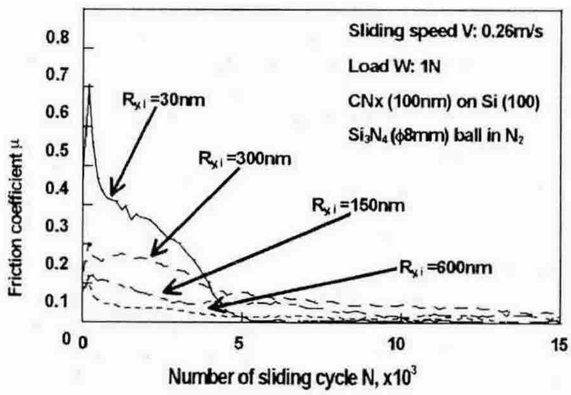

Fig.2 Effect of surface roughness of Si_3N_4 ball on friction

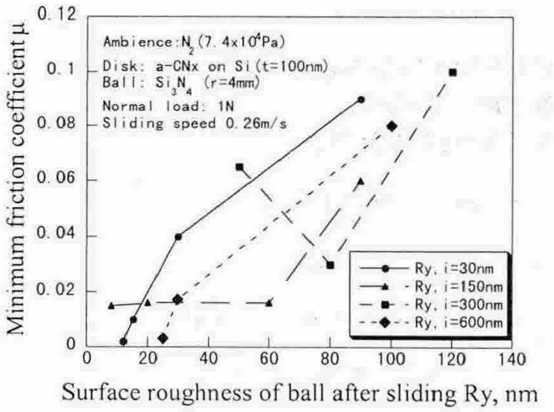

Fig.3 Effect of surface roughness of wear scar of ball on minimum friction coefficient

3.1 Effect of surface roughness of mating surface on friction

Some Si_3N_4 balls with different initial surface roughness Ry,i were prepared and done friction test against CNx coatings in nitrogen. Figure 2 shows the variation of friction coefficient with sliding cycles for different balls with different initial surface roughness. Friction coefficient for smooth ball is initially low, decreased suddenly and reached to very small value of friction coefficient less than 0.01. On the other hand, friction coefficient for the rough balls was initially low, decreased gradually and reached to relatively small value.

In order to know the relationship between friction coefficient and surface roughness, profiles of wear scar of balls were observed with an AFM. From those AFM images, we found the surface roughness on the wear scar of ball. Figure 3 shows the relationship between surface roughness Ry of wear scar of the ball and minimum friction coefficient. It can be seen that friction coefficients are proportional to the resultant surface roughness of ball.

3.2 Effect of transfer layer from a-CNx coating to Si_3N_4 ball on friction

Figures 4 and 5 show the AFM images of ball before and after sliding in nitrogen. Initial surface roughness Ry,i is 300nm. Friction coefficient reached to 0.007 for the ball in Fig.5. It can be seen that surface of ball changed to be smooth after sliding and coated with transferred layer. After obtaining very low friction coefficient, ball surfaces were smoothed and coated with very thin films as shown in Fig.5.

On the basis of results of AFM observation results, it can be considered that smooth and transfer layer of ball is necessary for very low friction.

4. CONCLUSION

In the sliding between a-CNx and Si_3N_4 ball in Nitro-gen, smooth surface in wear scar of ball provided low friction coefficient. Friction coefficient after running-in was proportional to the Ry value of wear scar of ball. Also smooth thin transferred layer was observed on the wear scar of balls with AFM after sliding test. Those results showed the smoothing of wear scar of ball, the generat-ing of the transferred layer from CNx was necessary for low friction.

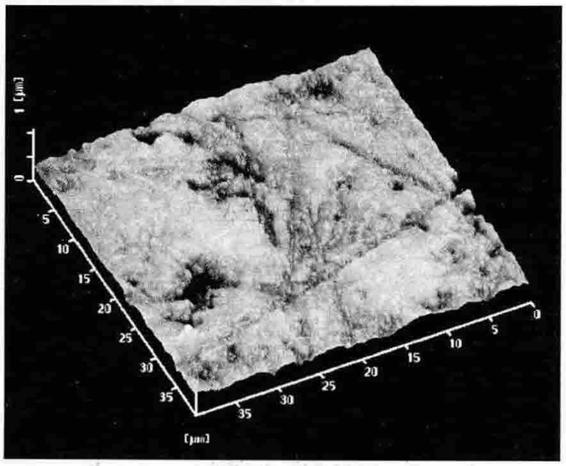

Fig.4 AFM image of Si_3N_4 ball before sliding

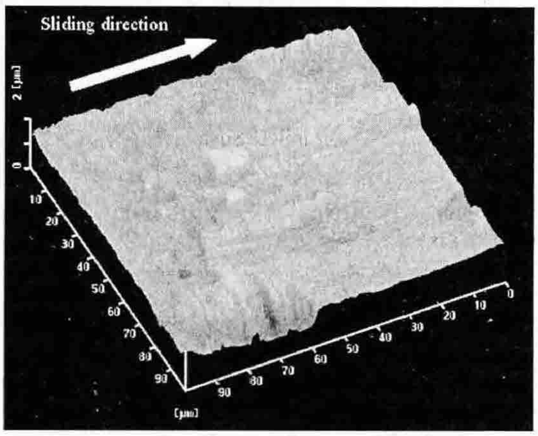

Fig.5 AFM image of Si_3N_4 ball after sliding

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