Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure
Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid
Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1

PAPER REF: 7091

EFFECT OF SURFACE ENERGY ON FRICTION COEFFICIENT OF CARBONACEOUS HARD COATINGS BY IN-SITU MEASUREMENT IN ESEM

Taichi Nakao, Makoto Terada, Noritsugu Umehara(*), Motoyuki Murashima
Department of Micro-Nano Mechanical Science and Engineering, Graduate School of Engineering, Nagoya University, Nagoya, Japan
(*)*Email:* ume@mech.nagoya-u.ac.jp

ABSTRACT

We developed the in-situ measurement method of surface energy in friction area during friction to clarify low friction mechanism of carbonaceous hard coating in ESEM (Environmental Scanning Electron Microscope) chamber by measurement of contact angles of condensed liquid micro droplets of water and diiodemethane. And then we clarified the effect of surface energy on friction properties of carbonaceous hard coatings by in-situ measurement of ESEM. We confirmed that friction coefficients of various carbonaceous hard coatings decreased with the surface energy of sliding scars. However the friction coefficient is not proportional to the surface energy.

Keywords: biomechanics, polypropylene, prosthesis, urogynecology.

INTRODUCTION

Carbonaceous hard coatings have great properties, such as low friction, high hardness and high wear resistance. In particular, CNx (Carbon Nitride) coating and a-C:H (Hydrogenated amorphous carbon) coating show ultra-low friction coefficient ($\mu < 0.01$) in dry nitrogen gas (Umehara *et al*., 2000). However, the mechanism of ultra-low friction has not clarified. We should develop the in-situ measurement method of friction area during friction to clarify this ultra-low friction mechanism of carbonaceous hard coating. Friction would relate to the adhesion. Adhesion should relate to the surface work function after surface energy of both mating surfaces.

In order to know the effect of surface energy on friction of carbonaceous hard coatings, we designed and made in-situ observation equipment of surface energy with friction tester in the ESEM chamber. The contact angles of condensed liquids as water and diiodemethan on the cooling stage of an ESEM can be used for the estimation of the surface energy on a minute friction trucks.

EXPERIMENTAL APPARATUS AND PROCEDURE

A pin-on-disk type oscillating friction tester was fabricated in the chamber of ESEM which can change the gas pressure up to 10 Torr. After the friction test of CNx coating, water and diiodomethane vapours were introduced and condensed minute droplets of liquids were grown on the friction trucks. After the observation of the contact angle of the droplets, we estimated the total, hydrogen bonding term and dispersion bonding term of surface energy, respectively (Yoshino *et al*., 2006). The CNx and a-C:H friction specimens were prepared to have various surface energy with the irradiation of ultra violet lay.

RESULTS AND CONCLUSIONS

Figure 1 shows the effect of surface energies on friction coefficient of CNx sliding against Si_3N_4 ball. The irradiation time as 0, 30, 60 and 120 min changed the surface energy and friction coefficient. Lower surface energy provided lower friction coefficient.

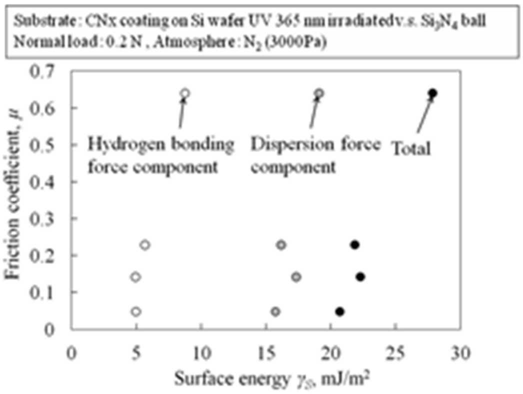

Fig. 1 - Effect of surface energies on friction coefficient of CNx

Figure 2 shows the effect of surface energies on friction coefficient of a-C:H sliding against Si_3N_4 ball. The irradiation time as 0, 30, 60, 120 and 240 min changed the surface energy and friction coefficient. Dispersion force component was much larger than the Hydrogen bonding force components. Lower surface energy provided lower friction coefficient.

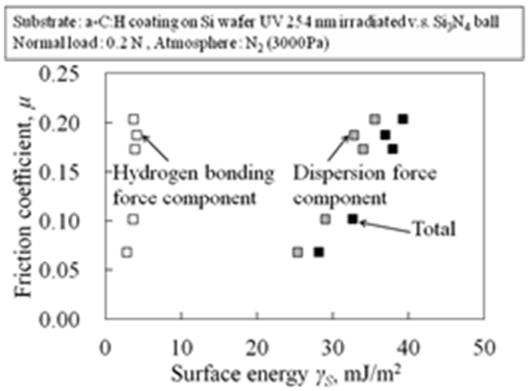

Fig. 2 - Effect of surface energies on friction coefficient of a-C:H

In order to know the effect of surface energy on friction clearly, we have done the friction tests of engineering polymer materials as PTFE, PE and POM. Figure 3 shows the effect of surface energy on friction for Polymer, CNx and a-C:H. Polymer shows good liner relationship between friction and surface energy. On the other hand, CNx and a-C:H did not show very small surface energy even if friction coefficient reached to about 0.05. In the case that friction coefficient reached to minimum value as about 0.05, surface energy of both DLC showed as 20 mJ/m^2, which is the surface energy of standard value of graphite. From these results, it can be considered that graphitization of the topmost layer occurred for CNx and a-C:H coatings during the friction in ESEM chamber.

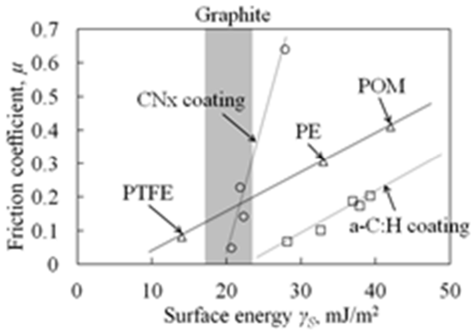

Fig. 3 - Effect of surface energies on friction coefficient of Polymer, CNx and a-C:H

REFERENCES

[1] Umehara, N., Tatsuno, M., Kato, K., Nitrogen lubricated sliding between CNx coatings and ceramic balls, Proceedings of the International Tribology Conference Nagasaki 2000, (2000), pp. 1007-1012.

[2] Yoshino, M., Matsumura, T., Umehara, N., Akagami, Y., Aravindan, S, Ohno, T., Engineering surface and development of a new DNA micro array chip, Wear, 260, 3 (2006), pp. 274-286.