TRIBOMICROPLASMA GENERATION IN DIAMOND LIKE CARBON AND RELATED FILMS

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ABSTRACT
Characteristics and mechanism of microplasma generated at a sliding contact is presented and discussed for diamond like carbon and related films.

INTRODUCTION
The author propose a new modified model of the triboelectromagnetic phenomena shown in Fig. 1, in which thermoelectronic and thermally stimulated electron emissions are newly included in addition to the last model, where triboelectromagnetic phenomena embraced tribocharging, tribomicroplasma generation, triboemission of electrons, ions and photons. The plasma in the electromagnetic phenomena is generated in a gap of sliding contact by discharging of ambient gas due to intense electric fields caused by tribocharging or tribo-electrification. Recently, the tribomicroplasma was discovered in a gap of sliding contact by the author et al. [2]. Figure 2 shows a contour images of tribomicroplasma discovered in a gap of sliding contact in a tribosystem of hemispherical diamond pin with a radius of 300 µm on a sapphire disk in ambient air under a normal force $F_N = 834$ mN and a sliding velocity $V = 32.4$ cm/s [2]. The plasma emits electrons, ions and photons as triboemission particles. The energy of the emitted photons was ultraviolet region in air atmosphere, while those of the emitted electrons ranged from low, say 1 eV to over 1k eV in low air pressure atmospheres. The triboplasma causes various physical and chemical phenomena including decomposition of organic gas to produce friction and wear reducing high molecular weight products [3] and degradation of perfluoropolyether (PFPE) fluids [4].

Figure 1. New conceptual view of triboelectromagnetic phenomena

Figure 2. Contour image of triboplasma; (a) side image and (b) plane image
The characteristics of the triboplasma on DLC and the related films are presented and discussed from the points of hydrogen and nitrogen contents in carbon film, electric resistivity of the film and triboelectrified surface potential.

RESULTS AND DISCUSSION

Figure 3 shows the dependence nature of the charge intensity of negatively charged particles (electrons), positively charged particles (positive ions) and photons emitted from a sliding contact of a diamond sliding on hydrogenated and nitrogenated carbon films under \( F_s = 200 \text{ mN} \) and \( V = 5.2 \text{ cm/s} \) in ambient air [2]. It is clearly seen in Fig. 3 that triboemission intensities of charged particles and photons increase with hydrogen and nitrogen contents. In hydrogenated carbon films, full plasma is generated beyond hydrogen content, \( C_H = 24 \text{ at}\% \). It is noticed that triboemission intensity in nitrogenated carbon film is lower than that of hydrogenated carbon film with a minimum.

Then, the triboemission intensity for the hydrogenated carbon film in Fig. 3 is replotted against the electric resistivity of the film in Fig. 5. Triboemission intensity increases with the increase of the electric resistivity of the hydrogenated carbon film to generate full plasma beyond the electric resistivity of the film \( 10^7 \text{ \Omega \cdot cm} \). Similar relationship was also observed for various solids including metals, semi-conductors and insulators [5]. Then the lower triboemission intensity observed in nitrogenated carbon film can be explained with the lower electric resistivity of the nitrogenated carbon film than that of hydrogenated one [1]. It is observed that tribomicroplasma generation increases with the thickness of the anodic aluminum oxide film [6].

Figure 3. Relation between charge and photon intensities against hydrogen and nitrogen content in carbon film

Figure 4. Dependence nature of an electric resistivity on hydrogen and nitrogen content in carbon film

Figure 5. Triboemission intensity of negatively and positively charged particles and photons vs. electric resistivity of hydrogenated carbon film

CONCLUSION

Triboplasma is generated in hydrogenated and nitrogenated carbon and anodic aluminum oxide films. The triboplasma generation increases with triboelectrified surface potential, electric resistivity of the film, and, in turn, hydrogen and nitrogen content in the carbon film and film thickness.

ACKNOWLEDGMENTS

This study is supported by Grants-in-Aid through the Ministry of Education, Culture, Sports, Science, and Technology of Japan.

REFERENCES