Tribology Focus Topic
Room: Central Hall - Session TR-TuP

Tribology Poster Session

TR-TuP1 Nanomechanical and Nanotribological Responses of Si/SiO_2 Interfaces, ***F.-Y. Lin***, *X. Sun, D.E. Yilmaz, S.R. Phillpot, S.B. Sinnott*, University of Florida

Nanomechanical and tribological responses of semiconductor/gate oxide interfaces have been demonstrated to significantly affect the performance of devices. Here, we use classical molecular dynamics (MD) simulations to investigate these responses at the atomic scale. The simulations utilize the variable charge, empirical charge optimized many-body (COMB) potential to describe the surface interactions and mechanical responses occurring within differing contacting interfaces. In particular, the mechanical response during nanoindentation and nanoscratching of a Si tip on SiO2 and HfO2 thin films is investigated to determine the influence of thin film structure and type on the measured properties as a function of normal load. In addition, the responses of crystalline and amorphous Si/SiO2 sliding contacts are examined and the impact of operating environment and interfacial charge transfer on the tribological properties is explored.

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TR-TuP2 Origin of a Broad Band Emission in Triboluminescence during Friction between Diamond and Quartz in a Gas: Contribution of a Micro-discharge caused by Triboelectricity, *T. Miura*, National Institute of Occupational Safety and Health, Japan, *E. Imai*, ***I. Arakawa***, Gakushuin University, Japan

The origin of triboluminescence of solid in air has been believed to be essentially photoluminescence excited by ultraviolet light from nitrogen discharge caused by triboelectricity (see Walton's review, Adv. Phys. Vol. 26 (1977) p.919.). In this study, we propose that electron-impact is a major and significant origin of the solid luminescence.

The experiment of friction between quartz and diamond was performed in rare gases or nitrogen by a pin-on-disk equipment in a vacuum chamber. A spatial distribution of the triboluminescence was observed by a microscope through the quartz disk and its spectrum was measured by a spectrometer.

Typical discrete lines due to the light emission of the gas discharge and a broad band (wavelengths of 300-600 nm) were observed in the triboluminescence spectrum. The microscopic measurement made it clear that the gas discharge occurred in a gap between quartz and diamond around the contact point and the broad band was emitted at the same place of the gas discharge.

By changing the gas pressure, however, we found that the discharge light almost vanished in the pressure range of 30-100 Pa of nitrogen, while the broad band emission intensely appeared in this range. The broad band intensity became a maximum when a mean free path of electron in plasma was close to the gap distance of the discharge.

It has been known that the quartz was negatively electrified by friction with diamond. We have performed cathode-luminescence experiment for the same diamond sample. A broad band appeared in the spectrum of the cathode-luminescence was identical to the broad band of the triboluminescence.

In conclusion, gas discharge caused by triboelectricity induces cathode-luminescence of the solid. This is the main cause of the broad band in the triboluminescence. Contribution of the ultraviolet light of the nitrogen discharge to the solid luminescence, in contrast, is negligible.

TR-TuP3 Frictional Study of Carbon Nanotube Arrays Grown on Artificial Hip Joint Metal Surfaces, ***M. Yoshimura***, *K. Sumiya*, Toyota Technological Institute, Japan

At present, a well-designed hip joint has a lifetime of 10-15 years. Since this is rather short compared with an increasing lifetime of human, there is great need to improve the durability and clinical lifetime of artificial joints. Reduction of wear debris through the coating of the material surface is one of methods to improve the durability. Here we grow carbon nanotube (CNT) array and composite film (CNT terminated with graphite layers) on the artificial bone surface (ASTM F75 (Co: 62 wt%, Cr: 30 wt%, Mo: 5 wt %)), and examin the tribological property by scratch measurement.

Alcohol chemical vapor deposition (ACVD) was employed to grow CNT arrays and composite films. Growth temperature, pressure and time were 800 C, 160 torr and 5 min. Ball-on-plate type tribo-test machine (Tribostation Type 32, Shinto Sci. Co., Ltd.) was employed. Normal loads were set at 50 g or 1 g. According to the recipe [1], CNT arrays standing perpendicular to the substrate and composite films were successfully grown on the ASTM surface. Tribological measurement with 50 g load reveals that both carbon film gives lower friction coefficient than a bare ASTM surface. In addition, CNT arrays showed a smaller friction than the composite films. SEM images of both surfaces after wear experiment under 1 g load show that CNT arrays fall flat to the substrate, and that cracks form in the graphite layers of the composite films. This study demonstrates possible use of CNTs as a solid lubrication for artificial hip joint metal materials.

[1] Y. Matsuoka et al., J. Vac. Sci. Technol. B29, 061801 (2011).

TR-TuP6 Comparative Study of Tribocorrosion Behavior of Biomedical Alloys Coated with Metal-Ceramic Multilayers, ***M. Flores***, *O. Jimenez, E. Rodriguez*, Universidad de Guadalajara, Mexico, *L. Huerta*, Universidad Nacional Autonoma de Mexico

The tribocorrosion behavior of Ti6Al4V and CoCrMo alloys alone and coated with TiAlN/TiAl multilayers was investigated. The multilayers were deposited onto the alloys by magnetron sputtering. The structure and composition of multilayers were studied by means of XRD and RBS techniques respectively. The tribocorrosion was performed using a ball-on-flat reciprocating tribometer, the tests were conducted in a simulated body fluid at 36.5 ± 1 °C of temperature and 7.4 Ph. The loads used were between 1N and 5N, the oscillating frequency was 1Hz. The counterparts were Al_2O_3 balls 10 mm in diameter. The tribocorrosion and corrosion were studied using electrochemical techniques such as open circuit potential (OCP), electrochemical noise, potentiodynamic and potensiostatic polarizations in a simulated body fluid. The individual and synergistic effects of wear and corrosion on total wear loss were estimated. The worn surface was studied by means of profilometry. For the used conditions the CoCrMo alloys shows a high tribocorrosion resistance respect to the Ti6Al4V. The results indicate that multilayers improve the tribocorrosion resistance of both alloys.

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