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Tribology of Si incorporated Diamond-like Carbon Films

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Tribological behaviors between Si incorporated DLC (Si--DLC) films and steel ball were investigated in the view point of tribo-chemical reaction. The films were deposited on Si (100) wafer from r.f. glow discharge of mixtures of benzene and diluted silane gases. The tribological behaviors were investigated by using ball-on-disk type wear rig in ambient atmosphere. The variation of the friction coefficient with numbers of contact cycle was compared between the films of various Si concentrations from 0 to 9.5 at.%.

It was observed that the friction coefficient decreased with increasing Si concentration in the films. Furthermore, the friction behavior became more stable even when very small amount of Si of less than 0.5 at. % was incorporated. By analyzing the composition of the debris formed, we could show that the low and stabilized friction coefficient is intimately related with the formation of the Si rich oxide debris. These result supports the mechanism that the hydrated silica debris is the reason for low friction coefficient in humid environment. Second evidence of the role of Si rich oxide debris could be found in the tribo-chemical reactions during initial stage of tribo-test. When the Si concentration was less than 5 at.%, initial transient period of high friction coefficient was commonly observed. After the transient period, the friction coefficient becomes lower with increasing contact cycles. The initial transient period becomes shorter and the starting and maximum friction coefficients in transient period decreased with increasing Si concentration. Composition of the debris on the wear scar surface was analyzed by Auger spectroscopy at various stages in the initial transient period. We observed that when the friction coefficient increased in earlier stage of the transient period, iron and oxygen was observed in the debris. However, decrease in the friction coefficient in the later stage of the transient period was associated with the formation of silicon rich oxide debris. This result also supports the friction mechanism of Si-DLC films that the formation of Si rich oxide debris results in low friction coefficient in ambient atmosphere.