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Influence of water adsorption layer on the friction properties of a-C:H films

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The tribological properties of a-C:H films in ambient air were investigated from the microstructural point of view. a-C:H films with various microstructures (polymer-like, diamond-like, and graphite-like structures) were prepared and their tribological properties were investigated using ball-on-disk friction tester in various relative humidity. The friction coefficients of the films in ambient air can be well explained by the surface oxidation and the thickness of water adsorption layers. The higher surface oxidation of the films results in thicker water adsorption layers, and the high shear force due to thick water layer would result in the high friction of the films.

Keywords: a-C:H film, friction, relative humidity, surface oxidation, water adsorption layer

1. Introduction

Hydrogenated amorphous carbon (a-C:H) films possess high hardness, chemical inertness, low friction coefficient and high wear resistance, which enable a-C:H films to be good coating materials in many tribological fields. On the other hand, according to deposition methods and parameters, many kinds of a-C:H films with different microstructure can be deposited[1], which makes them difficult to comprehend their properties and then apply to industry. In addition, friction environments have significant effect in tribology[2]. Particularly, the relative humidity must be considered when slid in ambient air. In the present study, we prepared a-C:H films with various microstructures on Si plates and bearing steel balls, and then, carried out friction tests at various RH to investigate their friction properties in ambient air.

2. Methods

a-C:H films were prepared on Si wafers and bearing steel balls using plasma-based ion implantation and deposition technique using toluene as a source gas. Negative pulse voltage, which is a main parameter for determining the microstructures of the films, changed from -1.5 kV to -10.0 kV, and 5 kinds of a-C:H films were prepared. Water adsorption layer thickness of a-C:H films were evaluated using Quartz Crystal Microbalance (QCM). Friction tests were carried out using a ball-on-disk type friction tester in various relative humidity. The friction tests were conducted for 2000 s at a rotating speed of 200 rpm, with an applied load of 0.98 N. The temperature during friction tests was 23 ± 1°C.

3. Results and Discussions

The evaluation of the microstructure of a-C:H films using Raman spectroscopy showed that the structure of a-C:H films can be classified into three main categories. i.e., polymer-like (PLAC), diamond-like (DLAC), and graphite-like amorphous carbon (GLAC). The thickness of water adsorption layers on a-C:H films (Fig. 1) showed that the PLAC films exhibited the thickest adsorption layer, which decreased as the film structure changed to DLAC and GLAC. The total thickness of the water adsorption layer was found to be strongly influenced by the RH and the surface oxidation of a-C:H films.

The friction results of a-C:H films showed high dependence of film microstructure on the friction properties of a-C:H films (Fig. 2). PLAC films which exhibited the thickest water adsorption layers showed the highest friction coefficient. The high shear force due to thick water adsorption layer would result in the high friction of the films.

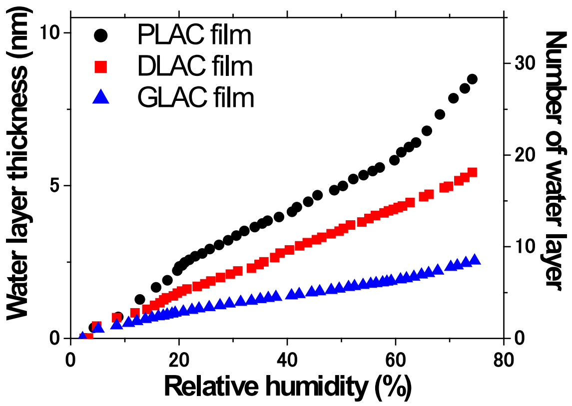

Fig. 1 Adsorption of water molecules on a-C:H films

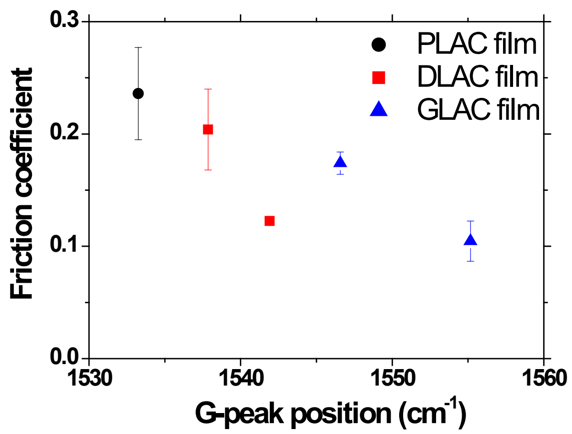

Fig. 2 Friction coefficients of a-C:H films at 75% RH

References

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