Deposition of Amorphous Carbon Nitride Thin Films and Their Microtribological Properties

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It has been theoretically proposed by Liu and Cohen in 1989 that carbon nitride has a possible structure of $\beta$-C$_3$N$_4$, in which the Si of $\beta$-Si$_3$N$_4$ has been replaced with C. It was announced that $\beta$-C$_3$N$_4$ had a higher bulk-modulus value than diamond. Research to form C-N compounds has been actively carried out. Recently, it has been reported that a carbon nitride film has shown a unique property, a high elastic recovery compared with that of a DLC film, even when the structure of this film was amorphous. In this study, carbon nitride films have been deposited by magnetically enhanced plasma ion-plating. The following two methods of deposition were investigated. One is reactive ion-plating, which is a reactive evaporation in a mixture of carbon vapor and nitrogen plasma. The second is a method of ionized evaporation produced in a mixed gas plasma using hydrocarbons and nitrogen gases. Evaluations of wear and deformation energy of the films were carried out by microwear and nanoindentation tests using an atomic force microscope (AFM) having a special transformer head added to the measuring units. The crystal structure and chemical composition of the films have been analyzed by means of FT-IR and XPS, respectively. The film formed by ionized evaporation using C$_2$H$_2$-Ar-N$_2$ plasma showed that its hardness increases beyond that of the film formed with reactive ion-plating; the structure of the C-N bond was confirmed from results of FT-IR and XPS. When a film is formed under CH$_4$-N$_2$ plasma, no microwear of the film occurs, resulting in good wear resistance. The results of deformation energy evaluations indicate that the film shows large elastic recovery.

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