TRIBOLOGICAL PROPERTIES OF TA-CNx COATINGS PREPARED USING ION BEAM ASSISTED FILTERED ARC DEPOSITION

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ABSTRACT

Carbon nitride (CNx) coatings exhibit a wide range of attractive properties that make them suitable for demanding mechanical and tribological applications. In this study, an ion beam assisted filtered arc deposition (IBA-FAD) method has been developed for the deposition of tetrahedral amorphous carbon nitride (ta(CNx)) coatings. Effects of nitrogen content on the structure as well as mechanical properties and tribological properties of the coatings were investigated. The results showed that hardness decreased with an increase in the nitrogen content since nitrogen decreased the fraction of sp\(^3\) carbon in the coatings. ta(CNx) exhibits low friction under oil lubrication and the maximum value was obtained for samples containing 8 at.% of nitrogen, which exhibited markedly low wear rate.

Keywords: Ta-CNx, nitrogen content, boundary lubrication, tribological properties.

INTRODUCTION

A great amount of research on carbon nitrides is focused on the realization of super-hard phase, as predicted by Liu and Cohen [1]. Unfortunately, production of carbon nitride coatings with the ideal structure has not yet been realized. Meanwhile, a-CNx coatings, instead of super-hard bulk carbon-nitride materials, have attracted significant attention as solid lubrication coatings. K. Adachi et al. reported that Si\(_3\)N\(_4\)/CNx and CNx/CNx provide friction coefficients of 0.01-0.001 and specific wear rates of < 10\(^{-7}\) mm\(^3\)/Nm in dry nitrogen gas [2]. However, the low hardness of a-CNx coating, which is usually lower than that of diamond like carbon (DLC) coatings, is a problem.

Thus, it is vital to improve the mechanical properties of a-CNx to ensure sufficient durability. For this purpose, nitrogen was doped into tetrahedral amorphous carbon (ta-C) in this study, and the coatings are named as tetrahedral amorphous carbon nitride (ta-CNx). For the actual applications in lubrication coatings of mechanical components, the evaluation on the films with oil-lubrication is necessary since most of the mechanical components use oil lubrication. Therefore, we investigated the tribological properties of ta-CNx coatings PAO lubrication in this study.

RESULTS AND CONCLUSIONS

Figure 1 shows variations in the hardness of ta-CNx with different nitrogen contents. Although the hardness decreases with an increase in the nitrogen content, it is still higher than 30 GPa at 11 at.% of nitrogen. This decrease in hardness could be attributed to the decrease in
the fraction of sp\(^3\) carbon in the matrix, which is consistent with the Raman spectroscopic results. The hardness of a-CNx coatings prepared in our previous study using IBAD method [3] is also shown in Fig. 1. The hardness of ta-CNx (IBA-FAD) is found to be about 3 times higher than that of a-CNx coatings (IBAD) with the same nitrogen content (~7-8 at.%). This could be attributed to the fact that the carbon source from the evaporated carbon target causes lower ionization rate than that from arc discharge.

![Fig. 1 - Hardness and Young’s modulus of ta-CNx coatings deposited by IBA-FAD and CNx coatings deposited by IBAD](image)

Figure 2 shows the specific wear rate of ta-CNx coating slid against SUJ2 disk. The ta-C coating shows a higher wear rate because of the peeling off. This is due to the high residual stress that leads to low adhesion between the substrate and the ta-C coating. The wear rates of ta-CNx coatings can be divided into two regions according to the wear rate. Low nitrogen region (2-5.16 at.%) shows a wear rate in the range of 1-4×10\(^{-8}\) mm\(^3\)/mN and high nitrogen region (8-11.3 at.%) shows a much lower wear, less than 10\(^{-8}\) mm\(^3\)/Nm. Broadly, the wear rate of ta-CNx is decreased with an increase in the nitrogen content.

![Fig. 2 - Specific wear rate of ta-CNx with different nitrogen content](image)

REFERENCES

