In situ Observation of the Structural Changes of DLC during Friction Motion

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1. Introduction

As an industrial application, Diamond Like Carbon (DLC) has been used in various components. Especially, in the automotive application, DLC is used in variety of conditions such as dry, E/G oil and fuel. However, the optimum structure of DLC has not been clarified in each environmental condition.

Recently, we have developed an in situ system to observe the behavior of lubricant during friction by combining the fast-scan Fourier transform infrared attenuated total reflection (FTIR-ATR) spectrometer with the friction equipment as shown in Figure 1 [1]. In this study, we will report the experimental data of structural changes of DLC in various conditions as measured using the in situ observation system.

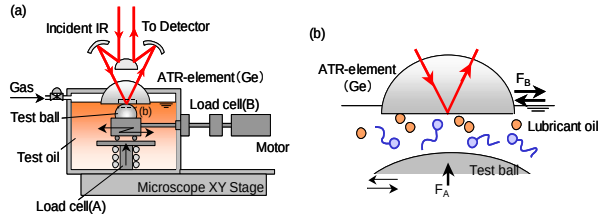

Fig.1 Schematic diagram of FTIR-ATR in situ observation system

2. Experiment

The infrared spectra were obtained by two experiments, annealing test and in situ friction test. The annealing test was conducted at 500°C for 2hr. Table 1 shows the test condition for in situ friction test.

Table 1 Experimental conditions

Specimen	a-C:H (on S45C Cylinder)
Speed	0.5mm/s
Load	55N (125MPa)
Time	6hr

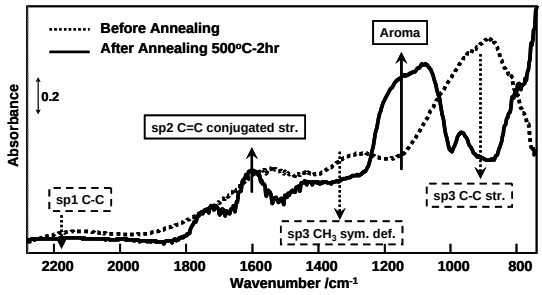

Fig.2 Infrared spectra after annealing

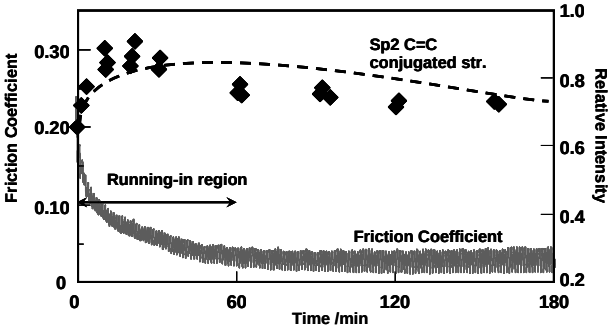

Fig.3 Time dependence of band intensity and COF

3. Result

Figure 2 shows the infrared spectra after annealing at 500°C. We have assigned bands of DLC with some papers (e.g. [2]). The spectra after anneal test shows the large change at ca. 1100 cm^{-1} which represented the aroma structure and ca. 1600 cm^{-1} corresponding to sp2 conjugated C=C. It is clarified the graphitization and aromatization are caused by the high temperature.

The intensity of the band at 1600 cm^{-1} and the friction coefficient obtained by using in situ observation system are shown in Figure 3. In the running-in region, the intensity of sp2 band obviously increases. The intensity of aroma band also increases during friction. However the behavior of sp1 band intensity is difference between anneal test and friction test. The sp1 band intensity decreases as the temperature rises. In contrast, that intensity increases during friction (Table 2).

4. Summary

The structural changes of DLC under friction were researched. The experimental results clearly show that friction induces the structural changes of DLC.

Table 2 The structural changes of DLC for each test

	Aroma	sp1C-C	sp2C=C	sp3CH_3
Annealing	+	-	+	-
Friction	+	+	+	-

5. References

[1] Sasaki K, Inayoshi N, Tashiro K., Rev. Sci. Instrum., 79, 2008, 123702.

[2] Heitz T. et al., Physical Review B, 58, 1998, 13957.