Raman Spectroscopy Study of Impacted DLC Coatings

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1. Introduction

Raman scattering is an excellent tool to characterize the structure of carbon atoms in diamond-like carbon (DLC). The study of DLC coatings in the sliding conditions has been conducted for a decade using Raman spectroscopy analysis. However, there is still insufficient information about how the structure of DLC coatings changes during repetitive impact. In this paper changes in the structure under 90^o repetitive impact at a large number of cycles are presented.

2. Experimental

DLC films were deposited by physical vapor deposition (PVD) method on tungsten high speed steel (SKH2) disc. The impact test was performed using a custom made impact tester, where a DLC coated disc was impacted by a chromium molybdenum steel (SCM420) pin at several impact loads under repetitive impact up to 100,000 cycles. This 90^o inclination of impact was run under lubricated conditions. The diameter of disc and pin are 10mm and 2mm respectively. In the present work, the frequency of the impacts was selected at 10Hz. The bonding structures of wear debris as well as transfer layer on the pin were studied using Raman spectroscopy. In order to analyze the bonding structure of impacted DLC disc taken from the surface of impact crater, the region from 800-2000cm^{-1} in Raman spectrum was fitted with two Gaussian curves.

3. Results and Discussion

Series of Raman spectra of transferred DLC on pin under different impact cycles, with two predominant peaks at approximately 1317cm^{-1} and 680cm^{-1} are shown in Fig. 1. In the previous paper[1], these two peaks originate from a hematite (α-Fe_2O_3) and magnetite (Fe_3O_4) phases respectively. It is clearly revealed that the tribochemical reaction of DLC coatings occurred after several impact cycles due to the oxidation of ferrum (Fe) in the transfer layer. Additionally, the G peak appeares to be significantly shifted towards higher frequencies, when compared to the as-received after 100,000 impact cycles. According to other reseachers[2,3], this implies that DLC coatings are gradually transformed into graphite-like carbon associated with increase in impact cycles. This phenomenon also occurred in wear debris, where the Raman spectra were obtained from the debris on the edge of impact crater.

From the results of Gaussian fit analysis, decreasing ID/IG ratio with full-width at half maximum (FWHM) of G-line and impact cycles evidently correlated with higher sp^3 fractions of impacted DLC coatings[3]. In addition, its hardness also increased as reported by other researchers[4]. From the observation of surface roughness using atomic force microscopy (AFM), it is believed that increasing sp^3 fractions and the hardness of the impacted DLC coatings is associated with the reduction of surface roughness during impacting[4].

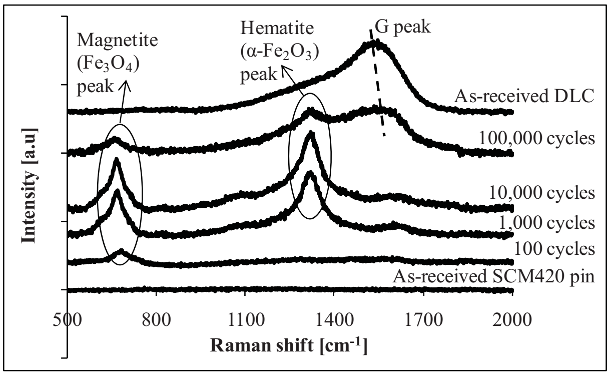

Fig.1 Raman spectra of transfer layer on pin under different impact cycles at impact load of 240N

4. Conclusions

From the Raman spectroscopic analysis, the results show that the tribochemical reaction occurred at the transfer layer and wear debris after several impact cycles under 90^o impact angle. This is due to the oxidation of Fe to α-Fe_2O_3 and Fe_3O_4 phases. In addition, the shift of G peak towards higher frequencies indicates that the DLC coatings gradually transformed into graphitic phases during impacting. As a result of decreased ID/IG ratio with FWHM of G line and impact cycles, the impacted DLC coatings tend to have higher sp^3 fractions and are harder after numerous impacts. This can be correlated to the reduction of surface roughness of the surface layer of impact crater after the impact.

5. References

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