Tribofilm Characterization by Surface Enhanced Raman Spectroscopy with Plasmonic Sensor

KEYWORDS: tribochemistry, tribofilm, surface enhanced Raman spectroscopy, plasmonic sensor

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INTRODUCTION

Raman spectroscopy is a useful tool to analyze tribofilms formed on wear track surfaces after friction or wear tests. However, its sensitivity is not sufficient enough for characterization of extremely thin tribofilms (thickness of several nanometers to several tens of nanometers). Yanagisawa et al. developed a transmission-type plasmonic sensor for surface-enhanced Raman spectroscopy (SERS) [1]. However, it was not confirmed whether their plasmonic sensor was suitable for characterization of the tribofilm. In this study, we developed a plasmonic sensor for SERS of the tribofilms (Fig. 1); we investigated tribofilms generated from lubricant additives by X-ray photoelectron spectroscopy (XPS) and SERS with the plasmonic sensor, and compared the results.

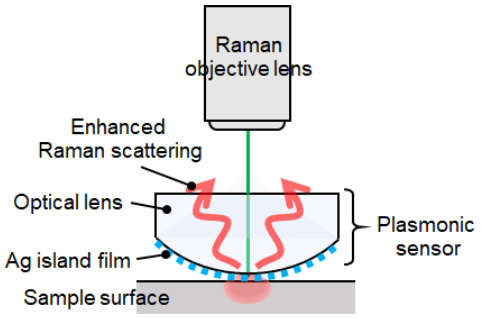

Fig. 1. Schematic of SERS measurement using plasmonic sensor.

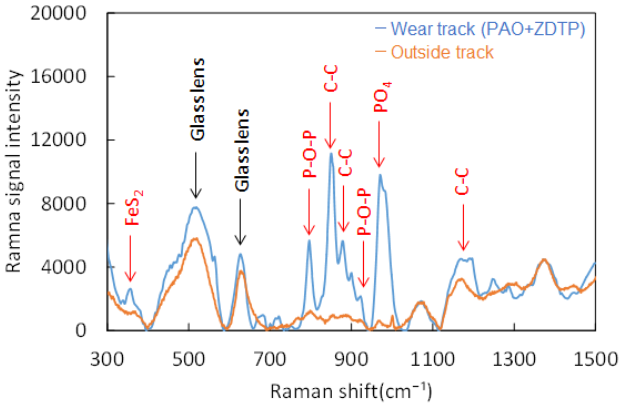

Fig. 2. SERS spectra recorded from inside and outside wear track using plasmonic sensor.

RESULTS AND DISCUSSION

Raman spectra of two samples: (1) poly-α-olefin (PAO) and (2) PAO + additive (ZDTP) were compared. No obvious peak was observed in the spectrum obtained from inside the wear track of sample (2) without using the plasmonic sensor. However, the Raman signal intensity significantly increased when the plasmonic sensor was used. In addition, several peaks related to P and S, originating from the additive, were observed in the spectrum recorded from inside the wear track using the plasmonic sensor (Fig. 2). Moreover, the spectrum showed several peaks assigned to FeS_2, P-O-P bonds, and PO_4 structures. Finally, we investigated the tribofilm samples by XPS. The spectra showed peaks corresponding to P, S, and Zn, as well as the PO_4 structure. Thus, these results indicate that the sensitivity of SERS performed with the plasmonic sensor is similar to that of XPS.

ACKNOWLEDGMENTS

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REFERENCES

[1] Yanagisawa, M., et al., “Transmission-type Plasmonic Sensor for Surface-Enhanced Raman Spectroscopy,” *Applied Physics Express*, **9** (2016)122002.