MEASRUREMNT OF ADSORPTION AND FRICTION PROPERTIES OF ADDITIVES BY VERTICAL-OBJECTIVE TYPE ELLIPSOMETRIC MICROSCOPY

K. FUKUZAWA[A*], Y. SONG[A], S. ITOH[A], N. AZUMA[A], H. ZHANG[A]
*** fukuzawa@nuem.nagoya-u.ac.jp**
[A] NAGOYA UNIVERSITY,
FURO-CHO, CHIKUSA-KU, NAGOYA, JAPAN

KEYWORDS
Lubricant additives; Mixed Lubrication; NanoTribology; Ellipsometry

ABSTRACT
The automotive industry is currently attempting to dramatically reduce friction loss by developing extreme low viscosity of lubricants. Since fluid lubrication does not function sufficiently due to low viscosity, importance of boundary lubrication that uses additives is more increasing. To understand the lubrication performance of additive films, it is essential to quantify the adsorption process and friction properties of additives; however, which is not well established due to the difficulty of measurement. In this talk, we present a method for measuring the adsorption and friction properties of additive molecules using ellipsometric microscopy.

In conventional ellipsometric microscopes, oblique observation corresponding to oblique illumination is used to ensure ellipsometric contrast, which results in a narrower field of view, making high-resolution observation difficult. Our proposed microscope (vertical-objective type ellipsometric microscope (VEM)) successfully achieves both ellipsometric contrast and high resolution by focusing the illumination light on a point off the optical axis of the back focal plane of the objective lens, which leads to illuminate the sample with oblique and collimated light while observing perpendicular to the sample surface (Fig. 1(a)). This has enabled high gap resolution of the order of 0.1 nm and lateral resolution of the order of 0.1 μm [1]. However, the further improvement is needed in the measurement of additive adsorption films in base oils. Since the refractive indices of base oil and additives are comparable, optical discrimination is difficult. To solve this problem, the slider was moved away from the substrate, the additive was adsorbed on the surface, and the lubricant was squeezed out of the gap by pressing the slider against the substrate (Fig. 1(a)). The thickness of the adsorption film is quantified by measuring the gap [2].

Figure 1(b) shows the measured adsorption characteristics of a polyalkylmethacrylate (PAMA) additive obtained using VEM: the adsorption process for films of the order of 1 nm can be quantified, and the adsorption film thickness increases as the molecular weight increases. Furthermore, it was found that the thickness of the adsorption film decreases due to sliding at different loads. Thus, this method can quantify the adsorption and friction properties of adsorption films whose thickness are on the order of 1 nm.

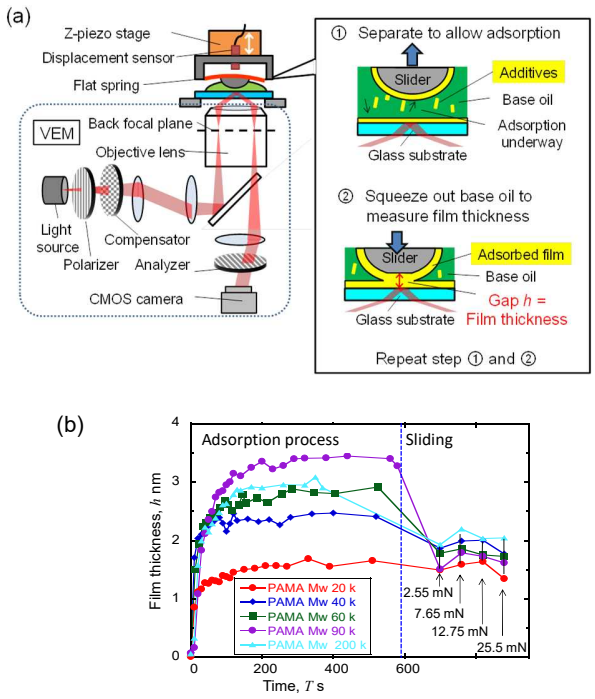

Fig.1 Measured adsorption and friction properties of additive films. (a) Set-up of VEM and (b) results for PAMA.

ACKNOWLEDGMENTS
The authors would like to thank ENEOS corporation for providing the PAMA samples.

REFERENCES
[1] Fukuzawa, K. et al., *Tribology International*, 122, 2018, 8.
[2] Song, Y. et al., *Tribology International*, 165, 2022,107341.