FM-AFM OBSERVATION OF THE ADSORPTION FILM STRUCTURE ON STEEL SURFACE IN OILINESS ADDITIVE SOLUTION

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KEYWORDS

Lubricant additives; NanoTribology; Surface topography, FM-AFM

ABSTRACT

Oiliness additives added into lubricants form adsorption film with nanometers thickness. It is well known that such adsorption film dominates the friction and wear properties. However, high-resolution analysis techniques are required to observe such nanometer thickness film. Also in-situ measurement is strongly desired because the adsorption film is formed in solution and the interfacial structure changes dynamically with the sliding of two substrates [1]. Due to such difficulties in analysing adsorption film precisely, its friction mechanism is still to be fully understood. Hence, revealing the details of adsorption film structure will lead to the clarification of the friction mechanism and the development of the higher performance lubricant.

FM-AFM (Frequency Modulation AFM) enables to observe interfacial structure with higher resolution than conventional AM-AFM (Amplitude Modulation AFM), and is expected as a microscopic technique to measure the detailed adsorption film structure in the thickness direction [2]. However, most of all FM-AFM studies so far are focused on smooth surfaces such as mica, and the adsorption film on actual steel surfaces has not been reported. In this study, the adsorption film structure of oiliness additives on steel surfaces was investigated by liquid cell FM-AFM (SPM-8000, SHIMADZU, Japan) in order to understand its friction mechanism.

The cantilever is oscillated at its resonance frequency by utilizing self-excited vibration on the control system of FM-AFM. When the head of the cantilever approaches a substrate, interaction force acts on the probe and shifts the self-excited frequency of the cantilever oscillation. The interaction force between the sample and the top of the cantilever can be measured by detecting this frequency shift. The image of X-Y plane can be acquired by scanning the cantilever so that the frequency shift is constant. Repulsive force distribution can be acquired from the magnitude of the frequency shift, and the distribution of molecules is visually grasped in the Z-X plane image.

We performed FM-AFM measurement on a steel surface in a solution of hexadecane with stearic acid. At the surface 7 hours after soaked in the solution (Fig. 1), two layers of repulsive force areas were observed in the Z-X plane image, and the morphology of X-Y plane was rough. After 29 hours (Fig. 2), expansion of the repulsive force area was observed in the Z-X plane image, and the morphology of X-Y plane became smoother.

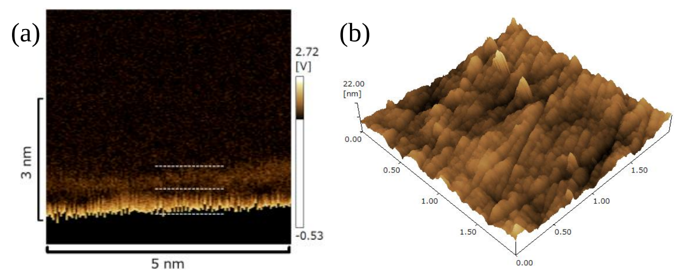

Fig. 1 The result of FM-AFM measurement 7 hours later (a)Z-X image (b)X-Y image

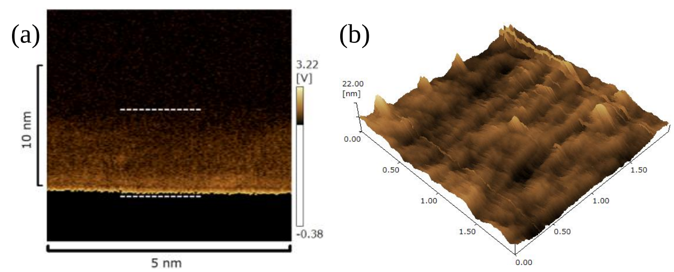

Fig. 2 The result of FM-AFM measurement 29 hours later (a)Z-X image (b)X-Y image

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