Measurement of Thickness of Thin Lubricant Film at Solid-Solid Interface by Neutron Reflectometry

Tomoko Hirayama¹, Tomoki Uno¹, Kazuko Inoue², Seiji Tasaki³, Masahiro Hino⁴, Toru Ebisawa⁵
¹Doshisha Univ., ²Ryukoku Univ., ³Kyoto Univ., ⁴KURRI, ⁵JAEA

Tribological phenomena usually occur at a solid-solid interface, where the presence of a lubricant greatly contributes to low friction. A lack of lubricant causes substantial wear and even seizure of two bodies under severe conditions. However, an in-situ observation is difficult to perform if some lubricant is present at a solid-solid interface because any common rays, such as X-rays and visible rays, cannot penetrate into metals. A neutron beam, on the other hand, is well known to be able to penetrate into almost all metals. Thus, we propose to apply a neutron scattering method to judge whether or not a lubricant is present at a metal interface. Reflectometry is generally recognized as a useful method to analyze vertical structures precisely on a target surface. In this study, we try to measure a thickness of thin lubricant film formed between two silicone blocks by neutron reflectometry. The instrument we used was 'MINE', which is a neutron reflectometer, in JAEA. First, some basic samples with periodic surface roughness were prepared; a grating thin film made of nickel was formed on one of the silicone blocks by photo-lithographic technology as part of a simple roughness model. In addition, the other plane silicone block was covered on the grating surface, resulting in our being able to obtain an ‘interface model’ with a well-defined clearance between the two silicone blocks. The clearance was set at about 100, 50, and 10 nm and was filled by air or two kinds of lubricants: water or base oil. As a result, we obtained different reflectivity profiles depending on each medium at the interface. In addition, the thickness of the lubricant film could be estimated by intervals of the interference fringes of the reflectivity profiles. We conclude that neutron reflectometry is a useful method to estimate lubricants quantitatively, even at a metal interface.

Fig. 1. Reflectivity profile of lubricant film at interface of two silicone blocks