

Water Density Near Surface of DLC Films Having Various Surface Energies Measured by Neutron Reflectometry

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Lubricants generally contribute to achieve low friction on sliding surfaces in many kinds of mechanical components. It is well known that lubricants may form some absorption layers near surfaces. Though macroscopic relationships between lubricants (or absorption layers) and tribological properties have been studied everywhere, there are no reports on densities and thicknesses of the special ultrathin layers formed at the solid-liquid interface.

In our laboratory, densities of lubricants near solid surfaces are directly measured by neutron reflectometry and discussed in the series of studies. The neutron can go deeply into the inner region of common metals because neutrons physically interact not with electrons but with atomic nuclei, thus the in-situ observations of solid-liquid interface can be easily realized. The reflectometry is generally utilized for analysis of vertical microstructures of a sample or the interface through the reflectivity profile. In this paper, three kinds of DLC films having different surface energies were prepared as base materials, and water was selected as a lubricant. The DLC films were called 'normal DLC', 'hydrophilic DLC' and 'hydrophobic DLC'; the first was deposited by plasma CVD using CH₄ gas on a silicone block, the second was treated by oxygen gas plasma on the surface of the normal DLC as post-processing treatment, and the third was deposited by plasma CVD using CH₄ and C₂F₆. The DLC films were soaked in water in a specially-designed sample holder, and the neutron beam was directly entered to the DLC/water interface from the side of silicone block. Then, the instrument we used was a neutron reflectometer 'MINE' in Japan Atomic Energy Agency (JAEA), and the neutron reflectiv-

ity profiles from the interface between DLC films and water were obtained by the instrument. Through an analytical fitting approach with Parratt's theory to the obtained profiles, we can see that: (1) the thickness of hydrophilic layer (O₂ plasma treated layer) formed in the surface of hydrophilic DLC is 15nm, (2) water infiltrates from the surface to the interior of hydrophilic DLC until 15 nm-depth, and the thickness of dense water layer infiltrated in the top surface of hydrophilic DLC is 2nm, and (3) the thickness of low-density water layer on the surface of hydrophobic DLC is 3nm, and its density is almost half of normal water, shown in Fig. 1.

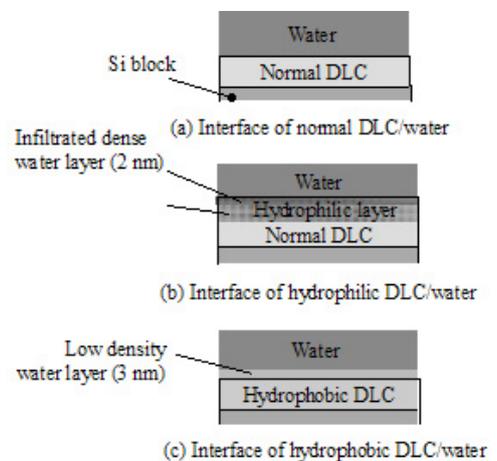


Fig. 1. Physical models estimated by neutron reflectometry