Surface potential measurement of alkyl-chalcogenide self-assembled monolayers using Kelvin probe force microscopy

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Self-assembled monolayers (SAMs) allow us to easily and dramatically modify the surface properties of various substrates such as metals, semiconductors, and insulators. For applications of SAMs to electronic devices, it is important for us to detect the electronic properties on the interface between the molecules and the metal substrate. Kelvin probe force microscopy (KFM) is a powerful technique to investigate surface potential (SP) distribution on the nanometer scale. Since SP of SAM reflects dipole moment of the organic molecules and interfacial dipole moment between the molecules and the substrate, KFM is expected to show us the effect of the anchoring groups of the adsorbed molecules on electric properties of molecule-metal bindings.

In this study, to evaluate transitions of SP caused by the difference of the anchoring groups of the adsorbed molecules, we investigated SP distributions of the two phase-separated self-assembled monolayers (ps-SAMs) formed from the isometric adsorbates on the Au(111) substrates; one was formed of dodecanethiol (DDT) and 3-mercapto-*N*-octylpropionamide (1ATC8), the other, didodecanediselenide (DDSe) and 1ATC8. The 1ATC8 domains were used as a reference in the SP measurement. Figures 1(a) and (b) show FM-AFM/KFM images of (a) DDT/1ATC8 and (b) DDSe/1ATC8 ps-SAMs. The topographies don't show clear features of the phase separation due to no difference in length between these molecules. In contrast, the SP images show the binary potential regions in the DDT/1ATC8 ps-SAM and the trinary potential regions in the DDSe/1ATC8 SAM. The domains with lower SP in the DDT/1ATC8 ps-SAM and that with the second highest SP in the DDSe/1ATC8 ps-SAM were assigned to the DDT regions and the DDSe regions, respectively, where the molecules were formed into closely packed structures. The SP of the 1ATC8 regions was 140 mV higher than that of DDT-adsorbed regions, and 120 mV higher than that of DDSe-adsorbed regions. Therefore the SP difference between the DDT regions and the DDSe regions was calculated as only 20 mV. These results indicate that the electric dipole moments on the interfaces of the SAMs were almost the same.

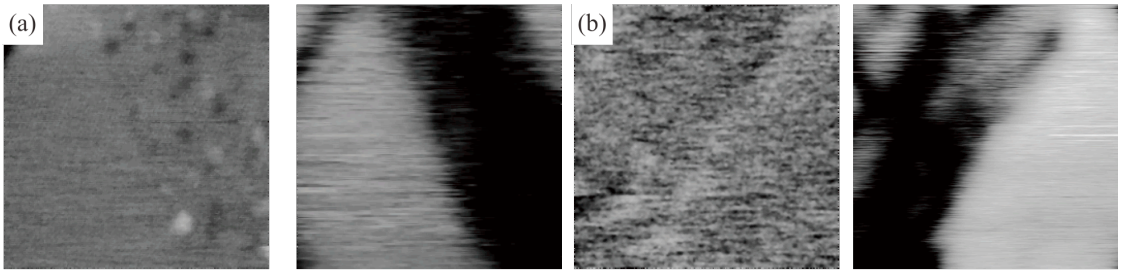

Fig. 1. Topographic (left) and surface potential (right) images of phase-separated SAMs composed of (a) DDT/1ATC8 and (b) DDSe/1ATC8 obtained by FM-AFM / KFM.
Δf =-8 Hz, Size: (a) 100 nm × 100 nm, (b) 80 nm × 80 nm.