# Molecular-scale Investigations on Mixed Alkanethiol Self-assembled Monolayers by Noncontact Atomic Force Microscopy

**Takashi Ichii**[1], Masashi Urabe[2], Kei Kobayashi[3], Kazumi Matsushige[1, 2, 3], Hirofumi Yamada[1, 4]
[1]Dept. of Electronic Science & Engineering, Kyoto University Katsura, Nishikyo, Kyoto 615-8510, Japan
[2]Venture Business Laboratory, Kyoto University Yoshida-Honmachi, Sakyo, Kyoto 606-8501, Japan
[3]International Innovation Center, Kyoto University Yoshida-Honmachi, Sakyo, Kyoto 606-8501, Japan
[4]Core Research for Evolutional Science and Technology, Japan Science and Technology, Kyoto, Japan
E-mail address: ichitaka@piezo.kuee.kyoto-u.ac.jp

Noncontact atomic force microscopy (NC-AFM) is capable of imaging various surfaces such as semiconductors, metals, and even insulators with true atomic resolution. This technique has been also applied to molecular-scale imaging of organic samples. The organic thin films consisting of two different molecules have remarkable advantages because their surface properties can be controlled by properly choosing molecular species and by changing the ratio. In this study, mixed self-assembled monolayers (SAMs) of alkanethiol and fluoroalkanethiol formed on Au(111) surfaces were used as samples. While alkanethiol SAMs with highly-ordered structures have been intensively investigated, there have been few molecular-scale studies on fluoroalkanethiol SAMs. We recently succeeded in obtaining molecular-resolution NC-AFM images of the fluoroalkanethiol SAMs and revealed the difference in molecular packing arrangement from the alkanethiol SAMs [1]. Comparative studies on the mixed SAMs are essential for understanding of the chemical interactions between the two molecules as well as the SAM film structures. In addition, the energy dissipation measurement by NC-AFM is expected to reveal their surface properties on a molecular scale.

Figure 1(a) shows a topographic image of mixed SAMs composed of 1-dodecanethiol ($CH_3(CH_2)_{11}SH$: $H_{12}$) and (2-perfluorodecane)ethanethiol ($CF_3(CF_2)_9(CH_2)_2SH$: $F_{10}H_2$) obtained by NC-AFM. The surface consists of the array of many dots forming the c(4 × 2) superlattice structure, which is a typical structure of alkanethiol SAMs, apart from the bright area in fig. 1(a). This is the area consisting of $F_{10}H_2$ molecules while the small dots in the array correspond to individual $H_{12}$ molecules. Figure 1(b) shows an energy dissipation image obtained simultaneously with fig. 1(a). We found that the energy dissipation on the $F_{10}H_2$ molecules were smaller than that on the $H_{12}$ molecules. This result indicates that the energy dissipation measurement can be used for molecular differentiation on a molecular scale.

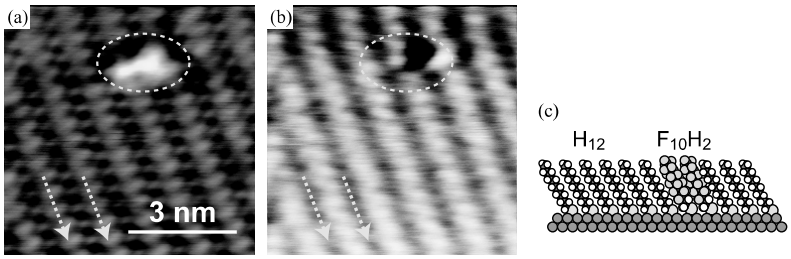


Fig. 1 NC-AFM images of a $H_{12}/F_{10}H_2$ mixed SAM, 7 nm × 7 nm, $\Delta f$ = - 40 Hz
(a) Topography (b) Dissipation (c) Schematic structure of the $H_{12}/F_{10}H_2$ SAM

[1] T. Ichii, M. Urabe, T. Fukuma, K. Kobayashi, H. Yamada and K. Matsushige, Jpn. J. Appl. Phys. in press.