Surface Potential Images of Molecular Systems on Insulating Substrates by Frequency-Mode Scanning Force Microscopy

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Molecular-scale electronics, first suggested by Amirav and Ratner, has attracted much attention in the last quarter-century. In the past several years, scanning tunneling microscopy has provided fascinating results for the tunneling conductivity of single molecule on metal substrates. However, such investigations have not directly led to actual molecular-scale devices due to the inadequacy for insulating surface. Because the electronic devices should be formed on insulating substrate as a necessity, effective methods for the study of single molecular structure and properties on insulating surfaces are much awaited.

We have demonstrated that frequency-shift mode Kelvin force microscopy (FM-KFM) and electrostatic force microscopy (FM-EFM) can be used for surface potential imaging of a molecular system on an insulating surface. Figure 1 shows (a) topography and (b, c) FM-EFM images of DNA network incorporating Au-nanoparticles arranged on an insulating mica substrate. The EFM images indicate the amplitude of frequency-shift signal modulated by AC component of the bias voltages under constant frequency-shift feedback condition with DC bias voltages of (b) –2 and (c) +1 V. The contrast of Au-nanoparticle is reversed by the change of bias polarity. Antithetically, the image contrast of DNA strands is not reversed by the same bias change. This suggests that the DNA-strands are electrically charged on the mica substrate.

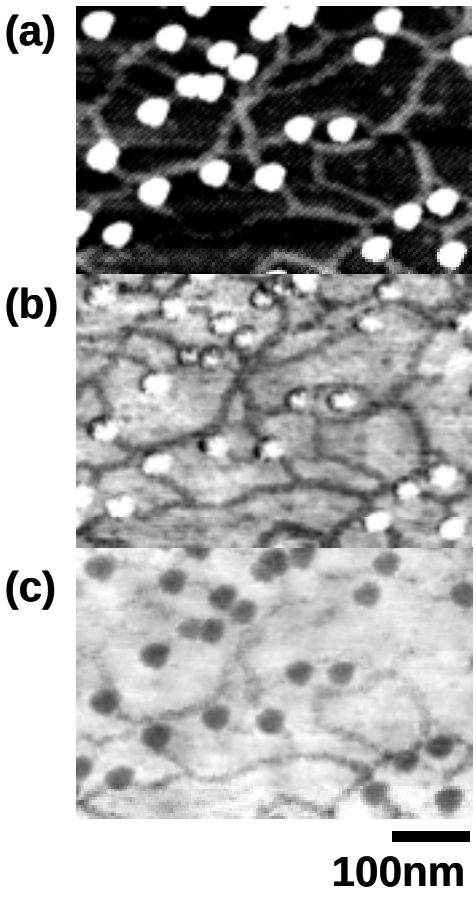

Fig. 1.(a) Topography and (b,c) electrostatic force microscopy images of DNA network incorporating Au nanoparticle on mica substrates.. Bias voltages in EFM are (b) –2V and (c) +2V. The images were obtained by frequency-shift mode.