Proximal multi-probe measurement and control method for nanometer-scale structures based on frequency modulation AFM

Hirofumi Yamada

(Kyoto University, Department of Electronic Science & Engineering, Associate Professor)

【Outline of survey】

Recent progress in frequency modulation AFM (FM-AFM) has allowed us to non-destructively investigate surface structures and properties of various materials with atomic resolution. The goal of this project is to establish a novel proximal multi-probe method based on FM-AFM for the high-resolution measurements and analyses of various materials as well as the control and fabrication of nanometer-scale structures, which cannot be done by the present single-probe AFM. The details of the projects are as follows:

* Development of "high-resolution multi-probe AFM" working in various environments including liquids. Each proximal probe, independently positioned with nanometer accuracy, can be brought in close proximity to other probes.
* Development of a local excitation-response measurement method. While an electric field/mechanical stress is applied to a local area of a sample by one probe, the electric/mechanical responses at different positions are simultaneously detected by other different probes.
* Modification/fabrication of surface nanometer-scale structures and manipulation of atoms or biological molecules by using of appropriate probes having different functions.
* Application of the multi-probe AFM to the "*in vivo*" analysis of biological samples. In particular, information transfer mechanism of the receptor membrane proteins is investigated and the possibility of the information control through the receptor proteins is also explored.

【Expected results】

Multi-probe AFM based on FM-AFM enables us to conduct high-resolution imaging during fabrication or manipulation processes as well as to make multi-probe measurements of material properties, both of which cannot be performed by the present single-probe AFM. Thus the results of this project are expected to offer practical high-resolution imaging/analysis methods and fabrication/control tools to a wide variety of fields related to nanoscience and nanotechnology. A tremendous contribution toward the developments of nanometer-scale electronic/mechanical devices in the future generation is expected to be made. In addition, since the multi-probe system can work in liquid environments, it can be suitably applied to the "*in vivo*" studies on biological molecules. It is capable of simultaneously analyzing several biological functions operating together at different positions of a sample, which will bring a huge contribution to nanobiology and life science fields.

【References by the principal investigator】

・S. Morita, H. Yamada, T. Ando: *Nanotechnology*, **18**, (2007) 084001.
・T. Fukuma, K. Kobayashi, K. Matsushige, H. Yamada: *Appl. Phys. Lett.*, **86**, (2005) 193108-1-3.
・T. Fukuma, M. Kimura, K. Kobayashi, K. Matsushige, H. Yamada: *Rev. Sci. Instrum.*, **76** (2005) 053704-1-8.
・H. Yamada and K. Kobayashi: "Applied Scanning Probe Methods VI", *ed. by B. Bhushan, S. Kawata,* Springer (2007) Chap. 17, pp.205-246.
・H. Yamada: "Non-Contact Atomic Force Microscopy, *ed. by S. Morita, R. Wiesendanger,* Springer (2002) Chap. 12, pp.193-214.

【Term of project】 FY2007− 2011	【Budget allocation】 18,500,000 yen (2007 direct cost)

【Homepage address】 http://piezo.kuee.kyoto-u.ac.jp/