【Grant-in-Aid for Scientific Research(S)】
Integrated Science and Innovative Science (New multidisciplinary fields)

Title of Project : Molecular-scale functional visualization of bio- and nano-materials by AFM functional probes

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Research Area : Nano/Micro science, Nanomaterials/Nanobioscience
Keyword : Nanoscale measurement, Atomic force microscopy

【Purpose and Background of the Research】

Although optical microscopy and electron microscopy have been widely used for microscopic studies of biological samples, each method has a limitation in its imaging capability. The former resolution is limited by the optical wavelength while the samples have to be imaged in vacuum in the latter method. In contrast atomic force microscopy (AFM) is capable of imaging samples in liquids with atomic resolution, which is exactly fit to nanobiology. However, high-resolution visualization of biological functions by AFM has not been established yet. This is because selective detection of a specific interaction force in AFM is not simple at all while a wide variety of interactions can be detected.

In this project, based on both frequency modulation (FM) AFM and dual probe AFM techniques, we aim to develop a novel imaging method being capable of visualizing molecular-scale biofunctions and to clarify the microscopic roles of various biomolecules in cell physiological processes by this method. We also develop the probes optimized for biofunction measurements and for giving various biological stimuli. In addition, the developed technique is applied to the molecular-scale investigations of various properties of a wide variety of nanometer-scale functional materials.

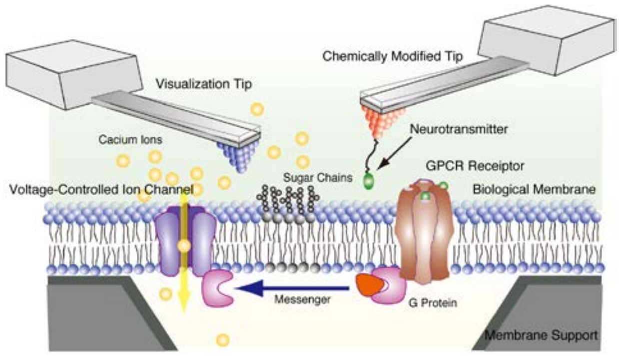

Figure 1 Molecular-scale visualization of biofunctions based on dual-probe FM-AFM technique.

【Research Methods】

The following studies are to be carried out. (1) The interaction force originating from a surface structure and that related to a biofunction are separately detected on a molecular scale by using of a normal imaging probe and a biochemically modified probe. (2) A molecular-scale response to a biological stimulus made by a bioprobe is measured by the counter probe in dual probe AFM. (3) The relationship between the hydration structure and the biofunction is investigated using chemically modified probes of which the hydrophilicity/hydrophobicity are controlled. (4) Local charge densities on the active regions of a biomolecule are measured by the wideband electric responses to an externally applied electric field.

【Expected Research Achievements and Scientific Significance】

The key technologies in this project are the high-resolution visualization of biofunctions, the 3D measurement of hydration structures by the force mapping method, and the local charge density measurement based on the molecular-scale electric force detection. These are directly connected to the determination of an active region leading to a specific molecular function, the understanding of biochemical roles of water molecules surrounding biomolecules, and the understanding of molecular recognition mechanism, which is finally expected to bring us the understanding of a wide variety of biofunctions at the cellular level. Furthermore, since the project is strongly connected to various solid-liquid interface phenomena, it is definitely of great significance, having an strong impact on various industrial areas as well as academic fields.

【Publications Relevant to the Project】

E. Tsunemi *et al*. “Development of dual-probe atomic force microscopy system using optical beam deflection sensors with obliquely incident laser beams”, *Rev. Sci. Instrum.*, **82** 033708 (2011).
K. Kimura *et al*. “Visualizing water molecule distribution by atomic force microscopy”, *J. Chem. Phys.*, **139** 194705 (2010).

【Term of Project】 FY2012-2016

【Budget Allocation】 144,300 Thousand Yen

【Homepage Address and Other Contact Information】

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