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Electrostatic Immobilization of Biomolecules using Nano-Electrode Array

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1. Introduction

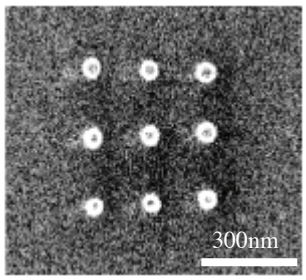
As recent advances in development of ultrasensitive instrumentation such as highly sensitive camera, advanced optics, scanning probe microscopes, etc. have allowed for the detection, identification, and dynamic studies on a single biomolecular level[1][2]. One of the important issues in single biomolecular study is immobilizing a target biomolecule onto a solid surface. To focus on a single molecule, it must be immobilized at desired location, preferably without non-specific adsorption to the other location, to improve the S/N ratio of observation and to preserve the activity of immobilized biomolecules. In this paper, an array of 3-dimensional nanometer sized electrode array are developed and experimentally demonstrated to immobilize biomolecules at the top of nano-electrode array by electrostatic force.

2. Experimental

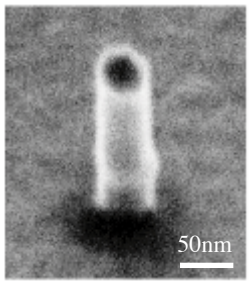
The nano-electrode array made of carbon were deposited onto an aluminum electrode, which is patterned on a glass substrate, by FIB-CVD method[3][4] using phenanthrene as a precursor of a carbon. Fig. 1 a) shows a SEM image of the nano-electrode array. Fig. 1 b) is the magnified view revealed that the diameter of the top surface area is about 50nm, and its height is about 300nm. The arrangement of electrical energization is shown Fig. 2. The electric field is created laterally by two outermost electrodes while the nano-electrode array in the gap have no electrical connection however each nano-electrodes deform electric field to create local maxima around the top of nano-electrodes. The reason why nano-electrode array is electrically floating, is based on the experimental fact that the electrohydro-dynamic convection on the floating electrodes become less severe compared with the electrode which is connected to power source.

3. Results

To demonstrate the immobilization of biomolecules, fluorescein isothiocianate labeled bovine serum albumin (FITC-BSA) was tried to immobilize onto the nano-electrode array. When a high intensity (≥3MV/m) high frequency (≈1MHz) electric field was applied between two energized electrodes, the target biomolecules were attracted toward the nano-electrode array and finally attached at the top of the nano-electrode array by dielectrophoresis. Fig. 3 shows the fluorescent image of nano-electrode array after cutting off electric field. Since an array of bright spots of FITC-BSA in Fig. 3 is well correspond to the SEM image



a) Top view



b) Magnified view

Fig. 1. SEM images of nano-electrode array

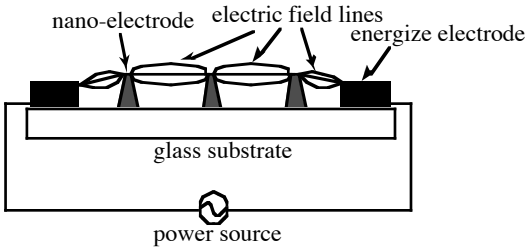


Fig. 2. Energize arrangements of an array of nano-electrodes

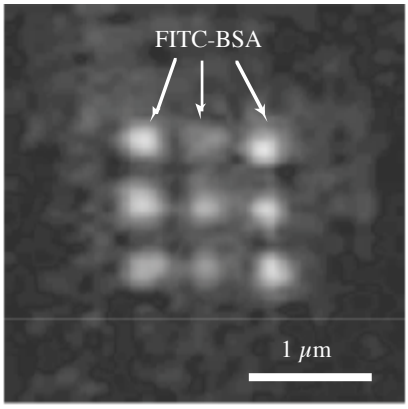


Fig. 3. Fluorescent image of immobilized FITC-BSA

of nano-electrode array in Fig. 1a), FITC-BSA were successfully immobilized at the top of nano-electrode array. The size of top surface area of a nano-electrode is more than10 times larger compared with that of a FITC-BSA, a number of FITC-BSA are supposed to be immobilized at the top of nano-electrode array in this photograph. Since the electric field around both side of nano-electrodes are larger than in the middle nano-electrodes, The number of immobilized FITC-BSA, which correspond to the intensity of bright spot, on the both side is larger than in the middle.

4. Conclusions

A nano-electrode array for single biomolecular research was developed using FIB-CVD. Since the size of nano-electrode is relatively larger than that of a single biomolecule in the present design, many biomolecules seems to be immobilized at a top of nano-electrode. By fabricating sharper electrodes, not small amount but only a single molecule could be immobilized in the future. This result would supply a chip-based single or a small number of molecules analysis and reaction systems.

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