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大気圧マイクロプラズマジェットを用いたＣＮＴドットアレイの空間制御表面官能基修飾

Spatially-regulated Surface Functionalization of the CNT Dot-Array Using Atmospheric Pressure Micro-plasma Jet

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1. Introduction

Carbon nanotubes(CNTs) have many excellent characteristics such as good electrical conduction property, high aspect ratio, mechanical strength, chemical stability, and so on. It is one of the materials that are expected in a field-effect transistors, an electron source for field emission display, biosensor and so on. For bio-application of CNTs, their surface dispersibility and immobilization with the biological molecules are required. The CNT surfaces are intrinsically inert because of their own chemical stability, therefore, we need to modify the CNT surfaces to introduce the functional groups, such as amino groups or carboxyl group, to immobilize the biological molecules.

So far, we succeeded in fabicating vertically aligned CNT dot-array and introducing amino groups and carboxyl groups onto the CNTs surface by the atmospheric pressure plasma jet (APPJ). In this study, we aim to develop the selective modification method of functional groups for biosensor fabrication by using the APPJ with a nano-capillary tip. To confirm amino group modification, we used the chemical derivatization method with fluorescent dyes which chemically connect with amino groups.

2. Experimental details

Micro-sized catalysts were patterned on the Si substrate by electron beam lithography, where we used Ni as catalytic metal and Cr as a barrier layer. As for the CNTs synthesis, we used a combined thermal and DC plasma CVD system, where a quartz tube was installed inside the electric furnace.

The schematic drawing of APPJ is shown in Fig. 1. In order to generate the plasma jet in a 0.6 mm inner diameter glass capillary with a thickness of 0.2 mm, He/NH_3 mixture gas was used as a working gas. The rectangular pulsed voltage with a duty ratio of 50% was applied on the electrode with the maximum voltage of ±7.5 kV at a frequency of 5 kHz. The capillary used in this experiment was fabricated by a micropipette puller. In the present experiments, the capillary with an inner diameter of 100 nm was used. The ultrafine plasma jet was ejected from the nano-capillary in the atmosphere.

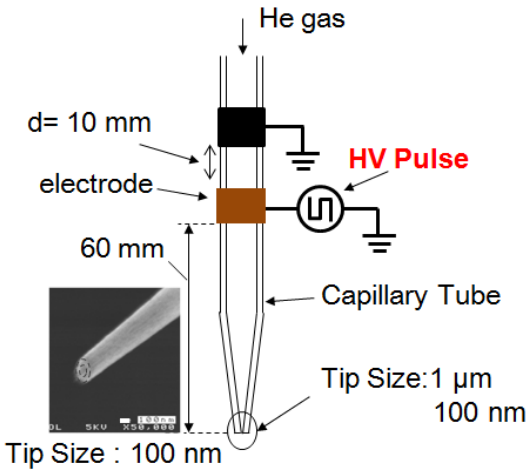

Fig. 1. Schematic of APPJ with a nano-capillary.

3. Result

The CNT dot-array was irradiated by the APPJ with a nano-capillary one by one. Figure 2 shows fluorescence microscope image after derivatization with the fluorescent dyes (SDP ester) which chemically connect with amino groups. It is seen from fluorescence microscope measurement that the functionalization of amino groups was successfully performed over the CNT surface. This result suggests the possibility of spatially-regulated surface functionalization of the CNT dot-array. The other results will be presented at the conference.

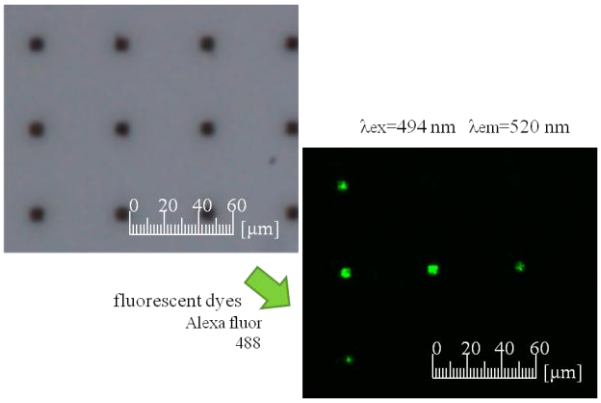

Fig. 2. Fluorescence microscope image of the CNT dot-array substrate modified by APPJ.