19p-E18-9

Advantages of Flattened Electrode in Bottom Contact Single Walled Carbon Nanotube Field Effect Transistor

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Currently, single walled carbon nanotubes (SWNTs) field effect transistor (FET) devices can be fabricated by either chemical vapor deposition (CVD) or solution casting. Comparing to the CVD-based SWNTs devices, SWNTs devices which are fabricated by solution casting has an advantage since the recent purification method to separate metallic and semiconducting SWNTs on a large scale were done in SWNTs solution. In the case of sensing devices, direct junction of SWNTs on the metal electrodes is favorable to eliminate ambiguous response of the sensor [1]. For the short channel length devices, electrodes are patterned by using electron beam lithography (EBL). In the top contact devices, the SWNTs must be deposited before applying EBL process. So, there is a risk since the SWNTs can be damaged by direct electron irradiation [2]. Furthermore, there are several steps following EBL process, such as, resist removal and cleaning procedure. Therefore it is important to fabricate good SWNTs devices by using bottom contact technique even in the short channel region.

We fabricated individual SWNTs field-effect transistor in sub-micrometer channel using flattened bottom contact electrodes. We compared our flattened electrodes to the non-flattened electrodes SWNTs-FET devices. Average height of flattened and non-flattened electrodes are approximately 4 and 42 nm, respectively. By using spin-coating deposition method, an array of SWNTs-FET devices can be fabricated simultaneously in one large substrate [1]. The number of SWNTs direct junctions is drastically increased by the use of flattened electrodes, especially at channel length of 200 nm. In this channel length, the number of SWNTs direct junctions in flattened electrodes is approximately 2 times larger than that of non-flattened electrodes devices which can be seen in Table 1. All of our devices also show ambipolar FET characteristic under vacuum condition. Our flattened electrodes devices have better balance of *p*- and *n*-channel mobility compare to that of non-flattened electrodes devices. These results show the advantages of flattened electrodes for bottom contact SWNTs-FET devices.

Table 1. Estimated number of SWNT direct junction per 2 μm channel width.

Channel length	Flattened electrode	Non-flattened electrode
200 nm	3.8±1	1.8±1.5
500 nm	4.6±2	2.8±1
1000 nm	3.4±1.5	3±1

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