# Patterned Growth of SWNTs for Facile Fabrication of Field Effect Transistor Device

Shinya Aikawa[1,2], Rong Xiang[1], Erik Einarsson[1], Junichiro Shiomi[1], Eiichi Nishikawa[2], and Shigeo Maruyama*[1]

[1] *Department of Mechanical Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan*

[2] *Department of Electrical Engineering, Tokyo University of Science, 1-3 Kagurazaka, Shinjuku, Tokyo 162-8601, Japan*

A single-walled carbon nanotube (SWNT) with small diameter (1-2 nm) is one of the most promising materials for application as an electron transporter, owing to its quasi one-dimensional structure. A carbon nanotube field effect transistor (CNT-FET) having an SWNT as its gate channel has been particularly investigated as an ideal nanoscale device for next-generation electronics [e.g., 1].

However, in most previous reports post-processing such as drop-casting of dispersed SWNTs or deposition of electrodes are required after SWNTs growth. Such fabrication process may induce significant damage of the SWNTs, degrading the high-quality characteristics of as-grown SWNTs. A CNT-FET consisting of as-grown SWNTs can be prepared by catalyst deposition on pre-formed electrodes [2], but diameter distribution of the SWNTs remains wide (1-3 nm). Recently we succeeded in restricting the catalyst deposition area by patterning a self-assembled monolayer (SAM) on a Si substrate [3]. This method has two advantages compared with conventional MEMS techniques (photolithography and lift-off). Firstly, since the SAM surface is hydrophobic it is possible to easily prepare substrates using a scalable liquid-based dip-coating method for catalyst deposition, which can synthesize SWNTs with small diameters (less than 2 nm) [4,5]. Secondly, the SAM can also be patterned with high resolution (~10 nm) using the electron beam of a scanning electron microscope (SEM), which also makes the patterning process visible.

We fabricated a CNT-FET with an as-grown SWNT as its gate channel using this method. The *I-V* characteristics were evaluated using the Si substrate as a back-gate. We measured the characteristics before and after SEM observation to see an effect of induced damage by electron beam irradiation. As a result, the $I_{on}/I_{off}$ ratio decreased after SEM observation. Here we discuss the reduced $I_{on}/I_{off}$ ratio after electron beam irradiation.

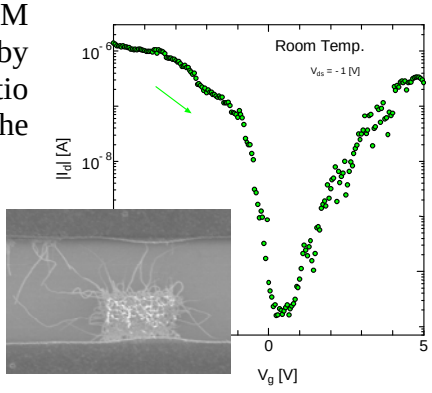


Figure 1. Transfer characteristics of the fabricated device (inset).

References:
[1] S. J. Tans et al., *Nature* **393**, 49 (1998).
[2] N. R. Franklin et al., *Appl. Phys. Lett.* **81**, 913 (2002).
[3] R. Xiang et al., *J. Am. Chem. Soc.* **131**, 10344 (2009).
[4] Y. Murakami et al., *Chem. Phys. Lett.* **377**, 49 (2003).
[5] Y. Murakami et al., *Chem. Phys. Lett.* **385**, 298 (2004).

*Email address: maruyama@photon.t.u-tokyo.ac.jp