Thursday, July 1

15:33-17:00 Poster Session 5

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Characterization of Thin Film Transistor Using As-grown Single-walled Carbon Nanotubes from Dip-coated Catalyst by Patterned Removal of Self-assembled Monolayer

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A carbon nanotube field effect transistor (CNT-FET) having a single-walled carbon nanotube (SWNT) as its gate channel has been investigated because of its potential applications in next-generation nanoscale organic electronic devices. However, the fabrication process using conventional MEMS techniques has many steps and it limits catalyst coating method to a dry process, such as vacuum evaporation. We previously reported that it is possible to pattern the growth of SWNTs using a wet process such as dip-coating by making hydrophilic and hydrophobic regions on a substrate surface [1]. In this study, we fabricated and evaluated the performance of a thin film transistor consisting only of as-grown SWNTs by selectively removing a self-assembled monolayer (SAM) from the catalyst deposition area. An octadecyltrichlorosilane SAM was used to make pattern on a Si substrate as follows: The SAM was formed on an OH-terminated Si surface and was selectively removed by vacuum ultraviolet (VUV) irradiation through a photomask to pattern the substrate. After SAM removal, the substrate was dipped into a Co solution to deposit catalyst [2], and SWNTs were grown by alcohol CVD (ACCVD) [3] only in the regions that had been irradiated by VUV. The I-V characteristics were measured using the Si substrate as a back-gate and the SWNT pads as source/drain electrode. The I-V characteristics of the fabricated device and possibility of transfer to a flexible substrate will be discussed. [1] JACS. 131, 10344 (2009). [2] CPL. Lett. 377, 49 (2003). [3] CPL. 360, 229 (2002).

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Field alignment of carbon nanotubes during growth and emission

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The inter-relation between the orientation angle of a tilted carbon nanotube and applied electrical field strength has been derived. In accordance to this relation, the resulting orientation angle is determined on the basis of the mechanical balance between the electric torque and the elastic mechanical torque. This inter-relation is used for evaluation of the I-V characteristics of a CNT-based cathode consisted of initially tilted nanotubes. The degree of deviation of these characteristics from the conventional Fowler-Nordheim function depends on both the average initial tilting angle of nanotubes and the Young modulus of the nanotubes. Contact potential difference caused by a difference in the electron work functions between the nanotube and the substrate results in charging the nanotubes which causes the self-tilting of CNTs comprising the array. The angle of self-tilting increases as the distance of the center of the array increases. Taking into account self-tilting of CNTs due to the contact potential difference changes the current-voltage characteristic of an array so that the optimum inter-tube distance depends on the average electrical field strength.

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Stability of Transparent SWNTs and DWNTs Network Films

Seung Bo Yang, *KAIST*

We studied the stability of single-walled carbon nanotube (SWNT) and double-walled carbon nanotube (DWNT) films as a function of surface modification. Conductivity measurements disclosed that gold ion and HNO3 treatment of the nanotube network films increased the electrical conductivity by more than a factor of 2 with negligible loss of transmittance. However, the long-term stability of the films varied depending on nanotube type and post-treatment method, with gold ion-treated nanotubes exhibiting higher stability than HNO3-treated nanotubes. Moreover, DWNTs showed better stability than SWNTs when treated with gold ions. Work function and optical absorption spectral measurements suggested that the dedoping process and the contact resistance of the nanotube networks may be important for stability under ambient conditions. These results are important for the development of surface-modified SWNTs and DWNTs for potential applications in solar cells, light-emitting diodes, sensors, and field-effect transistors.

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Unbundled semiconducting single-wall carbon nanotubes for thin film transistors

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Single-wall carbon nanotubes (SWCNTs) are expected as a promising material for thin film transistors (TFTs) because of their high carrier mobility, flexibility, and solution processability. Recently, we have reported a fabrication method of the networks of purely unbundled SWCNTs, and these networks show a high transistor performance even without the removal of metallic SWCNTs [1]. For further improvements, the use of highly-pure semiconducting SWCNTs is desirable. In this study, we have fabricated the TFTs using the networks of unbundled semiconducting SWCNTs. The SWCNTs were purchased from Meijo Inc. (So-type) and used as a starting material. Semiconducting SWCNTs were separated by using gel chromatography [2,3]. To fabricate TFTs, the sample solution was displayed on an amino-coated Si/SiO2 substrate, followed by the deposition of Ti/Au electrodes. The device has an on/off ratio of ~10^6 and a mobility of ~3 cm2V-1s-1. In this presentation, a detailed comparison of TFT characteristics between the pristine and the separated samples will be discussed. [1] Y. Asada et al. Adv. Mater. in press. [2] K. Moshammer et al., Nano Res., 2, 599 (2009) [3] T. Tanaka et al., Appl. Phys. Express, 2, 125002 (2009)

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New characteristics of carbon nanotube networks in electrolytes

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For applications in sensor devices carbon nanotube field effect transistors are of great interest due to the remarkable electronic characteristics of the nanotubes. Many of the published devices are single-tube transistors that are laborious to produce and very susceptible to defects of the one connected nanotube. We report on easily and reproducibly manufactured devices and their electronic behaviour when gated through an electrolyte