Local Transport Analysis in Network of Carbon Nanotubes by Scanning Gate Microscopy

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Abstract

Carbon nanotubes (CNTs) have been regarded as one of the most fascinating materials for scientific researches and industrial applications because of their potential for high-speed electronics due to the high electron velocity in CNTs and for flexible electronics due to their elasticity. Scanning gate microscopy (SGM) is one of such techniques for local study in semiconductor nano-structures. It has been applied for FETs consisting of a single-wall carbon nanotube (SWNT) and the networks.

In this study, we have applied the technique for the study of SWNT thin-film FET to determine the mechanism of the FET operation. Two kinds of SWNTs, synthesized by CoMoCAT® process (sample A) and semiconductor enriched ones by density gradient ultracentrifugation (DGU) (sample B), were used in this study. Clear SGM responses were observed only at some points but not uniformly in a whole of the channel. We found that almost all of SGM responses come from inter-tube junctions in sample A. One of the possible mechanism is that a modulation of Schottky barrier between the metallic/semiconducting SWNT existing in the network. In contrast to the experiments, SGM images observed in sample B showed different responses; several concentric rings have been observed corresponding to somewhere of intra-tubes. Recurrence of rings was observed in the back gate voltage sweep. Such ring structures in a SGM image indicate resonances with discrete energy levels in the SWNT network. Recently, we succeeded to observe local current-voltage characteristics at the SGM-active region. Step-like current-voltage characteristics and diamond-shaped contour plots are successfully visualized from the local SGM responses. It can be suggested that these responses would be attributed to the presence of Coulomb blockade effect at quantum dots formed in SWNTs.