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表面機能化触媒を用いたプラズマCVDによる単層カーボンナノチューブのカイラリティ制御合成

Plasma CVD Synthesis Single-Walled Carbon Nanotube using Surface Functionalized Catalyst

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Single-walled carbon nanotubes (SWNTs) are regarded as promising candidates using as the materials for fabricating high performance optoelectrical devices, since they have many outstanding properties such as flexibility and high carrier mobility. However, towards further application of SWNTs, chirality control of SWNTs is still remained as a very critical issue to be solved, because the physical properties of SWNTs are decided by the chirality. In order to obtain high purity SWNTs with specific chirality, our group has been working on chirality-controlled SWNTs growth and some progresses have been made towards the growth of narrow chirality-distributed SWNTs using the unique technics such as precise time-controlled plasma CVD and Au-catalyzed SWNTs synthesis [1-3]. To fully utilize the potential ability of SWNTs in future optoelectrical applications, further improvement of controllability for chirality-selective synthesis of SWNTs is required. In this study, we improved the previous method and developed a process for the chirality tuning of narrow chirality-distributed SWNTs.

SWNTs growth was carried out by diffusion plasma CVD system [1-3]. The methane and hydrogen mixture gas was used as a source gas and radio-frequency (RF; 13.56 MHz) power was supplied to the coils to generate inductively coupled plasma. The cobalt and molybdenum catalysts hold on a zeolite powder was used as a catalyst, which was set in the downstream region of plasma, enabling ion-damage free and high-quality synthesis of SWNTs. We introduced the catalyst -pretreatment process before the plasma CVD to control the surface state of catalysts.

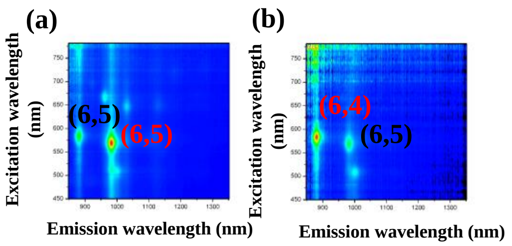

Fig. 1 PLE map of (a) (6,5) dominant and (b) (6,4) dominant SWNTs grown by plasma CVD.

Figure 1(a) shows typical photoluminescence-excitation (PLE) map of SWNTs grown without the catalyst pretreatment. The (6,5) SWNTs were dominantly grown with narrow-chirality distribution as similar with previous works [1-3]. Interestingly, the chirality distribution of SWNTs drastically changed with the catalyst-pretreatment process. The dominant chirality species changed from (6,5) SWNTs to (6,4) SWNTs (Fig. 1(b)). Then, systematical investigations were carried out aiming for finding out the changes of catalyst structures occurred during the catalyst-pretreatment process. Atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), and transmission electron microscopy (TEM) measurement were carried out to analyze the catalyst structures and surface state. It is found that there are clear differences not in the particle size but the surface state of catalyst before and after the catalyst pretreatment, which indicate that chirality of SWNTs are very sensitive to the surface state of catalyst and show us the possibility of controlling SWNTs by the well-controlled catalyst surface functionalization. Overall, we think that our findings can contribute to the growth of single chirality SWNTs with high purity.

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