Growth and field effect transistors of C_{60} nanowhiskers using pyridine

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Abstract

Fullerene nanowhiskers (FNWs) grown by the liquid-liquid interfacial precipitation (LLIP) method have attracted much interest due to unique properties. Pyridine is one of the good solvents for C_{60} and considered to have a large interaction with C_{60}. Here, we report the synthesis of C_{60} nanowhiskers using pyridine (C_{60}-pyridine NWs) and the characteristics of its field effect transistors (FETs). The vacuum-dried C_{60}-pyridine NWs show n-type semiconducting properties. After annealing at 100°C, the current value increased, and the electron mobility was measured to be 2.9×10^{-4} cm^2 /Vs in the bottom contact devices. The preliminary results for the fabrication of top contact FET devices will be also shown in this presentation.

1. Introduction

Fullerene C_{60} or C_{70} nano- and micro-crystals including FNWs grown by the LLIP method have attracted much interest due to unique physical properties such as mechanical[1,2)] and electrical properties[3,4)]. Pyridine is one of the good solvents for C_{60} and considered to have a large interaction with C_{60}[5)]. Such interaction may lead to the formation of novel C_{60} nanowhiskers (C_{60}NWs) with unique mechanical and electrical properties. In this study, we report the synthesis of C_{60}-pyridine NWs and the characteristics of its FET properties.

2. Experiment

C_{60}-pyridine NWs were grown by the LLIP method with pyridine and 2-propanol as good and poor solvent, respectively. The morphology and structure of the grown C_{60}-pyridine NWs were characterized by optical microscope (OM), scanning electron microscope (SEM), powder X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR) and Raman spectroscopy. The electrical properties of C_{60}-pyridine NWs were characterized by bottom contact FET devices fabricated by dropping some C_{60}-pyridine NWs on SiO_2/Si substrates. Dropped C_{60}-pyridine NWs were used to bridge the two electrodes (source and drain) as shown in Fig. 1. The electrical characteristics were measured under a vacuum of ~10^{-3} Pa. Furthermore, to remove the absorbed H_2O and O_2, as previous study about C_{60} NWs[6)] and C_{70} NWs[4)] , the fabricated device was annealed for approximately 12 days at 100°C. Generally, the electrical contact between sample and electrode in the top contact FET devices is better than that in the bottom contact. To enhance electrical contact of C_{60}-pyridine NWs, we also fabricated top contact FET devices by depositing Ti and Au onto C_{60}-pyridine NWs.

3. Results and discussion

From OM and SEM images, the obtained C_{60}-pyridine NWs have fiber-like shapes as shown in Fig. 1. The average diameter of C_{60}-pyridine NWs is 293±162 nm which is very thin compared to other C_{60} NWs. The crystal structure of C_{60}-pyridine NWs is identified as an FCC with poor crystallinity by XRD measurement. The lattice constant is determined as 14.28 Å. From FT-IR analysis, C_{60}-pyridine NWs contain pyridine solvent. The FET based on vacuum-dried C_{60}-pyridine NWs exhibits n-type semiconducting properties. After annealing at 100°C (Fig.2), the current value increased, and the maximum electron mobility was measured to be 2.9×10^{-4} cm^2 /Vs in the bottom contact devices. The value of the mobility is much lower than those of other C_{60}NWs[6] and C_{70}NWs[4] grown by LLIP method using chlorobenzene and *m*-xylene, respectively. In addition, the top contact FET devices for C_{60}-pyridine NWs were also fabricated and measured. The preliminary results for the top contact FET devices will be shown and discussed comparing with the results obtained in the bottom contact devices.

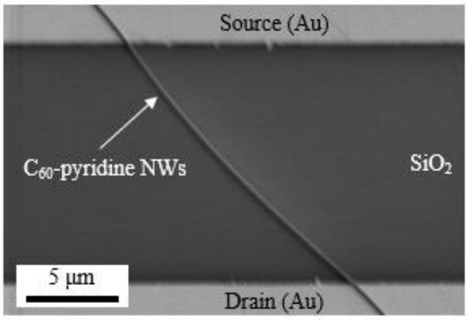

Fig.1 SEM image of C_{60}-pyridine NWs between source and drain electrodes.
(bottom contact device)

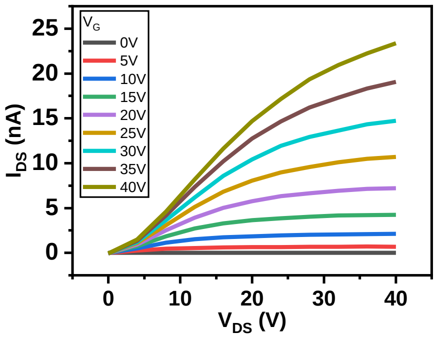

Fig.2 Output characteristics of the FET based on C_{60}-pyridine NWs after annealing at 100°C.
(bottom contact device)

4. Conclusions

We have synthesized C_{60}-pyridine NWs by LLIP method and measured characteristics of its FET properties. The FET based on vacuum-dried C_{60}-pyridine NWs exhibits n-type semiconducting properties. The maximum electron mobility was measured to be 2.9×10^{-4} cm^2 /Vs after annealing 100℃ under a vacuum of ~10^{-3} Pa. The possibility of the higher mobility will be discussed comparing with the result for the top contact FET devices.

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