Poster

Multiwalled carbon nanocoils synthesized by the catalyst of uniformly composed Fe-Sn

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Carbon nanocoil (CNC) is a kind of promising nanomaterial, that can be widely applied to electromagnetic wave absorber, parts for nano electromechanical systems, field-emission devices [1] etc. CNCs have been successfully synthesized by the catalysts of Fe/ITO [2] or Fe-In-Sn-O [3] so far. However, CNCs synthesized by these catalysts are lack of crystallinity, which may result in their relatively lower mechanical strength and electric conductivity compared with the normal multiwalled carbon nanotubes (CNTs). We have developed a new method to prepare the thin catalyst film, in which Fe and Sn clusters are uniformly composed. It is found that this method is valid in synthesizing CNCs that have much higher crystallinity than conventional CNCs.

Thin films consisting of Fe and Sn clusters were prepared by an arc plasma discharge method, where two sources of Fe and Sn can be evaporated alternatively or simutaniousely to fabricate the Fe-Sn thin films by co-deposition or by layer-by-layer deposition on SiO_2/Si substrates as shown in Fig. 1. The compositions of Fe and Sn in the films were controlled by the number of pulse discharge. The samples were then annealed at 150°C in air for 12 hours in order to oxidize the catalysts to prevent the Sn from vaporization during heating process. Carbon nanocoils were synthesized by the thermal CVD at 700°C for 15 min by introducing acetylene gas of 30 sccm in a He flow with a rate of 230 sccm.

Figure 2 shows the AFM images of the changes of the catalyst surfaces of co-deposited 4-nm-thick Fe-Sn (a) as deposited, (b) after annealing in air, (c) after heating to 700°C, and (d) after 1 s acetylene supply, respectively. It is found that the process of (a) to (c) is similar to that of a 4-nm-thick Fe film used for growth of multiwalled CNTs. The large difference appears in the process (d) where large particles with the diameters of larger than 40 nm are formed in the Fe-Sn catalyst, whereas only particles with diameters of 10 to 20 nm are formed in the case of thin Fe film. This is speculated to be resulted from the Sn, which has a lower melting point and a different surface energy from Fe. It is revealed by SEM observation that the CNCs are grown in a higher yield by the co-deposited Fe-Sn than by the multilayered catalyst, suggesting that the uniformly composed Fe-Sn catalyst is more valid in synthesizing CNCs. The coil diameters of grown CNCs are less than 100 nm, which are thinner than those of the conventional CNCs synthesized by the Fe/ITO catalysts [2]. The line diameters of these CNCs are around 20 nm, which is the same as the CNTs grown under the same CVD conditions by Fe catalyst. Figure 3 shows the TEM images of a grown CNC, composed of a coiled CNT with some strains in its body, which is called multiwalled CNC. It is also found that the multiwalled CNCs have a possible base growth mechanism, which is different from that of conventional CNCs with a tip growth mechanism [2]. The high potential of the thinner and high crystallized multiwalled CNCs indicates that they would have wide applications in new nanotechnology.

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References:

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[2] M. Zhang, Y. Nakayama, and L. Pan, Jpn. J. Appl. Phys. **39** (2000) L1242.
[3] T. Nosaka, O. Suekane, and Y. Nakayama: Abstr. Int. Conf. Science and Application of Nanotubes, 2003, p. 42.

Figures:

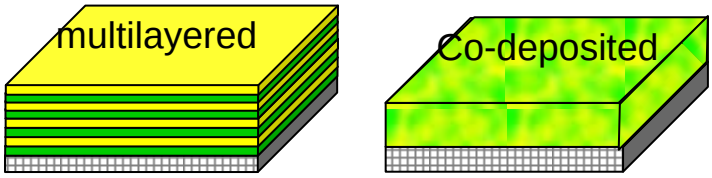

Fig. 1. Structures of two kinds of deposited Fe-Sn thin films

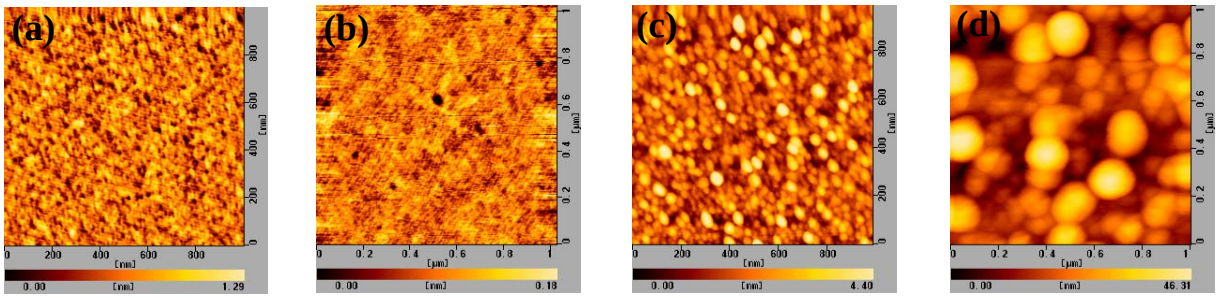

Fig. 2. AFM images of the surfaces of the co-deposited Fe-Sn catalyst (a) as deposited, (b) after annealing in air, (c) after heating to 700°C, and (d) after 1 s acetylene supply.

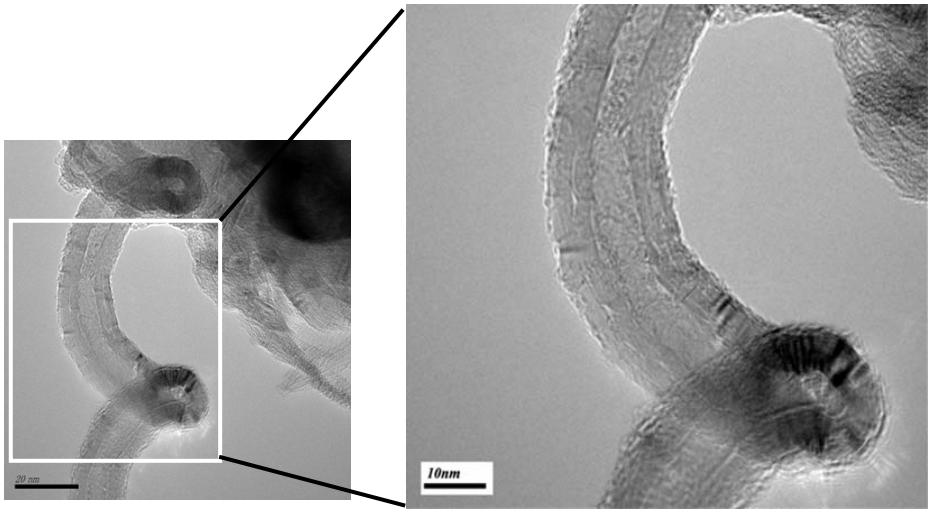

Fig. 3. TEM images of a synthesized CNC