A novel route of carbon nanotube production in organic liquid

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Well-aligned carbon nanotubes arrays were grown on silicon substrates by using a novel catalytic method in organic liquid such as alcohols. Un-equilibrium catalytic deposition gave significantly pure carbon nanotubes with very little soot within a few minutes in methanol and/or ethanol. Scanning electron microscope images indicate that the nanotubes arrays are grown perpendicular to the silicon substrate surface with a significantly high density like a flower arrangement frog. This very fast and dense production of carbon nanotubes can be attributed to the great difference of chemical potential between the substrate surface and reactant liquid.

We report a simple and efficicient method for large scale production of carbon nanotubes on silicon substrates. The reactor chamber consists of glass flask and glass condenser and tubes (Fig. 1). The iron oxide was used as a catalyst precursor with 4～12nm thickness on the silicon substrate prepared by the magnetron spattering method. Before the reaction, the reactor was purged with N2 to avoid an unexpected explosion. The substrate was placed directly in alcohol and resistively heated at 800～1200°C. The reactor was cooled in a cooling water bath to keep the liquid temperature below the boiling point. Although the substrate surface temperature was over 800°C, the surrounding liquid temperature was kept around room temperature. After the reaction for 1～5minutes, the sample was taken out from alcohol and dried. This method can provide large quantities of carbon nanotubes. The sample was characterized by a scanning electron microscope (SEM) and transmission electron microscope (TEM). No deposition was observed at the reaction less than 600°C. The reaction over 700°C gave a significant amount of carbon materials on the silicon substrate surface. Figure 2 shows SEM images the carbon nanotubes on silicon substrate grown at 800°C in 1-octanol. TEM observation revealed that these nanotubes were typical hollow malti-walled carbon nanotubes.

1) Y. F. Zhang et al. J. Jpn. Appl. Phys., ***41***, L408 (2002).
2) Y. F. Zhang et al. J. Mater. Res., ***17***, 2457 (2002).

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Fig. 1 Chamber for synthesis of carbon nanotubes in organic liquid

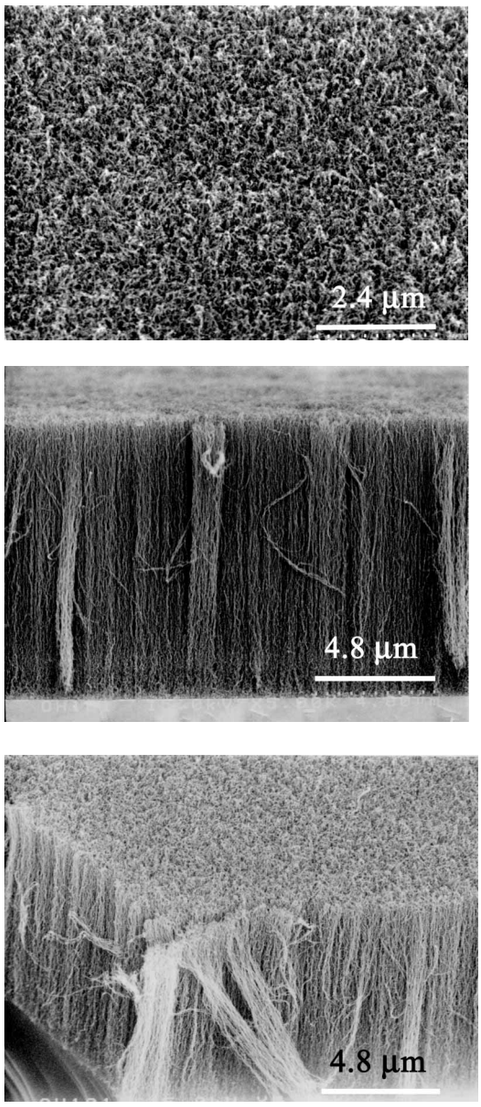

Fig. 2 SEM images of the carbon nanotubes synthesized in 1-octanol, (a) top view, (b) cross sectional view, and (c) birds eyes view