Anodic aluminum oxide template assisted growth of vertically aligned carbon nanotube arrays

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Abstract

In order to utilize the excellent field emission properties as specific applications, ordered carbon nanotubes (CNTs) arrays with controllable length and density has become an important issue. Highly CNTs have been successfully grown in vertical channels of the anodic aluminum oxide (AAO) template by microwave plasma electron cyclotron resonance chemical vapor deposition (ECR-CVD). Nanoporous AAO templates with hexagonal pore pattern were prepared by the two-step anodization of Al films. Following the electroplating of Co catalyst into the pore bottom, multiwalled CNTs were synthesized in the ECR-CVD system using a gas mixture of CH_4 and H_2. The microstructure of the CNTs was studied by scanning electron microscopy (SEM) and transmission electron microscopy (TEM). The CNTs with a very high packing density and a uniform size distribution are well-graphitized, and Co particles embedded at their tips implies the tip growth mechanism. The segments of CNTs stretching

out of the AAO nanopores still maintain relatively good alignment, and have a very slow growth rate, which allows us to obtain reproducible tube length by tuning the growth time. Field emission measurements of the CNTs showed derivable electron emission properties, attributed to their uniformity in size, good alignment, and good graphitization properties. Moreover, a simple method was proposed to control the tube number density of the Co-catalyzed CNTs on AAO template, which was realized by *in situ* regulating the flow rate ratio of CH_4/H_2 precursor gases during the CNT growth. The amorphous carbon byproduct of CNT growth was employed to confine the CNT outgrowth from AAO nanopores. There was a competition reaction between the CNT growth and the amorphous carbon deposition. It was found that the number of CNTs escaped from the AAO nanopores decreases linearly following the increase of the CH_4 concentration. The field emission of the AAO assisted CNTs can be optimized by tuning the tube number density.