Nitrogen-Incorporated Single-Walled Carbon Nanotubes for Devices

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We synthesized single-walled carbon nanotubes (SWNTs) with small diameter and narrow diameter distribution using acetonitrile (AcN)-mixed ethanol (EtOH) feedstock. Due to the presence of nitrogen (N) during synthesis, the SWNT mean diameter was dramatically reduced from approximately 2.1 nm to less than 1 nm as AcN was added as carbon source [1, 2]. Surprisingly, the main nitrogen configuration was found to be encapsulated diatomic N_2 molecules interior of SWNTs with the content of 1 at % [3, 4]. As the sequence of feedstock was switched during synthesis, SWNT diameter was changed along the vertically aligned array. A majority of nanotube junctions between two different diameter nanotubes were found to be discontinuous, while a minority of continuous junctions were revealed by high-resolution transmission electron microscope [5]. This diameter modulation was reversible upon the sequence of feedstock introduction. Additionally, the observed N_2 molecules on the top of double-layered SWNT vertical array, where the top layer was EtOH-grown array, imply that encapsulated N_2 molecules were migrating across nanotube junctions, indicating a viability of connected SWNTs with different diameters. We also address the role of nitrogen on influencing the SWNT diameter in which nitrogen affects only the surface of the catalyst particle, resulting in a change from the Octopus to the VLS growth mode, which results in a smaller diameter. Several devices using this nitrogen-incorporated SWNTs will be discussed.

References

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