Growth of Single-Walled Carbon Nanotubes with Controlled Structure

Jin Zhang*
Peking University, Beijing 100871, P. R. China.
Email: jinzhang@pku.edu.cn

Single-walled carbon nanotubes (SWNTs) are star candidates for next-generation micro- and nano-electronic devices due to their unique one-dimensional nanostructures and excellent electrical properties. However, due to the structural diversity of carbon nanotubes, the preparation of SWNTs is still facing the challenge of achieving both high purity and high yield at the same time, which has become a bottleneck in realizing their applications. Synthesis determines the future. In order to promote carbon nanotubes to the industrial production and real application, the controlled growth of SWNTs is imperative. Therefore, our research focuses on the structural controlled growth of SWNTs, aiming at realizing the direct growth of wafer-scale, high-density, structurally controllable horizontal arrays of SWNTs. This report mainly includes: the controlled growth of SWNTs with specific chirality through the design of solid catalysts and the regulation of nucleation thermodynamics and growth kinetics; growth of ultra-high-density SWNT arrays using Trojan catalysts; the development of a new catalyst loading method, ion implantation, and a vertical spray CVD system to achieve the direct growth of wafer-scale uniform, high-density SWNT arrays; and the establishment of a new characterization technique combining AFM with polarization optics to realize high-throughput characterization of wafer-scale arrays. Most recently, we developed an artificial intelligence (AI)-driven platform that integrates transformer-based language models tailored for carbon materials, robotic CVD, and data-driven machine learning models. Over a period of only 43 days, it exhibited marked advances in both catalyst innovation and controllable growth of SWNT arrays, accelerating the research of carbon nanotube synthesis.