Wafer-Scale Films and Devices of Spontaneously Aligned Carbon Nanotubes

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Despite many years of worldwide efforts, there is still no established method available for producing large-area single-domain films of highly aligned, densely packed, and chirality-enriched single-wall carbon nanotubes (SWCNTs). Here, we have developed a new process of vacuum filtration to produce a wafer-scale (i.e., inch-size) film of aligned SWCNTs [1]. This method works for SWCNTs synthesized by various methods and can be scaled up in all three dimensions. We fully characterized the produced large-area films through different microscopy, spectroscopy, and transport methods, demonstrating nearly perfect global alignment with extraordinary photonic and optoelectronic properties. The strikingly high degree of alignment of our films with a nematic order parameter of ~ 1 and a thickness of ~ 100 nm distinguishes our method from both existing two-dimensional and three-dimensional post-growth assembly techniques. We investigated the underlying mechanisms based on a proposed model of two-dimensional confinement induced phase transitions. We identified the factors that affect the degree of alignment, including the filtration speed, the SWCNT concentration, the surfactant concentration, the hydrophilicity of the filter membrane surface, the SWCNT length, and the SWCNT diameter.

1. X. He, W. Gao, L. Xie, B. Li, Q. Zhang, S. Lei, J. M. Robinson, E. H. Hároz, S. K. Doorn, R. Vajtai, P. M. Ajayan, W. W. Adams, R. H. Hauge, and J. Kono, “Wafer-Scale Monodomain Films of Spontaneously Aligned Single-Walled Carbon Nanotubes,” *Nature Nanotechnology*, published online on April 4, 2016, doi:10.1038/nnano.2016.44.