Continuous direct production of carbon nanotube films and fibers by floating-catalyst CVD

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Macroscale carbon nanotube (CNT) architectures, especially films and fibers, are desired for both fundamental research and potential applications [1]. Here, continuous CNT films and fibers are directly produced by floating-catalyst chemical vapor deposition (FCCVD). Based on the hydrocarbon-FeCp2 FCCVD system, the tubular CNT films can be directly and continuously fabricated with transformation from CNT aerosol into CNT aerogel in the process of CNT synthesis. The optimized synthesis process manifests a high carbon efficiency (~ 60%), high extrusion yield (hundreds of meters per hour), and stable controllability in the fabrication of freestanding films. Specially, this continuous CNT films have excellent transparent and conductive performance (Fig.1). The sheet resistance of as-synthesized film is aroud 180 Ω/sq for transmittance of 90%. The film conductivity can be improved by 3~4 times with chloroauric acid doping (sheet resistance / transmittance, ~50 Ω/sq / 90%). Moreover, the continuous CNT fibers can be directly fabricated by shrinking tubular CNT films with liquid [2]. For performance improvement, as-prepared fibers are further post-treated by acid resulting in the compaction and surface modification of the CNTs in fibers, which are beneficial for the electron and load transfer. Compared to the HNO_3 treatment, $HClSO_3$ or H_2SO_4 treatment is more effective for the improvement of the fibers' properties. After $HClSO_3$ treatment for 2 h, the fibers' strength and electrical conductivity reach up to ~2 GPa and ~4.3 MS/m, which are promoted by ~200% and almost one order of magnitude than those without acid treatment, respectively. The load-bearing status of the CNT fibers are analyzed based on the downshifts of the G' band and the strain transfer factor of the fibers under tension. The results reveal that acid treatment could greatly enhance the load transfer and inter-bundle strength. With the $HClSO_3$ treatment, the strain transfer factor is enhanced from ~3.9% to ~53.6%. Because of its low set-up cost and high production yield, scalability, and degree of control, this advanced FCCVD has potential in the fabrication of CNT-based transparent electrodes and high-performance fibers.

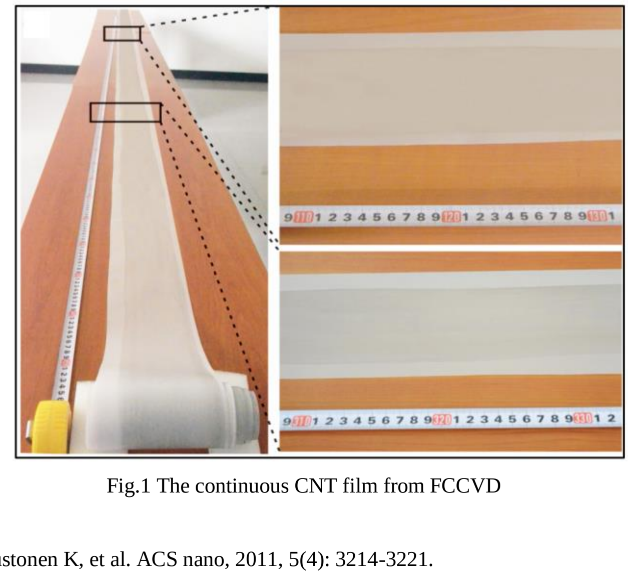

Fig.1 The continuous CNT film from FCCVD

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