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Production and Functionalization of Carbon Nanotubes for Energy Devices

(Sub)millimeter-long carbon nanotubes (CNTs) are attractive for use as current collectors in electrochemical energy storage devices due to their ability forming light-weight, self-supporting, electrical conductive, sponge-like films which can capture any capacitive materials. Such long CNTs have been synthesized on 2D substrates [1,2] but their efficient synthesis in 3D reaction space is important to meet the cost and scale requirements for such devices. We have realized batch and semi-continuous production of submillimeter-long single-wall [3] and few-wall [4,5] CNTs by fluidized bed chemical vapor deposition (FBCVD), in which 70% of C_2H_2 is converted to CNTs within 0.3 s (Figure 1) [4]. We use spherical ceramic beads instead of porous powder as catalyst support to retain CNT structure similar to on-substrate CVD and to enable easy separation of CNTs from the beads. The as-synthesized CNTs have a carbon purity >99 wt% with metal impurity <0.1 wt% [5] and ready for use without purification for many purposes. A tiny amount of CNTs as small as 1 wt% can capture capacitive particles of 99 wt% without any polymeric binder nor metal foil and yield self-supporting film electrodes, and a lithium ion full cell with $LiCoO_2$-CNT cathode and graphite-CNT anode is demonstrated (Figure 2) [6]. This CNT-based electrode architecture is effective to create electrodes of the emerging active materials such as Si anode [7] and S cathode with practically high gravimetric, areal, and volumetric loadings.

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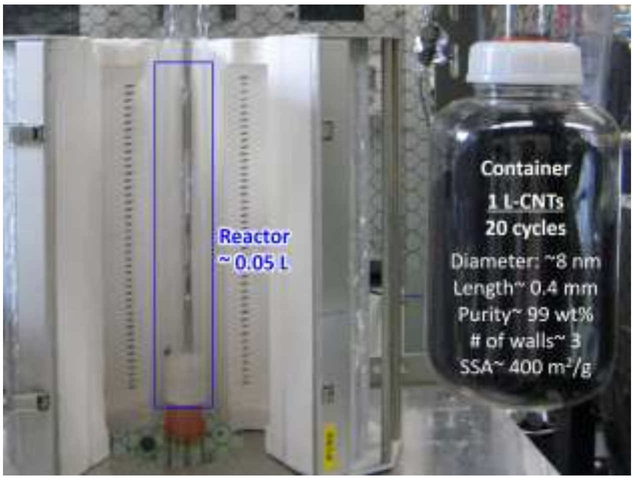

Figure 1: Semi-continuous, high-yield production of 500 µm-long, 99 wt%-pure few-wall CNTs by FBCVD [4].

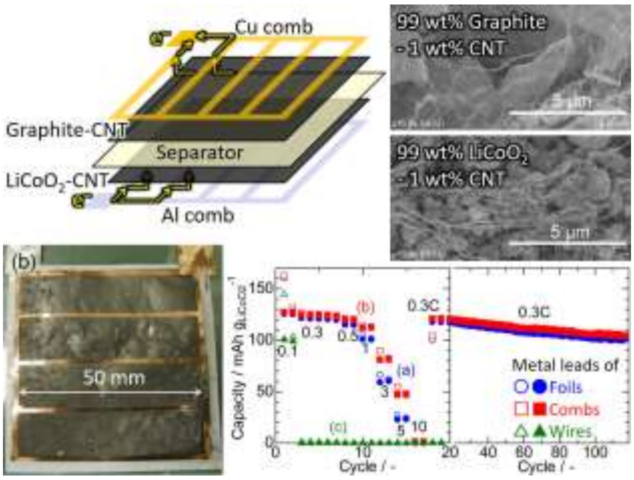

Figure 2: Lithium ion full cell with $LiCoO_2$ cathode and graphite anode based on CNT 3D current collectors [6].