Electronic Supplementary Material

Synthesis and Device Applications of High-Density Aligned Carbon Nanotubes Using Low-Pressure Chemical Vapor Deposition and Stacked Multiple Transfer

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We observed that the stacked multiple transfer process is sensitive to the thickness of the gold film. However, it is highly reliable and reproducible when gold film of the appropriate thickness is used. We tested the multiple transfer using 30 nm and 100 nm gold films, and the results are summarized in Fig. S-1. For the test, samples with relatively small catalyst stripe spacings were used, and the SEM images were intentionally taken at locations where different transferred layers are slightly shifted and rotated, so that nanotubes from different transferred layers can be clearly identified. We found that when thin gold film (30 nm as used in this work) was used, the nanotubes all collapsed onto the substrates during the etching process for samples with one-time, two-time, and three-time transfers (Figs. S-1(a)–S-1(c)). The transfer yield was close to 100% and the nanotubes remained relatively straight for all the samples tested. In contrast, when thicker gold film (100 nm) was used, the transfer yield decreased as the number of transfers was increased (Figs. S-1(d)–S-1(f)). For the sample with

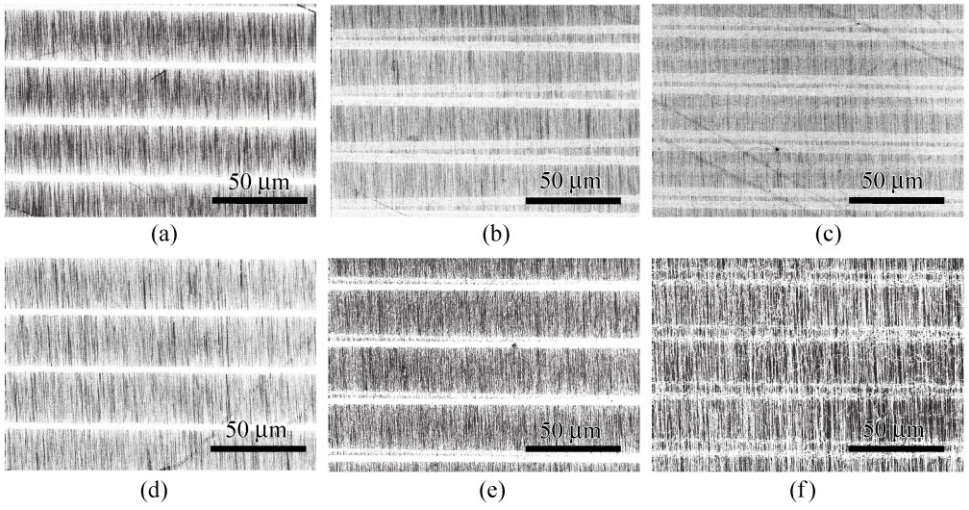

Figure S-1 Stacked multiple transfer using gold films of different thickness. (a, b, c) FE-SEM images showing the samples with (a) one-time, (b) two-time, and (c) three-time stacked transfer using 30 nm gold films. (d, e, f) FE-SEM images showing the samples with (d) one-time, (e) two-time, and (f) three-time stacked transfer using 100 nm gold films

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three-time transfer using 100 nm gold film, the nanotubes also became very wavy (Fig. S-1(f)). Therefore, in order to achieve high-yield stacked multiple transfer, it is crucial to use thin gold films and also minimize the perturbation during the gold etching process. Moreover, as the density increases, the demands on the orientational alignment increase. For our multiple transfer processes, the misalignment between different transferred layers is typically < 0.5°, and no more than 2° for the extreme cases. This is achieved by using accurately diced quartz samples and performing careful alignment during the multiple transfer processes.