Analysis and understanding the regrowth of Multi-walled carbon nanotube forests

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The growth of spin-capable multi-walled carbon nanotubes (MWCNTs) on metal catalyst has been a topic of key interest in recent years. [1, 2] The growth of densely packed arrays of aligned MWCNTs would be limited by the rate of carbon diffusion through its catalyst particle and the growth rate of the CNTs has also been supposed to be limited by the supply of carbon source from the gas phase. In addition, the growth rate of a CNT is faster when there is a greater area of catalyst particle not covered by carbon and cleaned catalyst surface. This would lead to carbon supply can limit growth for the CNTs as a greater exposed catalyst surface area would lead to a greater amount of decomposed carbon species.[3, 4]

It is generally accepted that CNTs grow as carbon precipitates from supersaturated catalytic metal nanoparticles. The growth mechanisms are classified into base growth or tip growth, depending on whether the metal and nano-particle remains anchored at the support or not. A previous paper[5] demonstrated that the two mechanisms could occur at the same time, and hence the original catalytic nano-particle separates into two parts during growth. After removing the CNT forest grown, a part of catalytic nanoparticle was left on the substrate, which can be used for subsequent CNT growth without additional catalyst. This repeated growth of CNT forest is called regrowth process, and the diameter of CNT can be reduced in accordance with the reduced catalyst size.

Figure 1 shows a SEM image of the nano-particles before the growth and after removing CNTs. The MWCNT forest was completely removed and donut-structured particles were observed on the surface. It shows that the hole inside the donut corresponds to the footprint of CNTs being removed, and that the donut to the residual amorphous carbon which was deposited during growth. The diameter of CNTs is reduced with repeated growth cycles, an effect of which is attributed to the diminishing size of the catalytically active nanoparticles with each cycle. After two growth cycles, the diameter of MWCNT can be narrowed with the reduced catalyst size.

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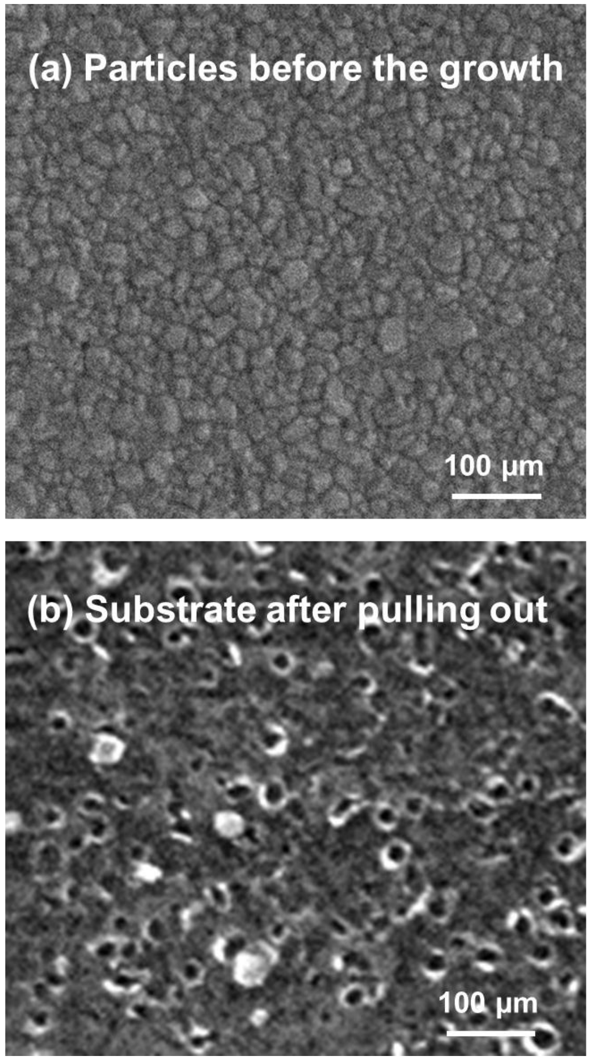

Figure 1: The high resolution SEM images of the substrate (a) before the growth and (b) after removing CNTs.