Dendrimer Assisted Growth and Patterning of Large Area Multiwalled Carbon Nanotubes mats

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Mats of Carbon Nanotubes (CNT) have been grown on nanometer sized Ni particles delivered by organic dendrimers. These mats of multiwalled CNT by chemical vapour deposition (CVD) can be patterned more easily than conventional Ni islands systems.

Among the different methods used to grow CNTs, CVD has a number of advantages associated with the technique when compared with others. This includes lower temperatures for growth and precise pre-defined locations among others. Due to the lower growth temperature, the growth needs to be assisted by catalytic particles, usually Ni, Fe or Co, that helps decompose the carbon source gas. Traditionally these particles are prepared by thermal annealing of a thin metal film deposited over the desired substrate. These surfaces are often produced by thermally annealing metal films that are either magnetron sputtered or thermally evaporated. As a result the size of the substrates that could be used was dictated by the size of the chamber in which the metal deposition was performed

In this work, the catalyst particles have been prepared by vacuum annealing of nickel carrying organic dendrimers. These have been transported from an aqueous solution onto a silicon substrate using spin coating or soaking (Figure 1a). These techniques are cheap and have the advantage of easy scalability over large areas. Once the dendrimers are deposited, the sample is vacuum annealed to release the nickel particles from inside of the dendrimers. This annealing step causes the coalescence of the dendrimers to form larger nickel particles coated with carbon (Figure 1b). The presence of this carbon layer has an additional advantage as it acts as a barrier for the diffusion of nickel into the silicon substrate avoiding the need for an additional barrier layer, usually Ti or SiO_2.

Multiwalled CNT mats are grown from these nickel particles by the reaction of the Ni catalyst particle with acetylene via CVD. The effect of varying the dendrimer concentration on the final CNT density and diameter is analyzed. High resolution SEM studies also show the characteristic ‘high electron reflection’ at the end of the tubes that is used as a signature for the ‘tip growth’ mechanism of nanotubes (Fig 2). Finally, the dendrimers have been patterned using dip pen nanolithography to control the location of the growth of the tubes.

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Figures:

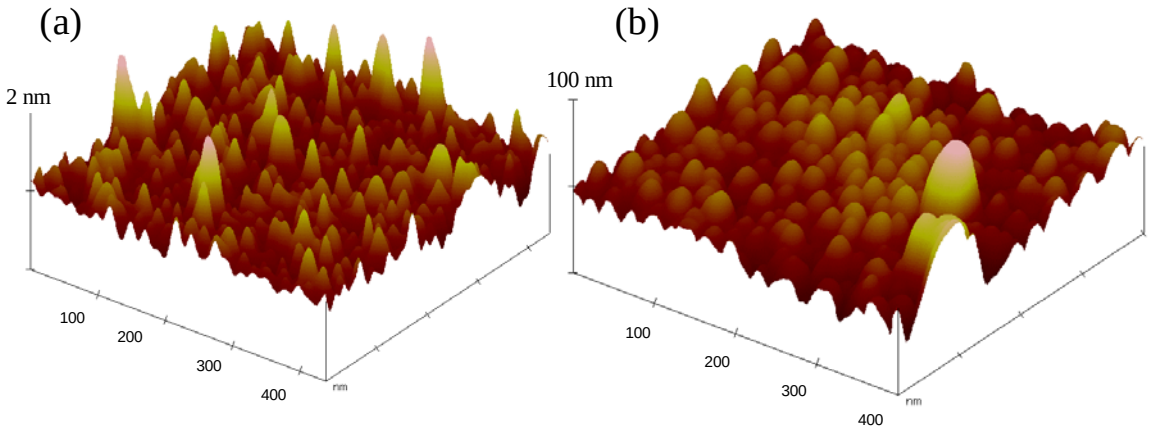

Figure 1: Tapping mode AFM images of (a) as deposited dendrimers (b) annealed dendrimers.

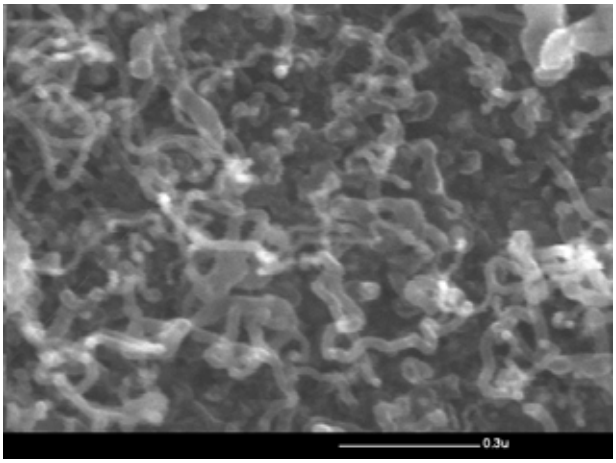

Figure 2: High resolution SEM image of multiwalled carbon nanotubes grown by CVD from nickel dendrimer delivered nanoparticles. The different contrast at the tips of the tubes is associated with the nickel particle, which promotes a tip growth mechanism.

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