Cobalt submonolayer catalyzing growth of single-walled carbon nanotubes elucidated by combinatorial masked deposition method.

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Catalysts of metal nanoparticles for single-walled carbon nanotubes (SWNTs) often suffer from their aggregation and coarsening during chemical vapor deposition (CVD) at elevated temperatures. Metal atoms and/or islands diffuse over substrate surfaces and approach equilibrium structure, i.e. single islands, within the surface diffusion length. If metals of proper thickness are prepared, they will spontaneously form nanoparticles under the CVD conditions with a size suitable to catalyze the growth of SWNTs. However, it is difficult to estimate surface diffusion length for most metal/substrate systems.

In this work, a library of Co patterns with nominal thicknesses ranging from 0.001 to 1 nm were prepared on an a-SiO_2/Si substrate by magnetron sputtering with *"combinatorial masked deposition (CMD)"* method [1], and SWNTs were grown on it by alcohol catalytic CVD [2]. Micro-Raman spectroscopy revealed that high quality SWNTs were formed by submonolayer Co catalysts of nominal thickness between 0.01 and 0.3 nm. Field emission scanning electron microscopy (FE-SEM) revealed that thick Co patterns yielded thick bundles of SWNTs with nanoparticles whereas thin Co patterns yielded thinner bundles or separated SWNTs with fewer nanoparticles. Interestingly, the maximum yield of SWNTs was achieved for Co thickness around 0.1 nm, implying that the spontaneously formed Co nanoparticles have a broad size distribution and only some proportion of the nanoparticles was catalyzing the growth of SWNTs.

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