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Abstract

TITLE:Combinatorial method to find proper thickness of submonolayer metals to catalyze growth of single-walled carbon nanotubes.

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ABSTRACT BODY:The approach to disperse pre-prepared metal catalyst nanoparticles on substrates for the growth of single-walled carbon nanotubes (SWNTs) by chemical vapor deposition (CVD) often suffers from the aggregation and coarsening of nanoparticles at elevated temperatures. On the other hand, it is well known that nanoparticles spontaneously form on substrates by vapor deposition processes. Metal atoms and/or islands diffuse over substrate surfaces and approach equilibrium structure, i.e. single islands, within their surface diffusion lengths. 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. Because it is difficult to estimate the surface diffusion lengths for most metal/substrate systems, in this work, a combinatorial method is proposed and applied to prepare a library of Co patterns. Co patterns with nominal thicknesses from 0.001 to 1 nm were prepared on an a-SiO2/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 thicknesses 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 smaller and fewer nanoparticles. It would be noteworthy that catalyst preparation condition, i.e. Co thickness, was determined by only one experimental run.The combinatorial method developed in this work can be applied to a wide variety of metal/substrate systems and CVD conditions. Furthermore, the catalyst preparation conditions, i.e. nominal thicknesses of metals, derived by this method are expected to be applicable to other catalyst preparation methods including wet processes.

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[2] S. Maruyama, R. Kojima, Y. Miyauchi, S. Chiashi and M. Kohno, Chem. Phys. Lett. 360, 229 (2002).