Investigating the Effect of Heat Pretreatment and Catalyst Mixtures on The Yield of Epitaxially Horizontally Aligned Carbon Nanotubes Grown on St-Cut Quartz

Imad Ibrahim,[1,2] Alicja Bachmatiuk,1 Felix Börrnert,1 Jan Blüher,2Bernd Büchner,1 Mark H. Rümmeli1,[2], and Gianaurelio Cuniberti[,2]

(1) IFW-Dresden e.V., PF 270116, 01171 Dresden, Germany
(2) Technische Universität Dresden, D-01062, Dresden, Germany.

Abstract

Single-walled carbon nanotubes (SWNT) are considered to be a potential material for next generation nano-electronics because of their physical and electrical properties. Their potential as key components for devices has already been proven in different applications including, field-effect transistors and logic circuits. For such applications, it's essential to synthesis SWCNT with controlled spatial position, orientation, alignment, yield and electronic type. One promising synthesis technique used for synthesizing horizontally or vertically aligned SWCNT is chemical vapor deposition (CVD). Using this method, different approaches to grow and control oriented SWNTs horizontally aligned on substrates have been explored, including low gaseous fluxes, electric fields, and selectively cut single crystal substrates such as ST-cut and AT-cut quartz. An important goal behind many of these studies is to control the density of the grown SWNT. Thermal annealing of the substrates prior the CVD process is an often implemented step to improve yield. Nevertheless, the role of the annealing step has not been fully investigated. In this study we systematically investigate the effect of the annealing step on the morphology and smoothness of the used ST-cut quartz substrates, in order to provide excellent conditions for high nucleation yields and allow for unhindered growth leading to long tubes (> 100μm). In addition, the surface morphology is shown to affect the size distribution of the catalyst nanoparticles which in turn affects their propensity to nucleate SWNT. The ratio of the metals (Fe:Co) in the catalyst mix is shown to be a less important parameter for the high yield synthesis of horizontally aligned SWNT on ST-cut quartz. The successful transfer of the grown SWCNTs onto other surfaces without incurring damage is also demonstrated.