

## Density Controlled Growth of Horizontally Aligned Single-Walled Carbon Nanotubes on R-cut Crystal Quartz Substrates

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Alignment control of single-walled carbon nanotubes (SWNTs) is very important for device application. It is known that horizontally aligned SWNTs are grown on crystal quartz substrates along the surface atomic structure [1]. Density of horizontally aligned SWNTs has been improved toward high-performance devices [2, 3]. For further improvement and control of SWNT density, understanding of alignment-growth mechanism is necessary. In this study, we performed chemical vapor deposition (CVD) growth of horizontally aligned SWNTs using R-cut crystal quartz substrate which is cut parallel to the natural R-face (1 0 1). R-cut crystal quartz substrates were pretreated by chemical etching in ammonium hydrogen fluoride and annealing in air at 900 °C. Patterned catalysts were prepared by photolithography and vacuum evaporation and SWNTs were grown by alcohol catalytic CVD method [4] using ethanol as the carbon source gas. Grown SWNTs were characterized by scanning electron microscopy, atomic force microscopy and Raman spectroscopy. It was found that the carbon feeding rate which was determined by both pressure and decomposition rate of ethanol gas affected the density of horizontally aligned SWNTs. Low carbon feeding rate was found to be suitable for high-density growth.

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