Yu, Qingkai, “Horizontally Aligned Growth of Single Wall Carobon Nanotubes and Sic Nanowires for Electronic Application”

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The electronic materials and devices in one-dimensional (1D) nano-structure have been explored enormously in the past decade, because their unique 1D structure and possible quantum confinement effects in two dimensions produce distinctive electronic and photonic properties. The precise control of location, direction, density and length of the 1D nano-structure is still a serious obstacle for many applications. In this thesis, the horizontally-aligned growth of single wall carbon nanotubes (SWNTs) and silicon carbide (SiC) nanowires (NWs) is investigated through several methods, and the mechanisms of the alignment are analyzed and discussed.

In the aligned growth by gas flows, it was found that long SWNTs can be aligned well in the direction of gas flows, but the short ones have random directions. The density of catalysts and concentration of precursor gas (such as CH4) have strong influence on the alignment. In the growth of atomic-arrangement-programmed (AAP) mode, horizontally aligned SWNTs with two alignment modes were synthesized on the same R-plane sapphire wafer. The comparison of these two groups of SWNTs suggests the competition between the two alignment mechanisms and indicates that atomic steps in high density have superior influence on the SWNTs’ alignment to the crystal structure on the surface of the sapphire substrate. A “raised-head” growth mechanism model is proposed to explain why catalysts can stay active during the horizontally aligned growth of relatively long SWNTs, even if there is a strong interaction between SWNTs and the sapphire substrate. Crystalline 3C-SiC core-shell and Y-junction nanowires have been synthesized by reaction of catalyzed carbon nanotubes and catalyst-free carbon nanofibers. Aligned SiC NWs were obtained on R-plane sapphire substrate with three directions. Most SiC NWs were aligned in the direction $[1\bar{1}0\bar{1}]$. Different from the free-standing SiC NWs, both 3C-SiC and 6H-SiC peaks were found by X-Ray Diffraction (XRD). The preliminary analysis suggests that the epitaxial interface between SiC NWs and sapphire substrates is most likely the key reason for the alignment of SiC NWs on sapphire substrates.