Growth and optical properties of the ZnO nanowires on quartz glass by a simple vapor deposition

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Abstract

Large area well-oriented ZnO nanowires grown on quartz glass substrates were fabricated by a simple vapor deposition via NiO-assisted growth method. The high-quality ZnO nanowires have a diameter of about 100 nm, and lengths up to several μm. We found that the diameters would increase as raising the ambient growth pressure. The TEM images were used to observe the detail crystalline structure of the ZnO nanowires and the selection area diffraction (SAD) shows the single crystal characteristic and the stress inside the nanowires. Crystal structure examined by XRD reveals that the a-axis of the ZnO nanowires is extended and c-axis is reduced. This is further confirmed by observing little down shifted of the Raman spectral peak at 435.96 cm^{-1} that is attributed to E2 phonon modes of ZnO nanowires. We suppose that the difference of the thermal expansion coefficient of the quartz substrate and the ZnO crystal brought the biaxial tensional stress. In addition, room temperature photoluminescence of the nanorwires showed intense excitonic emission at about 3.26 eV that indicates good optical quality and better quality for the nanowires grown at lower ambient pressure. The low temperature power-dependent and temperature-dependent photoluminescence spectra were used to observe the behaviors of the bound excitons, donor-acceptor pairs, and free-exciton with LO-phonon replica emission. The exciton-exciton scattering and the electron-hole plasma (EHP) emission were observed under high pumping power density.

藉由簡易相沉積法成長垂直方位生長之氧化鋅奈米線與其光學特性

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摘要

藉由簡易的氣相沉積法和氧化鎳晶核的輔助成長，可以在無晶態的石英玻璃上成長出大面積具有高指向性的氧化鋅奈米線。 這些高指向性的氧化鋅奈米線的直徑約在 100 奈米左右，而長度可達數微米。 我們發現氧化鋅奈米線的線徑會隨著製程的成長壓力而增加。 經由穿透式電子顯微鏡得以窺見氧化鋅奈米線的細部晶體結構，其選區繞射圖形也顯示出氧化鋅奈米線的單晶特性。 藉由X光繞射分析晶體結構，觀察到氧化鋅晶體的a軸拉長及c軸縮短的現象。 此現象也由拉曼散射光譜中，E_2模態稍微往低頻偏移，得到確認。 我們推測晶體內雙軸向拉伸應力的產生，可能為氧化鋅晶體與石英玻璃的熱膨脹係數差異所致。 除此之外，在室溫下觀察到具有高發光強度的 3.26eV光激光激子光譜，顯示出其高品質的光學特性，也得知在較低壓環境下成長之氧化鋅奈米線可得到較佳的光學特性。 利用在低溫下變化激發功率光激光譜和變溫光激光譜，我們觀察並判定束縛激子、施子-受子對、自由激子和LO聲子伴隨復合發光。 而在脈衝雷射的激發之下，也觀察到了激子-激子散射以及電子-電洞電漿體的發光。