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투명 전도성 전극에 대한 탄소나노튜브 네트워크 구조 특성과 전기적 특성의 상관관계

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본 연구에서는 탄소나노튜브 네트워크의 구조 변화에 따른 투명 전도성 필름의 전기적, 광학적 특성 변화를 관찰하였다. 탄소나노튜브 기반 필름의 전기적 특성은 탄소나노튜브의 직경, 길이에 큰 영향을 받을 뿐만 아니라 개별의 탄소나노튜브가 기판에 적층되어 형성되는 네트워크의 구조 변화에도 영향을 받는다. 이에 대해 본 연구에서는 분산제의 종류 및 농도에 따른 용액내 탄소나노튜브의 분산도, 산소 플라즈마 처리에 따른 기판의 표면장력, 탄소나노튜브의 정제에 따른 순도를 변화 시켰으며, 이에 따른 탄소나노튜브 네트워크 구조변화를 관찰하였다. 또한, 탄소나노튜브 네트워크의 구조변화에 따른 전기적, 광학적 특성 변화를 관찰하고, 이를 통해 탄소나노튜브 필름의 전기적 특성에 개별 탄소나노튜브간에 발생하는 접촉저항의 영향을 논의하였다.

Keywords: 탄소나노튜브, 투명 전도성 전극, 접촉저항

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Types and Yields of Carbon Nanotubes Synthesized Depending on Catalyst Pretreatment

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Double-walled carbon nanotubes (DWCNTs) were grown with vertical alignment on a Si wafer by using catalytic thermal chemical vapor deposition. This study investigated the effect of pre-annealing time of catalyst on the types of CNTs grown on the substrate. The catalyst layer is usually evolved into discretely distributed nanoparticles during the annealing and initial growth of CNTs. The 0.5-nm-thick Fe served as a catalyst, underneath which Al was coated as a catalyst support as well as a diffusion barrier on the Si substrate. Both the catalyst and support layers were coated by using thermal evaporation. CNTs were synthesized for 10 min by flowing 60 sccm of Ar and 60 sccm of H2 as a carrier gas and 20 sccm of C2H2 as a feedstock at 95 torr and 750°C. In this study, the catalyst and support layers were subject to annealing for 0～420 sec. As-grown CNTs were characterized by using field emission scanning electron microscopy, high resolution transmission electron microscopy, Raman spectroscopy, and atomic force microscopy. The annealing for 90～300 sec caused the growth of DWCNTs as high as ～670 μm for 10 min while below 90 sec and over 420 sec 300～830 μm-thick triple and multiwalled CNTs occurred, respectively. Several radial breathing mode (RBM) peaks in the Raman spectra were observed at the Raman shifts of 112～191 cm-1, implying the presence of DWCNTs, TWCNTs, MWCNTs with the tube diameters 3.4, 4.0, 6.5 nm, respectively. The maximum ratio of DWCNTs was observed to be ～85% at the annealing time of 180 sec. The Raman spectra of the as-grown DWCNTs showed low G/D peak intensity ratios, indicating their low defect concentrations. As increasing the annealing time, the catalyst layer seemed to be granulated, and then grown to particles with larger sizes but fewer numbers by Ostwald ripening.

Keywords: Double-walled carbon nanotube (DWCNT), Thermal chemical vapor deposition (CVD), Catalyst, Radial breathing mode (RBM)