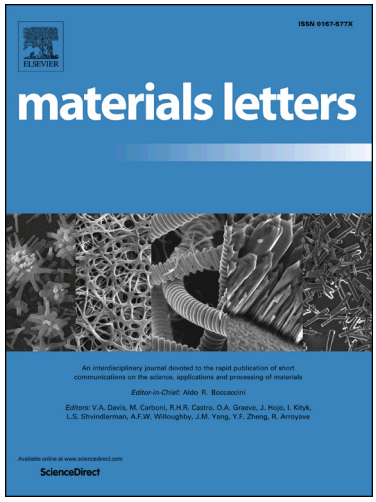

Fabrication of carbon nanotube transparent conductive films by vacuum filtration method

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Fabrication of carbon nanotube transparent conductive films by vacuum filtration method

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Abstract— Conductive thin films of carbon nanotubes (CNTs) are very promising materials as transparent electrodes because of their high conductivity, transparency, flexibility and low cost of fabrication compared to traditional materials like indium tin oxide (ITO). The quality of the film depends on the type of CNTs, dispersion conditions, fabrication and post-treatment processes. Single wall carbon nanotubes (SWCNTs) were firstly produced by the chemical vapor deposition (CVD) method and then thin films were fabricated by vacuum filtration method. The post-treatments, acid treatment and annealing, were applied to improve the film quality and optoelectronic properties. Homogeneity, density, morphology, the resistivity of the fabricated SWCNT thin films were analyzed by various characterization methods.

Keywords: carbon nanotubes, thin film, transparent and conductive electrode, annealing, acid treatment.

1. Introduction

Transparent conductive films (TCFs) have wide application areas, especially in optoelectronic applications due to their electrical and optical transparent properties [1]. Indium tin oxide is the TCF material owing to its high optoelectronic properties with low sheet resistance [2]. However, ITO has several drawbacks such as indium resources, fabrication methods, lacking flexibility and mechanically brittle, and degradation of device performance [3-4]. Therefore, in order to increase the efficiency of device performance, new alternative materials are needed to replace ITO.

Single wall carbon nanotubes have exhibited remarkable electronic properties since its discovery in 1991 by Lijima [5]. Many researchers have studied this form of carbon to clarify its high purity, chemically stability, electrical conductivity, attractive physical properties, characteristic electronic structures, easy production and controllable structure for development to apply optoelectronic devices [6-9]. Despite recent efforts for fabricating transparent conducting SWCNT films with low resistance and high transmittance, several obstacles to meet the requirement of transparent conductive electrodes still remain [10,11].

In this study, vacuum filtration method was applied to fabricate SWCNTs thin films. It mainly involved four steps: 1) dispersing SWCNTs in a surfactant (sodium dodecyl sulfate-SDS) solution, 2) vacuum filtering the CNT suspension onto a filtration membrane (forming a homogeneous film on the membrane), 3) dissolving the filtration membrane in a proper solvent, and 4) transferring the CNT film on to the desired substrate. Although the highly uniform distribution of SWCNTs in a networked thin-film was achieved, the film sheet resistance was found very high due to SDS residuals not completely removed from the film. Therefore, heat and acid treatments were applied to remove the remnant surfactants in the SWCNTs films successfully, and the conductivity increased even by eight folds after treatment. This will open a new way to elevate the comprehensive properties of the SWCNTs films.

2. Experimental

Carbon nanotubes were synthesized at 800°C by the fluidized-bed CVD synthesis of acetylene (C_2H_2) on a magnesium oxide (MgO) powder impregnated with an iron nitrate ($Fe(NO_3)_3 \cdot 9H_2O$) solution. After the synthesis,