Formation of Transparent and Conductive SWCNT/SiO_2 Composite Thin-Films on PET substrates using Molecular Precursor Method

H. Nagai,[1] K. R. Igarashi,[1] M. Sato[1]
[1]Department of Applied Physics, Kogakuin University of Technology and Engineering, 2665-1 Nakano, Hachioji, Tokyo, Japan

Transparent conductive films (TCF) are essential for optoelectronic devices, such as transparent electrodes for light-emitting diodes and solar cells. Transparent thin films of indium tin oxide (ITO) and fluorine tin oxide (FTO) on glass substrates are the most widely used for these purposes [1]. These typical TCO thin films provide an electrical resistivity of 10^{-3} Ω·cm and a high transmittance of over 80% in the visible-light region. Carbon nanotubes (CNTs)/inorganic composites have received much attention due to their optical, mechanical, electrical, and thermal properties. However, the poor adhesion of CNTs onto the substrate becomes a problem during the usage. SiO_2 is a highly transparent insulating material in the UV, visible, and infrared regions. Therefore, if conductivity can be added to SiO_2, it will become a new transparent conductive film with high adhesion. The single-walled carbon nanotube (SWCNT)-silica composite thin film on a quartz glass was formed by ultraviolet irradiation (20–40 °C) onto a spin-coated precursor film. With 7.4 mass% SWCNTs, the electrical resistivity reached 7.7×10^{-3} Ω·cm after UV irradiation. The transmittance was >80% at 178–2600 nm and 79%–73% at 220–352 nm. Heat treatment increased the transparency and pencil hardness without affecting the low electrical resistivity. Raman spectroscopy and microscopic analyses revealed excellent film morphology with good SWCNT dispersal. The low refractive index (1.49) and haze value (<1.5%) are invaluable for transparent windows for novel optoelectronic devices. Herein, we also report a promising composite thin film as a transparent and conductive material on PET (polyethylene terephthalate) substrates for flexible transparent conductive films.

[+] Author for correspondence: naga@cc.kogakuin.ac.jp