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ORIGINAL ARTICLE

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Investigation on the suitability of water/polyethylene glycol solutions for GO layer deposition in GO/Ag/GO films for transparent conducting electrode

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Abstract

A hybrid trilayered transparent conducting electrode (TCE) based on graphene oxide (GO) in the form of GO/Ag/GO multilayer synthesized using GO suspension in water and polyethylene glycol (PEG) is investigated for their suitability as TCE. The GO layers prepared from modified Hummer's method were suspended in water and EG solution separately and spin coated on a glass substrate. Ag film (~ 8 nm) was DC sputtered coated on these films before a second spin coat of GO layer to prepare two variants of trilayered structure (GO/Ag/GO). AFM/SEM images verified the smooth surface topology. Structural analysis by Raman spectroscopy showed shifting and broadening of GO peak, which represents defects/disorder with obtained I_D/I_G ratio as 0.70 and 0.98 for EG and DI water-based trilayered structure, respectively. Hall measurements concluded superior electrical and optical properties; with an average transmittance of ~ 75% in visible region, sheet resistance $R_s = 24.43\ \Omega$/sq, and high charge carrier concentration ($n = 2.11 \times 10^{22}\ cm^{-3}$) in films prepared with GO suspension in EG. The other combination prepared with DI water showed transmittance of ~ 73% and sheet resistance of 34.73 Ω/sq. X-ray photoelectron spectroscopy technique was further used to determine quantitative and chemical state information of elements by depth profile measurement of the trilayer electrode.

Keywords Graphene oxide · Transparent conducting electrode · Trilayer · Optoelectronic applications

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Introduction

With the escalating demand of smart devices, the requirement of transparent conducting electrode (TCE) being a vital component in these devices (e.g., organic solar cells, OLEDs, touch screen panels, flat panels, multilayer electrodes, thin-film transistors, and defrosters) has gone manifold. A search for a candid alternative to indium–tin–oxide (ITO) has already commenced (Ellmer 2012; Aleksandrova et al. 2015) due to its high cost, scarcity of supply, and brittle nature (Yun et al. 2013; Lokanc et al. 2015). The list of such viable alternatives exhibit doped metal oxide (Jayaraman et al. 2018), multilayer TCO (Sharma et al. 2017a), metal nanowire/mesh network (Ricciardulli et al. 2018; Sepat et al. 2019), and carbon materials (Moon et al. 2013; Shekhawat et al. 2018) (carbon nanotubes and graphene) which are continually engineered to meet stringent requirements posed by new generation of optoelectronic devices. The single-layered practical devices, however, faced many bottlenecks such a slow conductivity, less stability, high junction resistance, difficulty in large-area