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Screen-Printing of Functionalized MWCNT-PEDOT:PSS Based Solutions on Bendable Substrate for Ammonia Gas Sensing

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Abstract: Multi-walled carbon nanotubes (MWCNTs) were grown on a stainless-steel foil by thermal chemical vapor deposition (CVD) process. The MWCNTs were functionalized with carboxylic groups (COOH) on their surfaces by using oxidation and acid (3:1 H_2SO_4/HNO_3) treatments for improving the solubility property of them in the solvent. The functionalized MWCNTs (*f*-MWCNTs) were conducted to prepare the solution by continuous stir in poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS), dimethyl sulfoxide (DMSO), ethylene glycol (EG) and Triton X-100. The solution was deposited onto a bendable substrate such as polyethylene terephthalate (PET) with a fabricated silver interdigitated electrode for application in a room-temperature gas sensor. A homemade-doctor blade coater, an UNO R3 Arduino board and a L298N motor driver are presented as a suitable system for screen printing the solution onto the gas-sensing substrates. The different contents of *f*-MWCNTs embedded in PEDOT:PSS were compared in the gas response to ammonia (NH_3), ethanol (C_2H_5OH), benzene (C_6H_6), and acetone (C_3H_6O) vapors. The results demonstrate that the 3.0% *v*/*v* of *f*-MWCNT solution dissolved in 87.8% *v*/*v* of PEDOT:PSS, 5.4% *v*/*v* of DMSO, 3.6% *v*/*v* of EG and 0.2% *v*/*v* of Triton X-100 shows the highest response to 80 ppm NH_3. Finally, the reduction in the NH_3 response under heavy substrate-bending is also discussed.

Keywords: screen-printing; multi-walled carbon nanotubes; PEDOT:PSS; gas sensor

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1. Introduction

Nowadays, electronic equipment bending presents a major shift from rigid devices to flexible and stretchable systems. Because of their low-cost, thin and flexible characteristics, printed electronics provide a novel technology for the replacement of traditional inflexible devices. It has many advantages such as lightweight and easy preparation compared with the conventional vacuum deposition and photolithographic patterning methods. For the gas sensor applications, the printed techniques (direct-writing, inkjet-printing, screen-printing, 3D printing) provide a range of time-saving mechanisms and the full potential of sensing signals for application in the scope of gas sensors [1–4]. Toxic gases are major problems in human health and the environment. The causes of these problems are gases released from various industries during production processes. Ammonia (NH_3) is known to provide an effect on the human health as an explosive gas. As colorless gas with a distinct pungent smell, it can even lead to suffocation and death if the level of exposure is high. Therefore, monitoring and timely warning is important for settings in industrial