The fabrication of carbon nanotube-silicon hybrid photodetectors using a hydrophobic process of buffered-oxide etchant

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Abstract: We present the fabrication of carbon nanotube-silicon (CNT/Si) hybrid photodetectors and their electrical characterizations at ambient temperature under the illumination of a halogen lamp. The hybridized structure of the CNT/Si junction created in this work showed rectifying behavior of a p-n junction diode with a finite-bias voltage across the junction. By using the hydrophobic process of buffered oxide etchant (BOE), we studied the dependence of nanotube concentrations as a function of sheet resistance of the CNT films and their photocurrent generation at a fixed junction area. Our experimental results revealed a linear relationship between the sheet resistance and light transmittance, which was found inversely dependent. As the amount of the CNTs deposited in the etched Silicon area forming a p-n junction increased, the transmittance of light reduced significantly. Therefore, in a thick CNT deposition only a small fraction of light could pass through, which prevents a high-efficiency electron-hole pair generation in the Silicon layer. However, the high transmittance of light implies a thin film of CNTs must be used. This results in the formation of film inhomogeneity and high-sheet resistance. Thus, by adjusting the film thickness for a maximum transmittance of light and low-sheet resistance, we showed that a high photocurrent under this optimisation could be achieved in our hybridized structure. The power conversion efficiency (PCE) of the devices was investigated as a function of the light transmittance of the films and the photocurrent generation at zero bias. Our experimental study indicates an ease of fabrication process technique permitting further hybridization of the other nano materials or polymers to be exploited with a significant reduction of the material's costs and eco-friendly manipulation for future optoelectronic applications.

Keywords: Carbon Nanotube (CNT)/Si hybrid structure, p-n junction diode, BOE etchant, photodetector, Nanocomposites