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Room Temperature Gas Sensor Based on Helical Carbon Coils

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Abstract. Growth of helical carbon coils can be achieved by sputtered Inconel® 600 films on silicon (Si) substrates followed by thermal chemical vapor deposition (CVD) using acetylene as a carbon source along with the injection of sulfur hexafluoride (SF_6). The coils were used to prepare electronic ink for fabrication of flexible room temperature gas sensors. The ink as a sensing film was deposited onto silver-screen printed plastic substrates by drop casting. Before dripping the sensing film, the coils were purified using oxidation and acid treatments. The purified coils were then dispersed in different solvents such as deionized water (DI water), ethanol and dimethyl sulfoxide (DMSO) for comparisons. The performance of sensors was investigated for its response to ammonia (NH_3) and volatile organic compounds (VOCs) including ethanol, methanol, and dimethylformamide (DMF) in concentration of 1000 ppm at room temperature. Because the baseline resistance of sensor falls within the working range (i.e. kΩ), the coils dispersed in DI water are performed to show the highest selectivity and sensitivity to NH_3. The sensing mechanism of helically coiled carbon gas sensors has been also discussed based on the reducing reaction process between NH_3 and chemisorbed oxygen on the surface of purified carbon coils.

Introduction

Ammonia (NH_3) and other volatile organic compounds (VOCs) have been thought to the high toxicity. The monitor of them is very important in medical treatment, industrial process and environmental applications. Recently, the development of feature for gas sensor has been focused on low-cost, flexible, selective and sensitive detections at room temperature [1]. Moreover, carbon nanostructures such as multi-walled carbon nanotubes (MWCNTs), single-walled carbon nanotubes (SWCNTs) can be also considered as good candidates to design the high performance of NH_3 and VOC gas sensors [2-3]. Good dispersion and good solubility between active carbon materials and the solvent are significant to enhance the properties of carbon-based ink used for the preparation in printable gas sensor. Although the water was reported as a cost-effective solvent used in the fabrication of carbon-based gas sensor by printing technique, the nature of carbon in poor dispersion has limited in less selectivity and low sensitivity for gas sensor works [4]. The performance of carbon-based gas sensor has been reported to be dependent on the number of hybridized sp^2 networks and specific surface area [5]. Helical carbon coils as a fiber structure of carbon have attracted increasing attentions due to its high specific surface area and large number of sp^2 networks. The injection of sulfur hexafluoride (SF_6) was presented as a main cause for the formation of helical carbon coils using a thermal chemical vapor deposition (CVD) technique [6]. However, the poor dispersion of helical carbon coils within various solvents is still a big problem for the preparation of sensing films in gas sensor applications.