OPTIMIZATION OF AN IONIZATION BASED VERTICALLY ALIGNED MWCNTS GAS SENSOR

By

ATIEH RANJBAR KERMANY

A Thesis

Submitted to the Postgraduate Studies Programme
as a Requirement for the Degree of

MASTER OF SCIENCE

ELECTRICAL & ELECTRONICS ENGINEERING DEPARTMENT

UNIVERSITI TEKNOLOGI PETRONAS

BANDAR SRI ISKANDAR

PERAK

MARCH 2012

ABSTRACT

The current solid state ionization-based gas sensors have high operating voltage that increases the operating risk factor and are relatively bulky. The dimensions and power requirement of these sensors can be optimized by using carbon nanotubes (CNTs) as the gas sensing element. An ionization-based gas sensor using aligned multi-wall carbon nanotubes (MWCNTs) array has been developed where its sensing properties such as the response time, selectivity, sensitivity, and breakdown voltages of different gases were investigated through the variation of electrode gap and gas concentration. The MWCNTs array was produced using CVD method. The structural and electrical characterization were carried out by using X-ray diffraction, transmission and scanning electron microscopy, Raman spectroscopy and Hall Effect to determine the suitability of the as-produced MWCNTs array as an effective sensing element. The aligned MWCNTs array was incorporated into the sensor configuration in the gas chamber for testing of gases namely argon, air, 2% of hydrogen in air, ammonia, and helium with electrode separation ranging from 80 μm to 150 μm. The CNTs array is found to be of highly directional multi-wall type, with good crystallinity (I_D/I_G ~ 0.75), typical diameter and length of 10 nm and 20 μm, and mobility and conductivity of 17.5×10^3 cm^2/Vs and 3.3×10^2 S/cm, respectively. It was proven that the breakdown voltage decreasing as the electrode spacing reduces from 150 μm to 80 μm for all the gases among which helium was found to have the lowest breakdown voltage (119 V at 80 μm, 180 V at 150 μm) whilst air has the highest (249 V at 80 μm, 362 V at 150 μm). A reduction of more than 50% in the breakdown voltage, microsecond response time, highly sensitive and selective properties with room temperature operation had proven that the highly ordered MWCNTs array is an effective sensing element resulting in better performed gas sensor compared to the conventional solid-state sensors. Besides that, an average reduction of 15% in the breakdown voltage compared to non-aligned CNTs-based gas sensor confirmed the effect of alignment on the sensor performance.