VANADIUM FOG – DIRECT COATING OF CARBON NANOTUBES BY V_2O_5 IN AEROSOL STATE

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Vanadium pentoxide(V_2O_5) has been extensively studied for gas sensing and bolometer applications because of its unique electrical and optical properties. It has been reported that vanadium pentoxide possesses temperature sensitive properties that boost the implementation in bolometers. Moreover, V_2O_5 ability to adsorb and chemically interact with different gases integrated with pronounced band structure makes it a promising candidate for gas sensors. It should be mentioned that vanadium pentoxide also provides stable p-type doping of single-walled carbon nanotubes (SWCNTs).

However, vanadium oxide nanoparticles cannot be implemented easily to form an electrically conductive continuous or even a free-standing film that can be transferred on any kind of a substrate for further applications. Also, in case of gas sensors high resistance of V_2O_5 inhibits the detection of response. Addition of carbon nanotubes to V_2O_5 matrix might address these problems. However, each nanotube should be wrapped by V_2O_5 to reach the full potential of the composite. Nevertheless, high energy of interaction between nanotubes limits the disruption of the junctions between nanotubes. As the result of commonly used methods like spin- or dip-coating, SWCNTs on the surface of the film are covered with material but intersections between nanotubes are remained.

Here we propose a new method, “Vanadium Fog”, for the functionalization of SWCNTs with V_2O_5. The method comprises the mix aerosol of individual SWCNTs right after the aerosol CVD synthesis with for (aerosol) of vanadium oxytriisopropoxide in isopropyl alcohol. As the result, each carbon nanotube is soaked with droplets of solution followed by alcohol evaporation. To promote the conversion of vanadium oxytriisopropoxide into V_2O_5 via the hydrolysis/polycondensation mechanism, before deposition flow is diluted with wet air. Resulted carbon nanotubes coated with vanadium oxide are collected on nitrocellulose filter for transferring onto any other substrate for further application. Thereby, every SWCNT is covered with doping material and in the resulted films there is no any direct intersections between nanotubes.

The vanadium results in thin films with conductivity below pristine nanotubes but higher than that for pure V_2O_5. Temperature coefficient of resistance (TCR) measurements were conducted to investigate SWCNTs coated with V_2O_5 for bolometer application. Different behavior of conductivity of pristine SWCNT films with films of SWCNTs coated with vanadium proves the formation of nanotube junctions through V_2O_5. Aerosol coating leads to improvement composite performance as component of bolometers and gas sensors. The obtained composite films were transferred onto silica substrate with predeposited circuits for gas sensor application. Combination of carbon nanotubes with V_2O_5 showed higher sensitivity to volatile organic compounds than that for pure nanotubes and vanadium pentoxide.

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