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Optimization of a carbon nanotubes manufacturing process by the technique of PECVD

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Abstract

Carbon nanotubes (CNT) are valuable for their application in nanotechnology, electrical properties and high surface area, and in our particular case, for the manufacture of nanosensors.
In this work the technique of Plasma Enhanced Chemical Vapor Deposition (PECVD) was used for the manufacture of CNT.
The process was conducted in a horizontal tube reactor using methane as precursor gas and an R.F. discharge of 1000w output power acting as ionizing medium. Having achieved the synthesis of CNT on copper (Cu) substrates, heated with an internal electrical resistance to a process temperature of 900 ºC, the substrates were coated with ferric nitrate $Fe(NO_3)_3$, which served as a catalyst and nucleation center. The heating system used differs from traditional methods by its internal heating. Growth of CNT was achieved on vertical walls on Cu substrates and perpendicular to it; a prerequisite for the manufacture of nanosensors, which is the main objective of this work, as well as to reduce as much as possible the diameter of the CNT, being its main features 5μm average length and 7 nm average diameter.

Keywords: Plasma CVD; nanotubes; nanosensors

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1. Introduction

This work shows a CNT production process (Lasorsa et al. 2010) for use in the manufacture of nanosensors (Perez et al. 2010), which constitute a basic tool in nanotechnology. A CNT based sensor is constituted by a network of CNT, and a pair of electrodes as signal transmitters (Fig.1). This is a kind of electrochemical sensor that is based in the charge's transfer from one electrode to another. Any alteration in the structure of the CNT will produce alterations in its electrical resistance, which will lead the modification of the signal, providing information about a change. The change could be chemical, as in gas sensors, or biological as in antigen/antibodies sensors (Fig. 2). This last kind of sensor is in advanced research stage (Lasorsa et al. 2010; Perez et al. 2010).

In previous work (Lasorsa et al. 2010) it was described the technique to produce CNT and other nanostructures, as well as the distinctive features of our process compared with conventional techniques. In that process the CNT and nanostructures are retrieved and dispersed in isopropyl alcohol, in spite of the growth of CNT between metal electrodes, preferably Cu, that was pending. With the purpose of physically building the structure of the nanosensor described previously, this growth process was done in this work.

This growth was achieved by employing as substrate a sample holder used in transmission electron microscopy (TEM), which played a dual role: one for observation of the CNT, and the other one to form the metal structure to support their growth, which would fulfill the role of the electrodes in the case of a nanosensor (Fig.1). It is important to note that their growth occurred without any contention, except for their attachment to the substrate, which shows the stiffness of its structure and, at the same time, that the lack of contention brought out its process of formation, giving rise to nucleation from a particle of *Fe* in a spherical shape with an outside diameter of 6nm to 12nm, and compact structure.

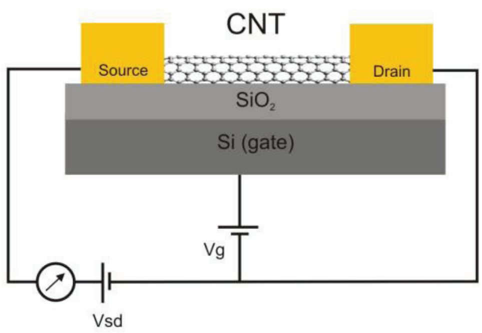

Fig.1: Structure of the biosensor.

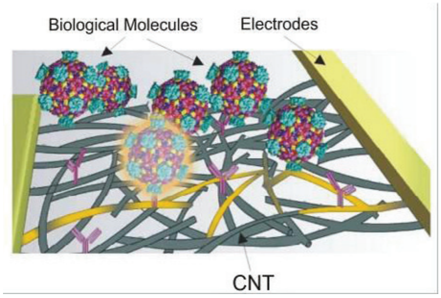

Fig. 2: Biological sensor.

The advantage of these nanodevices using CNT as a sensing element is that they have a huge specific surface which allows a great exposure, allowing the absorption of species that are still at very low concentrations and making these sensors elements of high sensitivity, with extremely fast response. This response is explained by the electronic configuration on the surface of the nanotube, leading to changes in the electrical current or voltage, when are exposed during a screening process to specific elements whose identification is sought. Applying this technology is intended to obtain sensors in micrometer scale. Achieving growth from a metal surface, and no other means of containment, is a decisive factor for the manufacture of nanosensors.