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SCIENCE DIRECT

Diamond & Related Materials 14 (2005) 784–789

DIAMOND AND RELATED MATERIALS

www.elsevier.com/locate/diamond

Growth of vertically aligned carbon nanotubes by CVD by evaporation of carbon precursors

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Available online 30 January 2005

Abstract

We report about the growth of carbon nanotubes, carbon microfibers and other forms of carbon on uncoated silicon and glass substrates, obtained by evaporating either a solid carbon precursor such as camphor or a liquid one such as cyclohexanol. The latter is a cyclic alcohol never used before in this field. The process of synthesis involves the coevaporation of the carbon precursor and ferrocene, used as the catalyst source, in nitrogen atmosphere. The morphology and structure of the samples grown at various substrate temperatures were characterized by Raman and FT-IR spectroscopy, HR-TEM and SEM analysis.

At a substrate temperature of about 650 °C a 'carpet' of vertically oriented nanotubes, with spare signs of other form of carbons, is obtained on silicon substrate, whereas a disordered carbon nanotubes structure and other carbon form are grown on glass substrates. The results demonstrate the ability of this method to grow carbon nanotubes on uncoated glass substrates.

Keywords: Nanotubes; Chemical vapor deposition; Morphology; Nanofibers

1. Introduction

Since they were first reported [1] carbon nanotubes (CNTs) have received a great deal of attention because of their potential applications [2]. Recently, due to their outstanding field emission properties, much effort has been devoted to synthesize vertically aligned CNTs, either by thermal or plasma enhanced CVD, on various glass substrates (such as borosilicate glass, sodalime glass,...) commonly used as low-cost substrates for display panels in Field Emission Displays (FED) [3,4]. However, the glass substrates are covered by a thin metallic film (such as Ni, Fe, ...[3,4]) in order to catalyse the CNTs growth and to avoid that bare glass inhibit the CNTs formation. The ability to grow CNTs on bare glass would disclose interesting perspectives, for instance as it can reduce the number of steps needed to prepare a device.

In this work we grow CNTs by a thermal CVD method, in which precursors are, at room temperature, solid or liquid. In particular we report on the use of cyclohexanol, a liquid cyclic alcohol which use in CNTs growth, at the best of our knowledge, was never reported before. The source of catalyst atoms is ferrocene, mixed in the gas phase with the carbon source. We will show by this method CNTs can be grown either on silicon wafers or on bare pyrex and corning 7059 glasses. The growth of vertically aligned CNTs can be obtained starting from the gas phase, with no need to coat the substrate with the catalyst.

2. Experimental

The growth of CNTs was obtained by chemical vapor deposition (CVD) of a gas mixture evaporated from catalyst powder and solid or liquid carbon sources. Deposition was carried out at different temperatures on various substrates (crystalline silicon, pyrex glass, corning 7059 glass) All substrates were cleaned with acetone and dried with a

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doi:10.1016/j.diamond.2004.12.030