Properties of Carbon Nanowalls Grown on Glass Substrates According to the Etching Microwave Power

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In this paper, we investigated the effect of microwave power, during the plasma-etching of grown carbon nanowalls (CNWs), on the properties of the CNWs. A microwave plasma enhanced chemical vapor deposition (PECVD) system was used to grow CNWs on a glass substrate using a mixture of CH₄ and H₂ gases. The grown CNWs were plasma-treated under the oxygen ambient (O₂) with different degrees of microwave power (500~1000 W, in steps of 100 W). After the post-plasma treatment, the cross-sectional and planar images of the CNWs were examined via field-emission scanning electron microscopy (FE-SEM) according to the microwave power of the plasma treatment. Then the structural characteristics of the CNWs were analyzed via Raman spectroscopy, and the changes in the light transmittance according to the degrees of the O₂ plasma treatment power were analyzed using UV-visible spectroscopy.

Keywords: Carbon Nanowall, Microwave PECVD, Post-Plasma Treatment, Optical Properties.

1. INTRODUCTION

Representative next-generation carbon-based nanomaterials that have been extensively studied include the following: fullerene,¹ a carbon-based nanostructure discovered in 1985; carbon nanotube (CNT),² discovered in 1991; and graphene,³ which was discovered in 2004. A recently discovered carbon-based nanomaterial, the carbon nanowall (CNW), has a two-dimensional structure with several layers of graphene grown vertically, unlike the CNT, which has a one-dimensional structure.⁴ Due to this structural characteristic, the CNW has the largest reaction surface area among known carbon-based nanomaterials. Thus, it is anticipated as the next-generation carbon-based nanomaterial that can be used in electrodes to improve the performance of elements.⁵⁻⁸ Furthermore, the CNW enables low-temperature synthesis on flat panels, giving the advantage of mass production of large-area products.⁹

In this study, CNWs synthesized on glass substrates were treated with O₂ post-plasma, and their structural and optical properties were checked according to the microwave power used in the plasma treatment. CNWs were synthesized on glass substrates by the microwave plasma enhanced chemical vapor deposition (PECVD) method using CH₄ (methane) and H₂ (hydrogen) mixture as the reaction gases. They were also plasma-treated using O₂ (oxygen) plasma using the microwave PECVD method.

2. EXPERIMENTAL DETAILS

In this study, we performed the CNW syntheses and the O₂ post-plasma treatments using a 2.45 GHz microwave PECVD system (Woosin Cryovac; M-PECVD). The CNWs were synthesized using glass substrates, which were cleansed with an ultrasonic cleaner using TCE (trichloroethylene), acetone, methanol, and deionized water (D.I. water), in that order, for 10 minutes each. To remove impurities except the gases needed to synthesize the CNWs, the base pressure in the chamber was set at 1 × 10⁻⁵ Torr using a turbo pump for 30 minutes. Then CH₄ and H₂ gases were flown into the chamber to keep the working pressure at 2 × 10⁻² Torr. The CNWs were