

Effects of CH₄ Concentration on Size of Carbon Nano-Particles Formed in Multi-hollow Discharge Plasma

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1. Introduction

Carbon nano-particles have been employed in a wide range of industries due to their particular extensive characteristics such as mechanical, chemical properties and other attributes [1-3]. Among many methods to synthesize carbon nano-particles, plasma process is one of the promising alternatives [4]. So far, we have successfully produced Si nanoparticles by using a multi-hollow discharge plasma chemical vapor deposition (MHDPCVD) in silane plasmas with a continuous wave discharge [5-6]. Here we employed the MHDPCVD to synthesize the carbon nano-particles (CNPs) using Ar diluted CH₄ gas. We studied the effects of CH₄ concentration on size of nano-particles.

2. Experiments

For the MHDPCVD method, the plasmas were generated by applying 60 MHz radio frequency power of 40 W to the multi-hollow electrode consisting of 8 hollows of 5 mm in diameter. Ar and CH₄ gases were introduced to chamber through the hollows. Total gas flow rate was 100 sccm. Si substrates and TEM meshes were set at 50 mm downstream from the electrode. The substrate temperature was room temperature. Size distribution and structure of CNPs were confirmed by TEM and Raman spectroscopy with 532 nm green laser, respectively.

3. Results and discussion

Figure 1 shows the size distribution of CNPs deposited on the TEM mesh as a parameter of the gas flow rate ratio of Ar to CH₄. The mean size increased from 26.6 nm for the CH₄ concentration of 11% to 37.6 nm for 14%. The total area density decrease from $6.14 \times 10^{14} \text{ m}^{-2}$ for 11% to $1.72 \times 10^{13} \text{ m}^{-2}$ for 14%. Above the CH₄ concentration of 25 %, we could not found CNPs in 1mmx1mm in sample area. A small number of nano-particles above 100 nm in size may be generated for such high CH₄ concentration. We measured Raman spectra of CNPs for 11 % and 14 %. Peaks of D- and G-band appear on the background PL in the both concentrations. Therefore, the synthesized CNPs consist of polymer and graphite.

Thus, the CH₄ concentration is a control knob of the size of CNPs.

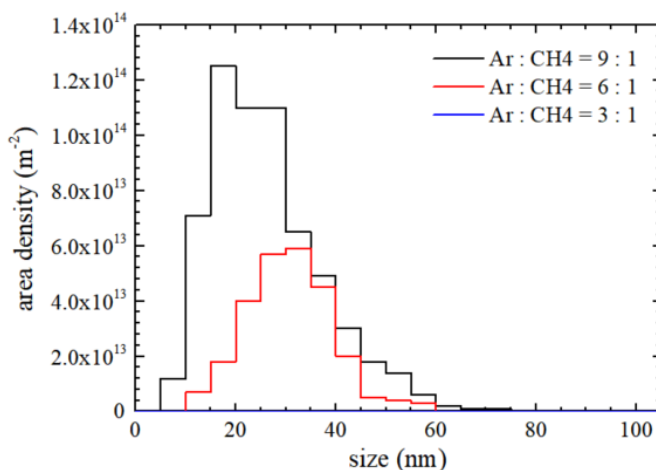


Figure 1. size distribution of carbon nano-particles formed as a parameter of Ar/CH₄ ratio.

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