CH_4+Ar マルチホロー放電プラズマで生成したカーボンナノ粒子の基板堆積に対するガス流量の影響

Influence of gas flow rate on deposition of carbon nanoparticles produced by CH_4+Ar multi-hollow discharge plasma onto substrates

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1.Introduction

Carbon nanoparticles (CNPs) have been studied in many fields due to their unique properties [1-2]. Reactive plasma is a promising process to synthesize carbon nanoparticles [3]. So far, we have continuously produced Si nanoparticles of 2 nm in size by using a multi-hollow discharge plasma chemical vapor deposition (MHDPCVD) [4]. In this study, we applied the CH_4+Ar MHDPCVD to synthesize CNPs and examined the deposition on substrates.

2. Experimental

Experiments were carried out using the MHDPCVD that has 8 hollows of 5 mm in diameter in each electrode. 60MHz discharge power of 40 W was supplied to the electrode. TEM meshes and Si substrates were set on the grounded substrate holder placed 50 mm far from the electrodes. The substrate temperature was room temperature. CH_4+Ar gases were supplied into the reactor from the back side of the electrodes. The gas flow rate ratio was set at CH_4:Ar=1:6. Total gas flow rate was from 10 to 200 sccm. The gas pressure was kept at 2 Torr. The size of nanoparticles was measured using high resolution TEM. Their structure was characterized by Raman spectroscopy using 532 nm laser light excitation.

3. Results and discussion

Figure 1 shows TEM images of the deposited CNPs as a parameter of the gas flow rate. The mean size of CNPs monotonically decreases from 252 nm for 10 sccm to 37.7 nm for 120 sccm. The corresponding area density increases from 3.0×10^{12} m^{-2} for 10 sccm to 5.2×10^{14} m^{-2} for 120 sccm. The structure of CNPs for 10 and 20 sccm is mostly polymer. The CNPs above 50 sccm are polymer and graphite. The results suggest nanoparticles are agglomerated during the transport toward the substrates. The smaller CNPs show lower melting point, probably leading to the graphite structure.

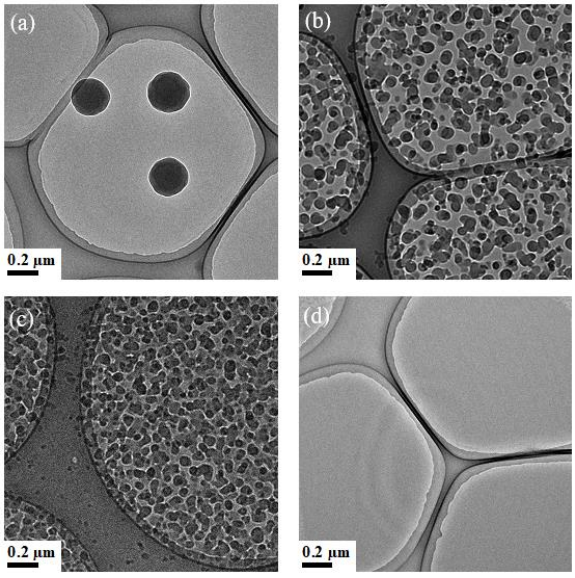

Figure 1. TEM images of deposited CNPs as a parameter of the gas flow rate. (a)10 sccm, (b) 50sccm, (c) 120 sccm and (d) 125 sccm.

The deposition of CNPs on the substrates is drastically changed above 120 sccm. There are no CNPs on the substrates. In this case, CNPs should be formed in the gas phase, but they cannot be deposited onto the substrates. These results suggest that CNPs deposition to the substrate depends on the size and gas flow.

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