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Nano-structural control of carbon-based thin films by PECVD and their surface modification

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Catalyst-free growth of carbon nanomaterials were performed by microwave plasma-enhanced chemical vapor deposition using CO as a carbon source gas. The effect of CO: H_2 and CO: O_2 ratio on the morphology of carbon films is investigated. Without an addition of hydrogen, vertically aligned CNFs were synthesized. At lower H2 : CO ratio carbon nanowalls were synthesized, while polycrystalline diamond films were deposited with much higher H2 : CO ratio. We have also investigated the effect of electric field on the structure of carbon nanomaterials and the well-parallelized carbon nanowalls were successfully synthesized by the addition of strong electric field near the substrate. We were able to parallelize CNWs with comb-shaped multi-wire-type electrode which creates electric fields to control the shape and angle of CNWs. However, when we insert the parallelizing electrode into microwave plasma zone in the waveguide position, sparking on the electrode occurs and easily metal electrodes are severely damaged. To avoid the sparking on the electrode, we inserted the parallelizing electrode with substrate into the discharge tube slightly down flow area from the wave guide position. The plasma density of this position is originally too weak to synthesize CNWs. Thus, we additionally applied the magnetic field in the microwave plasma to create dese ECR plasma. We set the resonance point outside of waveguide zone and inserted the parallelizing electrode into the resonance zone in the down flow of waveguide zone. We have investigated the effect of shapes, sizes, and location of parallelizing electrodes. We tested two types of electrode system, contacting and non-contacting electrode system. The possible mechanism for controlling the nanostructure of carbon nanomaterials is discussed. We have also studied to fabricate composite thin films by coating the carbon nanowalls layer with metal oxides and their electrochemical property was analyzed.

Keywords
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