学 位 論 文 概 要

題　目　　In-flight Coating of Carbon Nanotubes by Plasma-Enhanced Chemical Vapor Deposition Process

（プラズマ CVD プロセスによるカーボンナノチューブの浮遊コーティング）

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In this dissertation, a plasma-enhanced chemical vapor deposition (PECVD) process for the preparation of coatings on the surface of carbon nanotubes (CNTs) suspended in gas, i,e. in-flight coating, is studied for metal oxide and polymeric materials. Coatings on CNTs are important for new and improved properties and functions, which are attributed to the external material on the surfaces. The major contents of this thesis are listed as follows.

Chapter 1 describes the background, motivation, review of previous researches, and the objectives of the thesis.

In **Chapter 2,** the preparation of titania (TiO_2) coated CNTs is discussed. Vapor of titanium tetraisopropoxide and aerosolized CNTs were simultaneously fed into a plasma zone. The effects of various parameters of this coating process on the morphology of the resulting coating layers were studied. The thickness and surface roughness of the layers increased with the increase of the vapor concentration and the pressure in the plasma zone. The residence time in the plasma zone changed the morphology of layers from sparse and granular to thick and continuous ones. These results indicate a possibility that the morphology of coating layers is controlled by the process parameters.

The crystallization of TiO_2 coating layers by annealing was investigated in **Chapter 3.** The coating layers were amorphous as prepared by the present PECVD process. The layers were converted to anatase TiO_2 by annealing at 450 °C. The layers showed rutile phase by annealing in nitrogen at higher temperature, e.g. 900 °C. Annealing first in nitrogen and then in oxygen caused the crystallization and densification of the coating layer followed by the removal of the CNT in the core. Hollow TiO_2 nanotubes, a promising nanostructured material, were thus obtained successfully.

In **Chapter 4**, this process was applied to the preparation of polymeric coatings. Vaporized methyl methacrylate monomers were used as the precursor to obtain poly methyl methacrylate coating layer. Electron microscope observation of the products revealed that the CNTs were covered with continuous layers of various thickness. Chemical analyses showed that major functional groups contained in both the monomer and polymer were retained even after the coating process using plasma. The analyses also indicated polymerization of the monomers. Therefore, the results obtained here suggest the applicability of this process for plastics materials.

Chapter 5 highlights the summary of each chapter and suggestions for further investigations.