Role of etchant on the morphology of plasma grown carbon nanofibers: Theoretical modeling

R. Gupta¹, S. C. Sharma¹, N. Gupta¹

¹Department of Applied Physics, Delhi Technological University (DTU), Shahbad Daulatpura, Bawana Road, Delhi-110042

Abstract

The present work reports a theoretical model to study the effect of etching gas flow rate on the final shape of the carbon nanofibers (CNFs) synthesized via plasma enhanced chemical vapor deposition technique (PECVD) is developed. The analytical model developed accounts the plasma sheath effects along with the charging rate of carbon nanofiber surface, kinetics of various plasma species (electrons, positively charged ions and neutrals), and growth rate of carbon nanofibers. In this analytical model, the processes considered for the growth of carbon nanofibers on the catalyst nanoparticle surface are; thermal dissociation of hydrocarbon gas, ion- induced processes, adsorption and desorption of hydrocarbon and etching gas; the surface and bulk diffusion of carbon species, incorporation of carbon species in the form of graphene layers around the catalyst particle, stress generated by graphene layers on the catalyst particle, and etching of carbon species or graphene layer. The results of this investigation demonstrate that flow rate of etching gas extensively affect the morphology of the carbon nanofibers. It is found that tilt angle of carbon nanofiber increases and tip diameter of carbon nanofiber decreases with increase in etching gas flow rate in the plasma chamber. In addition, we found that base diameter of the carbon nanofiber increases with decrease in flow rate of etching gas. Our theoretical results are in line with experimental observations. The present study can be utilized to synthesize the efficient field emission devices based on carbon nanofibers.