Analytical model to study the effect of alignment mechanism on the growth characteristics of carbon nanotubes in PECVD chamber

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The authors have developed an analytical model to study the effect of alignment mechanism of carbon nanotubes (CNTs) in the plasma enhanced chemical vapor deposition (PECVD) system. The alignment mechanism and growth of CNTs in a methane hydrogen plasma are modelled in the current work. The significance of plasma parameters and bias potential of the substrate on the electric field of the plasma sheath is studied. The role of the electric field in the plasma sheath to provide the necessary electrostatic force on the CNTs alignment in the plasma are studied by taking into consideration the steady state fluid equations, kinetics of the plasma sheath, charged species dynamics and neutral atoms in a reactive plasma, kinetics of the catalyst particle, and creation of atomic species of carbon and hydrogen over the surface of catalyst nanoparticle and incorporating various processes vital for the growth of CNTs in plasma. Taking into account the initial conditions and the glow discharge parameters the numerical solutions for the equations are obtained. The outcomes of the studies revealed that the alignment of the nanotube depends on the force exerted at the tip of CNTs. This force is responsible for the plasma sheath electric field which is dependent on the plasma parameters and the bias voltage at the substrate. This electrostatic force is also dependent upon the dimensions of the nanotube growing in the plasma environment and modifies itself continuously conferring to the instantaneous nanotube measurement and alignment during the growth. The present study can be apprehended to manufacture CNTs aligned vertically in plasma for better applications in the areas of field emission devices. The results of the present study have been compared with the existing experimental observations.

References

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