Allotropes of Carbon Nanoparticles Synthesized by HFCVD

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Nanomaterials exhibit both emergent and tunable properties that differ from their bulk scale counterpart. This has been readily demonstrated with carbon materials like graphene, carbon nanotubes, and others. Of the carbon allotropes diamond possesses material properties that make it an ideal candidate for applications requiring robust mechanical, chemical, and thermal stability. The many favorable properties of diamond in combination with the high surface area of nanoparticles lends to further tailoring of specific applications through surface functionalization. Nanodiamonds have been shown to be useful for biomedical imaging, composite materials, and drug delivery. The application space of nanoparticles can be further increased with core-shell particle structures by utilizing the unique properties that arise from the core and shell material. Growth of various carbon allotropes in nanoparticle form has been demonstrated within the chemical vapor deposition (CVD) reactors typically used to grow diamond films. Presented here is the use of a hot-filament CVD (HFCVD) reactor for the growth of diamond and other carbon allotropes, with the use of the reactor extended to demonstrate the growth of core-shell nanoparticles. The reactor contained a series of tungsten filaments with temperatures near 2100 ℃. Supplied to the reactor were mixtures of methane, hydrogen, and argon. Samples were collected either onto a variety of substrates. The structure, composition, and surface chemistry were then characterized with techniques including TEM, XRD, and Raman. Several studies were performed to examine the relationship between process parameters and resulting characteristics of the nanoparticles. Each parametric study aimed to evaluate the relationship between the parameter and the resulting size, structure, and composition of the synthesized nanoparticles. Parameters investigated included gas composition, pressure, and substrate temperature. Through control of the process the characteristics of particles were able to be controlled.