

Theory of Charged Clusters Linking Nano Science and Technology to Thin Films

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Based on experimental and theoretical analyses, we suggested a new possibility that the CVD diamond films grow not by the atomic unit but by the charged clusters containing a few hundreds of carbon atoms, which form spontaneously in the gas phase [J. Crystal Growth 62 (1996) 55]. These hypothetical negatively-charged clusters were experimentally confirmed under a typical hot-filament diamond CVD process. Thin film growth by charged clusters or gas phase colloids of a few nanometers was also confirmed in Si and ZrO₂ CVD and appears to be general in many other CVD processes. Many puzzling phenomena in the CVD process such as selective deposition and nanowire growth could be explained by the deposition behavior of charged clusters. Charged clusters were shown to generate and contribute at least partially to the film deposition by thermal evaporation. Origin of charging at the relatively low temperature was explained by the surface ionization described by Saha-Langmuir equation. The hot surface with a high work function favors positive charging of clusters while that of a low work function favors negative charging.