Controlling Composition of Particles Grown in Dusty Plasmas*

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Nanoparticles (NPs) are very fine, nanometer sized clusters of atoms that are important in many fields. They can have unique chemical and optical properties which depend on the composition of the nanoparticles. Low temperature plasmas have been known to produce particles or "dust" and decreasing their impact has been an active area of research for semiconductor processing for years. More recently, low temperature plasmas have been used to purposely create NPs. The highly non-equilibrium and dynamic environments of plasmas can be used to produce particles with specific compositions that may otherwise be difficult through traditional methods. Particles that are made of distinct layers, "core-shell" NPs, have been made experimentally using plasmas, but the specific mechanism for particle formation and growth is still speculative [1].

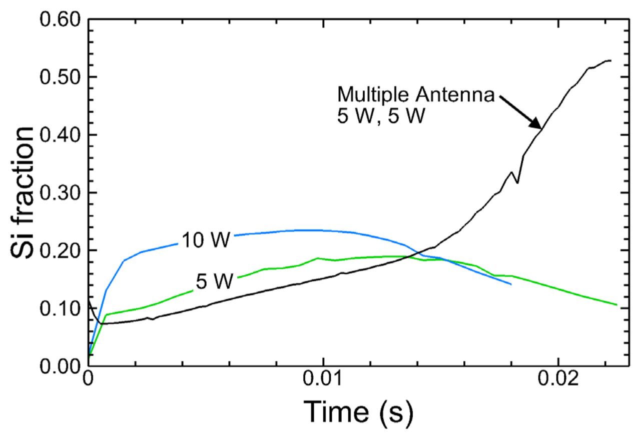

Figure 1 – Si fraction of nanoparticles while grown in the plasma over time for different power: single antenna at 5 W (green) and 10 W (blue), and using multiple antenna placed strategically with 10 W total. This shows that the plasma can be manipulated to form nanoparticles with controllable compositions.

In this work, results of a computational study of the formation of "core-shell" nanoparticles in low temperature plasmas will be discussed. Specifically, particles with a Ge "core" surrounded by a Si "shell" were modeled growing in laboratory scale tube reactors from $Ar/SiH_4/GeH_4$ gas at a few Torr. A 3D kinetic model for dust particle dynamics and growth, the Dust Transport Simulator (DTS), coupled with a multi-fluid plasma simulator, the Hybrid Plasma Equipment Model (HPEM), was used in this investigation. Results showing particle growth rates and composition as functions of inlet composition and power will be discussed.

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References

[1] Katharine I. Hunter, Jacob T. Held, K. Andre Mkhoyan, and Uwe R. Kortshagen. *ACS Appl. Mater. Interfaces* **9**, 8263 (2017).