GEC13-2013-000406

Abstract for an Invited Paper
for the GEC13 Meeting of
the American Physical Society

Microplasma synthesis of sub-5 nm metal clusters: A novel platform for study and discovery[1]

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Homogeneous, gas-phase nucleation of particles in reactive plasmas is well known. Dust formation in chemical vapor deposition (CVD) processes is undesired and can lead to deleterious effects on device fabrication and performance [1]. Recently, plasma systems have been developed to purposefully synthesize nanoparticles for technological applications [2]. The advantage of plasmas over other chemical methods include the high purity, uniformity of particle size, and the possibility of accessing unique chemistries through the non-equilibrium environment. In this talk, I will present our contribution to this rapidly emerging field: the development of a new class of atmospheric-pressure, low-temperature microplasma systems that enables the synthesis of unagglomerated, sub-5 nm particles in a single step. The synthesis of clusters in this size range is of current interest for the study and discovery of novel nanomaterials. To illustrate this point, two examples will be presented. One, clusters of Ni, Fe, and other metals are produced from their corresponding organometallic precursors [3]. Alloys with precisely controlled compositions are also obtained by tuning the relative amount of the precursors in the plasma phase. The availability of metal clusters with well-defined size and composition has allowed us to systematically study carbon nanotube nucleation and growth, and relate the properties of the catalyst to the as-grown tube diameter and chirality [4]. Two, we have carried out studies of carbon cluster formation and observed the presence of diamond-phase carbon [5]. The nucleation of diamond at near ambient conditions supports theoretical predictions of the stability of sp^3 diamond over sp^2 carbon and suggests a potential route for their existence in the cosmos.

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[1]NSF Award No. CBET-0746821 and AFOSR Award No. FA9550-10-1-0160