5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

A nanodusty plasma experiment to produce large extended 3D dusty plasma cloud on-ground laboratory

Bidyut Chutia[1], S. K. Sharma[2], H. Bailung[3]
[1,3] Dusty Plasma Laboratory, Physical Sciences Division, Institute of Advanced Study in Science and Technology,
[2] Department of Physics, Assam Don Bosco University
e-mail (speaker): bidyut.chutia.jist@gmail.com

.

A dusty (complex) plasma consists of electrically charged solid particulates of sizes varying from nanometer to micrometer exhibits various static and dynamic behaviors such as dust voids [1], dust density waves [2,3], instabilities [4], vortices [5,6], strong-coupling effects [7] etc. Dusty plasma containing nanometer sized particles on its own has been a dynamic topic both in terms of fundamental and technological research in recent times due to its richness of many interesting phenomenon and technological aspects [10,11]. Study of dust density waves in a 3D dust cloud of micron particles in microgravity condition has been also performed in various parabolic flight experiments and in International Space Station. A comparatively cost effective and alternate way to study dust density wave on ground laboratory is to use the nanoparticle cloud grown from reactive plasma discharge. Such nanodusty plasma offers various advantages along with some complexities as well for example detection of the particles, unknown particle size and density. Being smaller in size nanoparticles form a dust cloud with a large dust density which in turn affects the background plasma.

In this work, a large volume 3D dust cloud containing in-situ grown nanometer sized particles is produced in a newly developed versatile table-top experimental device. Carbonaceous nanoparticles having almost uniform size throughout the dust cloud are grown using capacitively coupled rf discharge in Ar-C_2H_2 gas mixture with low precursor gas flow rate (~ 2 sccm) and minimal rf power (~ 1 W). The vertical and radial extension of the dust cloud is 40 cm and 5 cm, respectively. The pure Ar plasma in the setup is characterized by measuring the discharge parameters as well as plasma parameters under different discharge conditions. The temporal evolution of average particle size is determined by analyzing the Scanning Electron Microscope (SEM) images of the particles. The dust density measured by using the laser extinction method, which is found to be of the order of $10^{16} - 10^{12}\ m^{-3}$ for discharge duration of (2 – 10) min. A spontaneous dust density wave (DDW) is also observed in the dust cloud.

References
[1] Y. Bailung *et al*, Phys. Plasmas **25**, 053705 (2018)
[2] T. Deka *et al*, Phys. Plasmas **24**, 093706 (2017)
[3] T. Flanagan *et al*, Phys. Plasmas **17**, 123702 (2010)
[4] H. Tawidian *et al*, Plasma Sources Sci. Technol. **23**, 065009
[5] Y. Bailung *et al*, Phys. Plasmas **27**, 123702 (2020)
[6] M. Kaur *et al*, Phys. Plasmas **22**, 093702 (2015)
[7] Y. Hayashi *et al*, J. Vac. Sci. Technol. A **14**, 506 (1996)

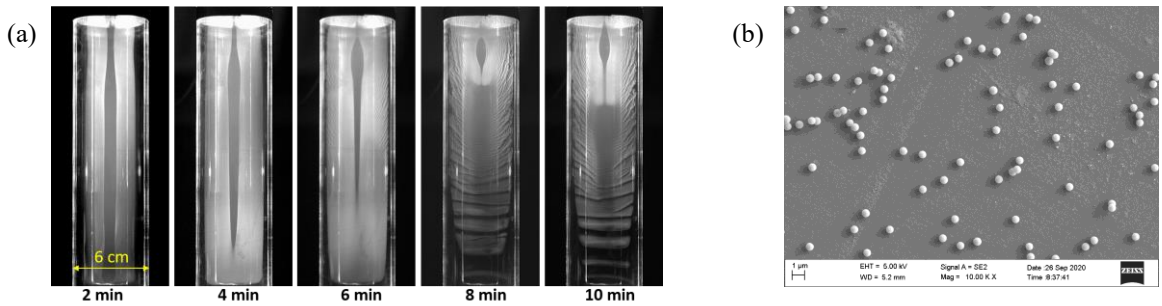

Figure 1. (a) Typical snapshots showing evolution of the dust cloud for initial 2 min to 10 min (in steps of 2 min). The rf power is 1 W, Ar flow rate: 6 sccm, C_2H_2 flow rate: 2 sccm. Total pressure: 20 Pa. (b) Typical SEM image of in-situ grown particles collected after 10 min of Ar-C_2H_2 discharge.