DENSE DUST CLOUDS FORMATION IN CRYOGENIC PLASMA

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Characteristics of dust structures depend on Debye radius, therefore its change at cooling of dust plasma leads to the reduction of distance between particles and to increase of dust structure density [1]. For the first time, the formation of dust structures from 4.14 microns in diameter MF particles in a neon glow discharge plasma at pressure 0.2-1.1 Torr (T=295 K) and temperature of liquid nitrogen was studied experimentally. The discharge tube of 200 mm length with 16.5 mm i.d. with the hollow cathode and cylindrical anode was cooled by a stream of gaseous nitrogen in optical cryostat. The temperature of a wall of the discharge tube was adjusted in the range 77.4-300K. It was revealed, that the reduction of temperature of gas leads to the appearance of longitudinal fluctuations of particles and reduction of inter-particle distances. At a temperature 200K and current 0.6 mA, the inter-particle distances were observed to reduce down to 50-60 microns in the centre of the structure and 150-200 microns at its edges, from the initial distance of about 280 microns at 295 K. The reduction of gas temperature down to T=77 K resulted to the inter-particle distance reduction down to 25-37 microns in all sections of a dust structure. In this case the fluctuations of particles in a vertical direction with amplitude to 150 microns were observed. One can explain the fluctuations of particles by variation of the longitudinal electric field which is caused by the change of density of gas because of the longitudinal temperature gradient. At increase in pressure of gas and a discharge current, the average distances between particles change slightly, but the dependence of the form of a dust cloud versus the discharge current is observed stably. Pressure reduction leads to the reduction of the quantity of particles in dust cloud and to the stratification of the cloud with the formation of dense clusters consisting of 3-4 particles (in the longitudinal direction), with distances 125-150 microns between them and 25-40 microns between particles in clusters. The voltage-current characteristics of a positive column with dust particles at cryogenic temperatures, was observed to differ essentially from that at a room temperature. This distinction may be explained by the influence of dust particles on the properties of glow discharge, which was analyzed in [2], as well as by the increasing role of atomic metastable states in the course of ionization at low temperatures.

1. V.E. Fortov, et. al., “Plasma-Dust Structures at Cryogenic Temperatures ”, Doklady Physics, 2002,V.47, Issue 1, pp. 21-24.
2. V.V. Shumova, et. al., “On the influence of dust particles on the properties of dc discharge”, VI Int. Conf. Plasma phys. and plasma tech. (PPPT – 6), Minsk,sept. 28 – oct. 2, 2009, Cont. papers, V.2, pp. 744-747.