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INVESTIGATION OF EXTENDED DUSTY PLASMA STRUCTURES

We continue to produce and to grow dusty plasma structures in a DC glow discharge plasma. The size of dusty plasma structures is comparable to the size of the positive column. The previous studies have shown that the such dusty plasma structures can involve over 10^6 *particles.*

Keywords: dusty plasma, extended dusty plasma structures, complex plasma.

1. The Growth of Extended Plasma-Dust Structures

Initial estimates show that the structure is about 73% of the plasma volume (determined by the boundaries of a glow) and about 40% of the internal volume of a discharge tube in this area. The volume of structures was about tens of cm^3. With regard for the interparticle distance, the number of particles in the plasma can be estimated to be about 6.5 million [2]. In the experiments, we use the argon glow discharge. As a dust, we took either a polydisperse zinc powder with the main fraction of particulates several micrometers in size or an MF monodisperse powder with a particle size of 3.28 microns. The discharge tube had a container with particles at its upper end. The injection of particles occurred by shaking the container. Shaking the container happened every time with the same force, and, thus, we can say about the relative constancy of the number of particles thrown into the plasma. The growth mechanism of plasma-dust structures in all cases was the same. After the first injection, a small structure, which is the center of crystallization for the subsequent completion of particles, is formed. In many cases during the first injection, the vast number of injected particulates is not retained in the observed strategies and fall to the bottom of the discharge tube. Only a small number of particles are organized to form a small structure. This structure forms the core, around which the subsequent injection of new particulate powder being completed. With the growth of the number of particles of a dust formation, flying by the structure and falling to the bottom of the discharge chamber, is reduced. A structure generally grows in the axial and radial directions.

2. Zinc Particles in Argon Plasma

The experiments were conducted in the pressure interval 10–200 Pa and discharge currents between 0.5–8 mA. In most cases, the lower boundary of this current was a current, at which the discharge is not attenuated by the dust injection. Typically, the lower bound is larger than 1 mA. The upper boundary was a current value, at which the structure was not able to grow even with a large injection of dust particles at a given pressure.

Sufficiently important is the fact that the registered extended dust structures are unique in terms of the volume occupied by the plasma space. Their uniqueness lies not only in that they have a large volume, but also in the fact that they occupy the whole current-carrying section of the channel, i.e., they fill in the entire region of the plasma, by possibly changing the conditions in the plasma.

After repeated measurements, we observed the presence of an extended region of the dusty structure shown in Fig. 1. The area lies between the two curves, which show the lower and upper limits of the discharge current. In the region between the curves, a long dusty structure can be formed. At lower pressures, the structure is not built because of strong fluctuations, which lead to the destruction of the structure. At high pressures, the dust structure consists of the individual strata that are not combined into a single monolithic chip. The growth rate depends on the structure of the discharge current flowing. The growth rate of the dusty plasma structure is defined as

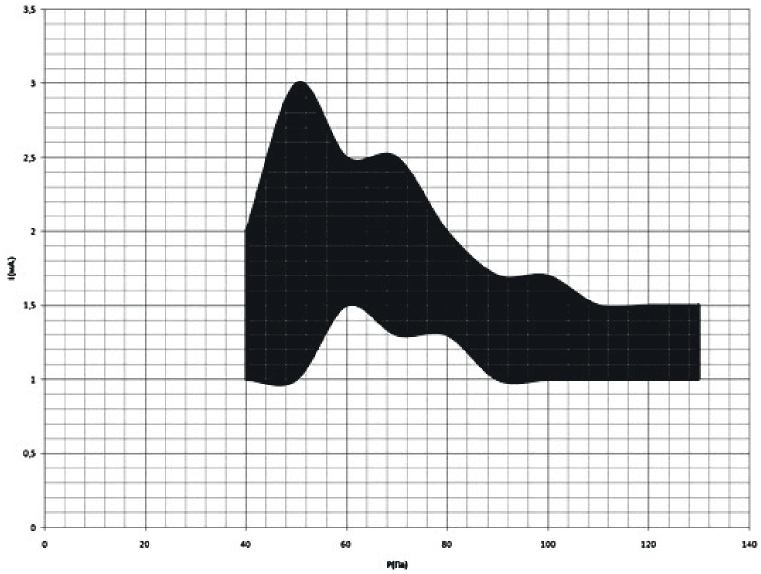

Fig. 1. Area of existence of extended dusty plasma structures in argon plasma

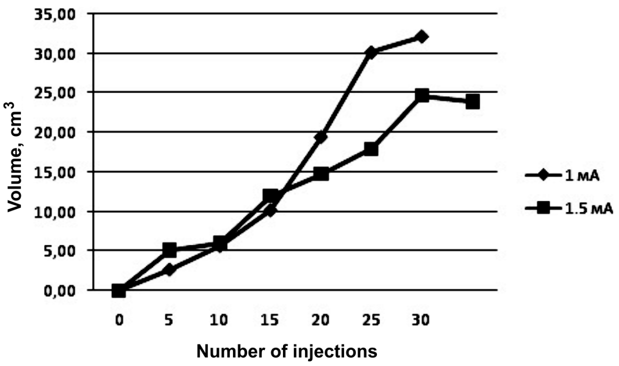

Fig. 2. Growth of dusty plasma structures in argon plasma. Zinc particles are used

Fig. 3. Growth of dusty plasma structures in argon plasma. MF particles are used

the ratio of the volume of a dusty plasma structure to the amount of dust injected into the discharge. When the current increases, the structure is growing faster than at a lower current, but if the current reaches a certain threshold, the structure ceases to be built. For comparison, in argon at a pressure of 40 Pa and a current of 2 mA, the structure grows twice faster than at the same pressure and a current of 1.5 mA.

The graphs (Fig. 2) illustrate the dependence of the dusty plasma structure of zinc particles in argon plasma on the number of injections for different discharge currents. The gas pressure in the tube is 60 Pa.

3. MF Particles in Argon Plasma

In the experiments discussed above, uncalibrated zinc particles have been used. Unlike previously used zinc particles, melamine-formaldehyde is a monodisperse powder with a known particle diameter of 3.28 microns. The melamine-formaldehyde powder has nonmetallic nature, unlike zinc. In this case, we have an opportunity to test the hypothesis that the length of the plasma-dust structures are possible only with the participation of metal powders. Experiments were carried out at pressures in the interval 40–50 Pa, and a discharge current was 1 to 3 mA. As a result, we managed to obtain the dust crystals of more than ten cubic centimeters in volume, which is comparable to the volume of the positive column. Thus, this work shows that the extended plasma-dust structures can consist of non-metallic powders.

The graphs illustrate the dependence of the plasma-dust structure formed from melamine-formaldehyde in argon plasma on the number of injections for different discharge currents. The gas pressure in the tube was 40 Pa.

4. Results

We have obtained the extended plasma-dust structures in the systems Ar–Zn and Ar–MF. The boundary parameters are given by the discharge current and the pressure, at which it is possible to obtain the extended plasma-zinc-dust structures in argon plasma for three different discharge tubes, as well as the extended plasma-dust-MF structures in the glow discharge of argon.

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ДОСЛІДЖЕННЯ ПРОТЯЖНИХ
ПЛАЗМОВО-ПИЛОВИХ СТРУКТУР

Р е з ю м е

У даній роботі продовжено отримання та вирощування в плазмі тліючого розряду постійного струму пилових структур, розмір яких можна порівняти з розміром позитивного стовпа розряду. Попередні дослідження показали, що в такі пилові освіти може бути залучено понад 10^6 макрочастинок.

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ИССЛЕДОВАНИЕ ПРОТЯЖЕННЫХ
ПЛАЗМЕННО-ПЫЛЕВЫХ СТРУКТУР

Р е з ю м е

В данной работе продолжено получение и выращивание в плазме тлеющего разряда постоянного тока пылевых структур, размер которых сравним с размером положительного столба разряда. Предыдущие исследования показали, что в такие пылевые образования может быть привлечено более 10^6 макрочастиц.