§31. Formation Process of Dust Particles in Edge Plasma of a Fusion Device

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Dusts are found formed in fusion experiment devices like LHD, and identification of their formation mechanism is one of the hottest topics in nuclear fusion research. Dust formation in edge plasma may increase tritium retention as they hydrogen isotopes. The fundamental processes related to dust formation in the edge plasma environment have not been understood yet. Thus, we have started a molecular dynamic (MD) simulation to investigate if gaseous phase reaction results in dust growth. However, the simulation requires a long calculation time. Therefore, a small experimental setup to investigate dust formation in a gaseous environment has been designed and built.

The experimental chamber is made of a 10 cm diameter, 10 cm long cylindrical glass tube. Figure 1 and 2 show the experimental setup and electrode arrangement to levitate the produced dust. Dust can be also introduced into the discharge by a dust feeder. The dust containing plasma formed in the chamber can be continuously observed through the glass chamber. The argon plasma has been maintained in the chamber by a dc glow discharges as shown in Fig. 3. Methane diluted with H_2 is fed into the chamber to see if carbon dusts are formed directly.

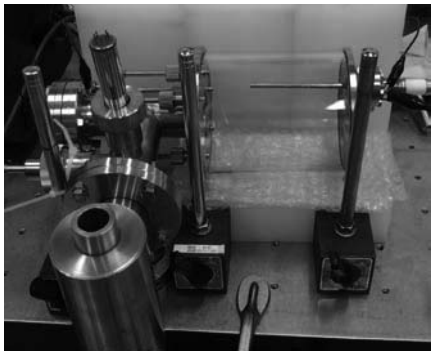

Fig. 1. Experimental setup.

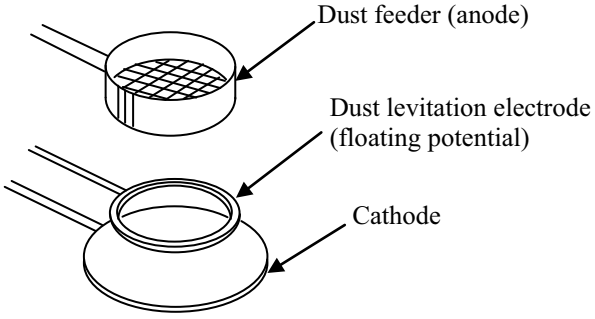

Fig. 2. Arrangement of electrode in experimental setup.

Fig. 3. Argon plasma formed in the experimental chamber shown in Fig. 1.

The dust formation experiment has been done with similar experimental setup in our group. The stable plasma was maintained by a dc glow discharge, and the plasma parameters were measured with a Langmuir probe. Typical electron temperature was below 1 eV, while the electron density ranged from 10^8 to 10^9 cm^{-3}. When the carbon dust was supplied to hydrogen plasma from the dust feeder, a cloud was observed to be formed below the dust feeder. The particle size of the dust in the cloud was far much smaller than the originally supplied dusts. The mechanism that these finer dusts are levitated in the region far from the carbon dusts is being studied. Figure 4 shows the dust cloud below the dust feeder in the past experiment.

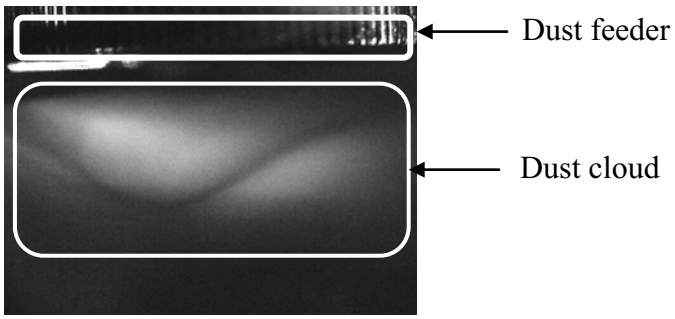

Fig. 4. Dust cloud below the dust feeder

The first task is to produce fine dust in CH_4-H_2 system. Calculations based on MD require too long time to complete dust formation, infrared spectra of carbon dust containing plasma are planned to be investigated to fill-up the gap between theory and experiments. Namely, quantum (Gaussian 03) and classical molecular dynamic (MD) simulation will be used to investigate if gaseous phase reaction results in dust growth. The observed infrared spectra will be compared with vibration energy levels of large hydrocarbon molecules predicted from MD calculations. Size distribution of dust particles formed in the plasma will be observed by illuminating the plasma with a He-Ne laser beam.