## §2. Release Condition of a Metallic Dust Particle from Plasma-facing Wall

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Dust particles with different sizes, shapes and compositions are observed in plasma during discharges and they accumulate after discharges on plasma-facing wall (PFW). The elements of dust particles originate in structure materials of divertor plates and first wall. It is supposed that the dust particles are generated by plasma-wall interaction and transported toward the core plasma as impurities. Therefore, release from the PFW and dynamics of dust particles need to be studied and controlled, but they are not well understood so far.

In this study, the release condition of the dust particle from the PFW is investigated. Forces on a spherical and metallic dust, which radius is much smaller than the Debye length, are analyzed theoretically and the plasma condition for the dust particle release is derived[1, 2].

1D sheath plasma model is applied. A spherical dust particle is on a vertical or horizontal flat plasma-facing wall, where the latter case is shown in Fig.1. The magnetic field is applied vertically to the PFW. he radius of the dust particle $R_{\rm d}$ is assumed to be much smaller than the Debye length, where the dust does not affect the potential profile near the PFW. The electrostatic wall potential drop is determined by the floating condition, where at the sheath entrance the electrostatic potential and electric field are zero. The PFW and the dust particle are charged negatively due to the high mobility of electrons. The velocity distribution functions of electrons and ions are assumed to be Maxwellian and shifted-Maxwellian distribution, respectively. Electron velocity distribution functions are truncated at the negative high velocity tale, because of the absorption to the PFW. Ion shift velocity is assumed to be the ion sound speed at the sheath entrance. In these situations the electrostatic force FE on the dust particle is a repelling one from the PFW. On the other hand the ion friction force Fi due to accelerated ions by the negatively charged dust, pushes it to the PFW. The release condition of the dust on the horizontal wall is expressed as $F_{\rm E} > F_{\rm i} + F_{\rm g}$.

The release condition is determined by the quantity $R_{\rm d}/n_{\rm se}T_{\rm e}$, where $R_{\rm d}$, $n_{\rm se}$ and $T_{\rm e}$ are the dust radius, electron density at the sheath entrance and electron temperature, respectively. Plasma ions push the dust particle toward the wall, which means the smaller dust particle in higher electron pressure has a possibility to be released from the PFW. For example, a tungsten and carbon dust particle with $R_{\rm d} = 1\mu$m in $n_{\rm e}$ reaches $1 \times 10^{18}{\rm m}^{-3}$ and ion temperature $T_{\rm i} = 0$ is released at the electron temperature higher than 7.1 and 0.71 eV, respectively, as shown in Fig. 2

1) M. Ueno, N. Ohno, Y. Tomita, G. Kawamura, to be published in Contrib. Plasma Phys.

2) M. Ueno, N. Ohno, Y. Tomita, G. Kawamura, M. Shindo, “Release condition of metallic dust particle from plasma-facing wall”, Plasma Conference 2011, (22P071-P, Ishikawa, Japan) November 2011.

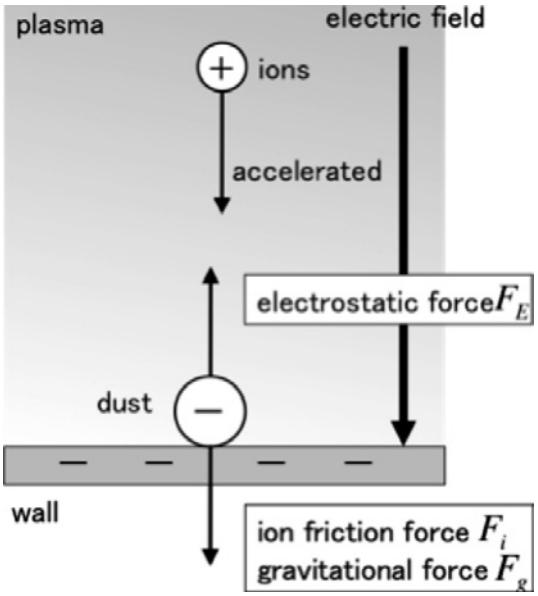


Fig. 1: Model configuration and forces on dust particle. The dust particle is released in the case of $F_{\rm E} > F_{\rm i} + F_{\rm g}$.

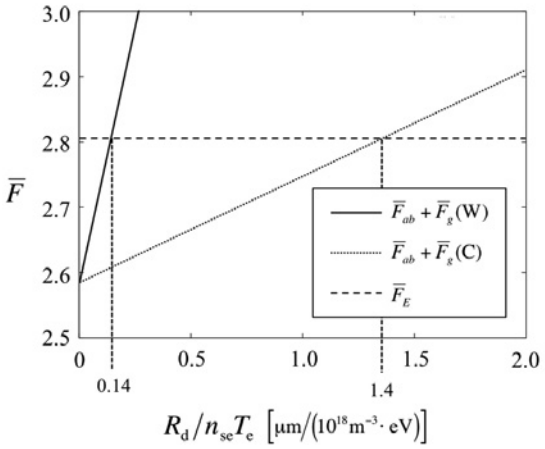


Fig. 2: Forces on a tungsten and carbon dust on the wall at $T_{\rm i} = 0$. A tungsten and carbon dust particle is released when $R_{\rm d}/n_{\rm se}T_{\rm e}$ is less than 0.14, 1.4, respectively.