§54. Simulation Study of Ion Reflection for New Diagnostic Method of Ion Energy Distribution in Edge Plasma

Hasegawa, Y. (Grad. Univ. for Advanced Studies), Masuzaki, S., Noda, N., Ohyabu, N., Sagara, A., Suzuki, S., Motojima, O., Voitsenya, V.(IPP, Kharkov, Ukraine)

A new diagnostic method of ion energy distribution[1] using ion reflection on the solid, one of the processes of plasma-wall interaction, is simulated using a Monte Carlo simulation code TRIM.SP.[2] with gyro motion and sheath potential. The scope of this diagnostic in fusion devices is relatively low ion temperature region such as the edge plasma.

For simple model for calculation, the magnetic field direction is assumed to be normal to target plate, there are three region in the model as follows; 1) plasma region (hydrogen plasma), 2) sheath region, 3) target material(tungsten). The isotropic three dimensional Maxwell distribution represented by ion temperature T_i is assumed as the ion velocity distribution in plasma region. In the sheath region, ions are accelerated by the sheath potential Φ_S with collisionless condition. On the target material , smooth and clean surface is assumed. The pitch angle of ions is represented θ. Incident ion flux Γ(E,θ) to the sheath region from the plasma region can be expressed with the azimuthal symmetry as

$$d\Gamma(E,\theta) = \frac{E}{(kT_i)^2}\sin 2\theta \exp\left(-\frac{E}{kT_i}\right) dE d\theta \quad (1)$$

where E is kinetic energy of particle in the plasma, k is the Boltzmann's constant.

The incident angle of ions to the target ,Θ , can be obtained using θ, ion kinetic energy E and sheath potential Φ_S as

$$\tan\Theta = \frac{\sqrt{E}\sin\theta}{\sqrt{E}\cos\theta + \sqrt{e\Phi_S}} \quad (2)$$

The energy distribution of reflected hydrogen atoms is shown in Fig.1. Results are summarized as follows.

(1)As shown in Fig.2, the peak energy E_p do not depend on T_i, but have linear dependence on sheath potential. The sheath potential formed in front of the target can be known from the E_p value. It means that electron temperature can be deduced from E_p, if electron emission from the target can be neglected.

(2) In the energy range of $E_{ref} > E_p$, the distribution can be approximated by the expression following

$$\frac{f_{ref}(E_{ref})}{E_{ref}} = A\exp\left(-\frac{E_{ref}}{T_{ref}}\right) \quad (3)$$

where f_{ref} is distribution function of reflected particles, A is a constant and T_{ref} is the constant representing f_{ref} respectively. From Fig.2, the depend on sheath potential weakly. It means that incident ion temperature can be deduced from T_{ref} value. In this case, we assumed isotopic Maxwell distribution for the simplest case. For other case, ion energy distribution is estimated by fitting method.

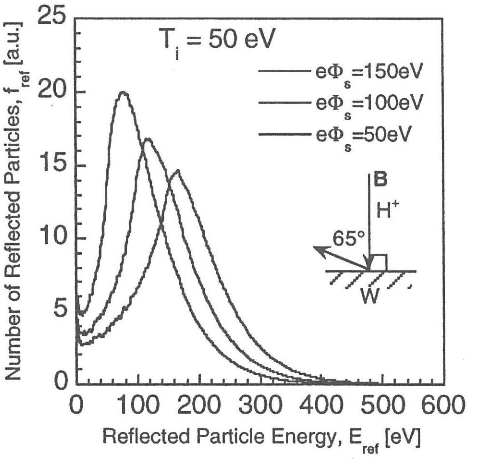

Fig.1. The reflected hydrogen atoms energy distribution f_{ref} is shown using TRIM.SP.

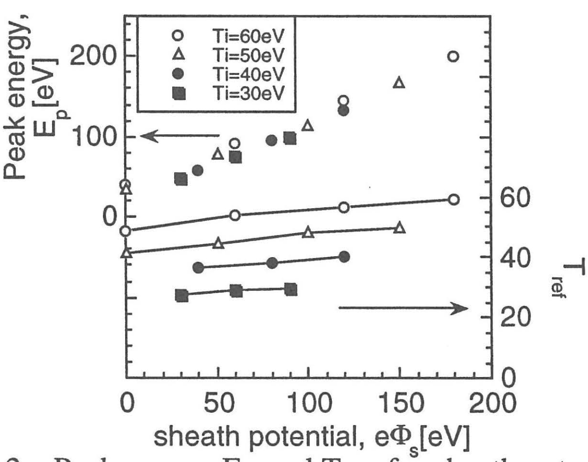

Fig.2. Peak energy E_p and T_{ref} for sheath potential.

Reference

[1] Voitsenya, V., et al.,NIFS-465, National Institute for Fusion Science, JAPAN (1996).

[2] Eckstein, W., Computer Simulation of Ion-Solid Interaction(Springer, Berlin, 1991).