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1. Introduction

At present it is thought that the lifetime of a tokamak reactor will be determined by the stability of structural elements in contact with the plasma (first wall and divertor plates). The work being carried out presently on tokamak reactor design is making rigorous demands on the accuracy of erosion rate estimates (the speed at which erosion of the structural elements occurs) and also on estimates of the quantity of impurities entering the plasma. The experimental data available suggest that with comparatively long operating pulses the principal cause of first wall erosion will be sputtering by charge exchange neutrals, and that divertor plate erosion will be largely due to the principal plasma ions and to self-sputtering. Estimates of the sputtering rates of the first wall materials were obtained by Guseva and co-workers [1], who used sputtering coefficients averaged over a Maxwellian distribution of perpendicularly incident particles. The sputtering coefficients for a given energy were calculated from experimental values on the basis of the Sigmund theory, corrected in the low energy region [2]. In order to estimate the sputtering rate of divertor plate materials, various expressions for the sputtering coefficients are used, which are extrapolated to low energies and are valid for normal particle incidence. In doing this, one takes the value of the sputtering coefficient for an energy approximately equal to the energy acquired by a particle in the field of the Debye layer [3]. It is not difficult to show that the wall thickness Δ sputtered by a flux of particles of different types j in a year of continuous reactor operation will be:

$$\Delta = \frac{5{,}27 \cdot 10^{-16} A}{\rho} \langle S_j q_j \rangle, \qquad (1)$$

where Δ is in mm/yr, A is the atomic weight of the target in units of hydrogen atom mass, ρ is the density of the target material in g/cm^3, $S_j(E,\theta)$ is the sputtering coefficient for particles of type j with energy E and angle of incidence θ and q_j is the density of the flux of particles of type j, in particles/cm^2. The brackets <...> indicate averaging over the angular distribution and over the energy of incident particles. Thus, in order to obtain a relatively accurate estimate of Δ, correct definition of the distribution of incident particles, their charge state and the sputtering coefficient $S_j(E,\theta)$ are required.

In the present paper we compare the existing data for the sputtering coefficients and derive values averaged over both the energy spectrum and the angular distribution. In most cases a Maxwellian particle distribution function is used for averaging over the energy spectrum. However, near the divertor plates the charged particle distribution function can be seriously distorted, so that the use of data for a sputtering coefficient averaged over the equilibrium distribution function can give incorrect values. The erosion calculations in this paper take into account the distortion of the distribution function and the angular dependence of the sputtering coefficient. Let us first consider the shape of the distribution function for particles incident on a material surface.

2. The particle distribution function near the surface

The charged particle distribution function near the receiving plates of the divertor must be strongly non-Maxwellian. This is explained by the extreme non-equilibrium of the processes occurring in this region, due, in particular, to the presence of a space charge and the influence of surface effects (existence of sinks and sources on the surface). The detailed structure of the distribution function near the plates inevitably depends on many parameters, and at present it is impossible to take all of them accurately into account. In what follows, therefore, we shall limit ourselves to an analysis of the main effects which, in our opinion, govern the essential difference between the distribution function near the wall and the distribution function of particles far from the plates in the inflowing plasma flux. Due to the relaxation processes (caused by collisions, scattering on the waves, and so on), the distribution of the ions far from the receiving plates must go into an equilibrium distribution which, under the conditions of a plasma flowing towards the plate, may be regarded as a Maxwellian distribution shifted by the amount of some directional velocity v_0. The velocity v_0 is determined by the longitudinal plasma gradients, by the presence of sources and by the acceleration in the field of the plasma sheath, [4, 5]. In typical wall plasma conditions ($n_e \simeq 10^{13}$-10^{14} cm^{-3}, $T_e \simeq T_i \lesssim 100$ eV), the inequality $\rho_e \leq \lambda_D < \rho_i < \lambda_p$ is fulfilled (where $\rho_{e,i}$ is the cyclotron radius of the electrons and ions, λ_D the thickness of the Debye layer, and λ_p is the mean free path of a charged particle up to the wall). The presence of neutral gas near the plates will obviously not affect the distribution of charged particles flying towards the wall if λ_p is greater than the characteristic hydrogen atom distribution length near the plate. This condition is fulfilled when the plasma density, which determines the neutral distribution width, is greater than (or of the same order as) the atom density. In all this, the influence of magnetic field and atomic ionization can be disregarded. The plasma ion distribution function at the threshold of the Debye sheath (at a distance of ~ λ_D from the plate) can be represented as a shifted equilibrium function:

$$f_0 = \frac{2j_0}{v_T^2}\frac{1}{\pi v_T^2}\exp(-u_{\perp 0}^2 - (u_{\parallel 0} - M_0)^2), \qquad (2)$$

where $j_o = (1/4)n\sqrt{8T/\pi m_i}$ is a one-way flow towards the plate; $u_{\perp o} = v_\perp/v_T$ and $u_{\parallel o} = v_\parallel/v_T$ are the transverse and longitudinal components of velocity relative to the direction of the magnetic field lines divided by the thermal velocity $v_T = \sqrt{2T/m_i}$; and $M_o = v/v_T$ is the Mach number. Expression (2) reflects the fact that from a distance equivalent to the mean free path λ_p the ions in a collisionless regime are accelerated towards the plate as a whole in the plasma sheath field, such that at the entrance to the space charge region, the average velocity of the ions satisfies the Bohm condition. Since the distribution function in this regime depends only on the integrals of motion, near the plate one has:

$$f_d = \iint f_0(u_\perp, u_\parallel)\delta(u_\perp^2 - u_{\perp 0}^2)\delta(u_\parallel^2 - \frac{e(\varphi - \varphi_0)}{T_i} u_{\parallel 0}^2)du_\parallel^2 du_\perp^2 , \qquad (3)$$

where φ_o is the plasma potential far from the plate. Putting the plate potential at zero ($\varphi = 0$), we obtain the following expressions for the distribution function of ions incident on the plate:

$$f_d = \frac{2j_0}{F(M_0)v_T^4}\exp\left[-u_\perp^2 - \left(\sqrt{u_\parallel^2 - \frac{e\varphi_0}{T_i}} - M_0\right)^2\right];\ u_\parallel > \sqrt{\frac{e\varphi_0}{T_i}};$$

$$f_d = 0;\ u_\parallel \leqslant \sqrt{e\varphi_0/T_i}\ ; \qquad (4)$$

$$F(M) \equiv 2\pi\int_0^\infty f_i(v)v_\parallel dv_\parallel dv_\perp = \exp(-\frac{Z_i^2}{2}) + \sqrt{\frac{\pi Z_i}{2}}\,\mathrm{Erf}(-\sqrt{\frac{Z_i}{2}}).$$

Note that in deriving the expression (4) we have assumed that the ions recombine fully on the plate and that the magnetic field line orientation is normal to the surface of the receiving plates. Clearly, then, as the angle of incidence of the field lines with respect to the plate (ψ) becomes smaller, the value of M_o, which is proportional to cos ψ, will tend to zero and within the limit of tangential incidence ($\psi \rightarrow \pi/2$) the distribution in (4) will become one-way Maxwellian. The dependence of the distribution shift on the angle of incidence is associated with the fact that the sheath electric field orientation is normal to the surface and that the projection of this field in the direction of the magnetic field line decreases as the angle of incidence becomes smaller. In fact, if we take the roughness of the surface into account, both normal and tangential intersection of the magnetic field line with the surface would be possible. In calculating the sputtering we have allowed for the least favourable situation, which occurs when the field lines intersect the surface perpendicularly.

It follows from (4) that the distribution of ions incident on the surface of the plate is in general non-Maxwellian since the velocities are governed by the law of energy conservation. In compliance with the Bohm condition, at the threshold of the Debye sheath - in the absence of any longitudinal pressure gradient - M_o is taken to be equal to $\sqrt{Z_i/2T_e/T_i} \approx \sqrt{Z_i/2}$ where Z_i is the charge of any arbitrary ion accelerating in the plasma sheath potential ~ $T_e/2$. For the potential drop in the sheath we use the usual expression $e\phi_o \approx T_e \ln \sqrt{m_i/2\pi m_e}$ (where m_i is the mass of the principal plasma ions), which is valid in the absence of secondary electron emission and provided the condition $\sum_k n_{Z_k} \cdot Z_k \ll n_i$ holds (n_{Z_k} is the density of impurity ions with charge Z_k and n_i is the density of the principal plasma ions), when the influence of impurity ions can be disregarded.

The distribution function for the atoms, which sputter the divertor plates, is taken as equal to $f_i(M_o)$. It is assumed that, in a time of the order of the time between charge exchange collisions, the distribution of cold atoms leaving the surface of the plate relaxes to the ion distribution near the plate.

The distribution of atoms impinging on the first wall of the reactor is taken to be Maxwellian. In contrast to the authors of Refs [1, 2], we have allowed for the angular distribution of incident atoms in calculating the sputtering coefficient for the first wall of the reactor.

3. Energy and angular dependence of the sputtering coefficients

First let us discuss the expression for the sputtering coefficient $S(E,\theta)$. Up until now no unambiguous solution has been obtained to the sputtering problem in the low-energy region, $E < 1$ keV. This is largely because we have no unified conception of the interaction potential between the incident particle and the solid state particles in the energy range of interest. By selecting different types of potentials (for example Thomas-Fermi-Firsov, Born-Meyer and others) we arrive at different expressions for the sputtering coefficients. In principle it should be possible to check the correctness of these coefficients by comparing them with experimental data; however, the available experimental data on particle sputtering at low energies are at best fragmentary and suffer from a broad scatter owing to the serious experimental difficulties encountered in determining extremely low values of $S(E,\theta)$. Accordingly, the usual procedure at the present time is to use empirical formulas which give fairly good agreement with the available experimental data. The formula which has become most popular is that proposed by D. Smith [6] on the basis of the Lindhard model. In Ref. [3], the following modification of Smith's formula has been proposed:

$$S_1(E,0) = \frac{C}{U_0} Z_1^{0,75} (Z_2 - 1,8)^2 \left(\frac{M_1 - 0,8}{M_2}\right)^{1,5} \frac{E - E_{TH}}{(E - E_{TH} + 50\, Z_1^{0,75} \cdot Z_2)^2}, \tag{5}$$

where $C = 2 \times 10^3$ for hydrogen and 400 for other incident particles; U_o is the binding (sublimation) energy of the target atoms, in eV; Z_1 and Z_2 are the atomic numbers of the incident particle and the target particle, respectively; M_1 and M_2 are the mass of the incident particle and the target atom, in units of proton mass; E is the energy of the incident particle, in eV; and E_{th} is the threshold energy of sputtering as given by the expression

$$E_{Th} = \frac{(4M_1 + M_2)^2}{4M_1 M_2} U_0. \tag{6}$$

At low energies ($E-E_{th} < 50\ Z_1^{0.75}\ Z_2$), it follows from expression (5) that the variation of the sputtering coefficient with energy is linear. In the limiting case of high energies Eq. (5) gives $S \sim 1/E$. The experimental data, however, are better described by a relationship of the type $S \sim \ln E/E$ [7]. At high energies a relationship of this kind is predicted by the formula proposed in Ref. [8] on the basis of an analysis of numerous experimental and theoretical studies. According to Ref. [8], we have

$$S_2(E,0) = Q\,\frac{3{,}441\sqrt{E/E_{TF}}\,\ln(E/E_{TF} + 2{,}718)[1 - (E_T/E)^{2/3}](1 - E_T/E)^2}{1 + 6{,}355\sqrt{E/E_{TF}} + E/E_{TF}(6{,}882\sqrt{E/E_{TF}} - 1{,}708)}. \tag{7}$$

where E_{TF} is the particle interaction energy at the distance of closest approach (in the centre-of-mass ~~system~~), ~~and~~ E_t is the threshold energy for various "incident particle + target atom" pairs. Values of the parameters Q, E_t and E_{TF} for a number of pairs are to be found in Ref. [8]. It is instructive to compare calculations of the sputtering coefficient for the case of normal incidence using expressions (5) and (7), and also to compare these with the experimental data taken from Refs [8, 9]. The results of such a comparison for a number of incident particle energies are shown in Tables 1-8.

From the data in these tables it is clear that the calculations using expression (7) agree better, on the whole, with the experimental data, and so in what follows we shall use this equation. Table 9 shows values of the parameters Q, E_t and E_{TF} for a number of "incident particle + target atom" combinations. In cases where the values of these parameters are not known for some particular combination, expression (5) was used for the calculations. Table 10 presents values of U_o and the density ρ for a number of materials of particular interest for a reactor.

Let us now consider the relationship between the sputtering coefficient and the angle of incidence of the incident particle, θ. The behaviour of this dependence has been considered in a number of papers (see for example Ref. [3], the most thorough analysis being given in Ref. [10]). According to Ref. [10], the following approximating formula can be used to describe the angular dependence:

$$S(\theta) = \frac{1}{\cos^f\theta} \exp[- f \cos \theta_{optim} \; (\frac{1}{\cos \theta} - 1), \qquad (8)$$

where the parameters f and θ_{optim} are determined from experimental data and from numerical calculations. For the case of sputtering by light ions, f is independent of energy and θ_{optim} is defined by the relation:

$$\theta_{\mathrm{optim}} = 90^\circ - 57{,}3\frac{\eta}{E^{1/4}} \tag{9}$$

The parameters f and η in this expression (for E = 1 keV) are given in Ref. [10] for ions of hydrogen, deuterium, tritium, helium and various target materials. Figure 1 shows $S(\theta)$ for the case of iron sputtering by deuterium ions. We see that with increasing energy the maximum value of the sputtering coefficient rises, and that the range of angles for which $S(\theta)/S(\theta = 0) > 1$ becomes broader. Yamamura and co-workers [10] have shown that, for light ions, calculations of $S(\theta)$ using expression (8) are in good agreement with the experimental data. Unfortunately, in the case of sputtering by heavy ions and self-sputtering the situation is much less favourable. According to Ref. [10], in this case one has:

$$f = (1 + 2{,}5\,\frac{1-\xi}{\xi})f_s\,; \tag{10}$$

$$\theta_{\mathrm{optim}} = 90^\circ - 57{,}3\,\psi^{0{,}45}, \tag{11}$$

where $\xi \equiv 1 - (E_T/E)^{1/2}$, $\psi \sim 1/\sqrt{E}$, and f_s is calculated by using the Sigmund theory.

From expressions (8), (10) and (11) it follows that the magnitude of $S(\theta)$ for sputtering by heavy ions is extremely sensitive to the incident particle energy, both in the near-threshold energy range ($\psi \to 0$, $f \to \infty$) and in the high energy region ($\psi \to 0$, $\theta_{\mathrm{optim}} \to 90^\circ$). For $E \to \infty$, the exponent in expression (8) vanishes and the role of the cut-off factor becomes negligibly small. Accordingly, a non-physical divergence of $S(\theta)$ appears for $\theta \to 90^\circ$, which means that for the time being the shape of the angular dependence of the sputtering coefficient for sputtering by heavy ions remains an open question.

4. Average value of the sputtering coefficient

The sputtering coefficient averaged over the energy and angles of incidence,

$$\bar{S}_j = \frac{\int f_i(E)S(E,\theta)\sqrt{E}\cos\theta\, d\cos\theta\, dE}{\int f_i(E)\sqrt{E}\cos\theta\, d\cos\theta\, dE},$$

can be written as:

$$\bar{S}_j\left(\frac{\text{atom}}{\text{ion}}\right) = S_{T_0}\int_0^1 tS(t)dt\int_{\epsilon_*}^{\infty} \exp\left(-\frac{\epsilon}{\beta}(1-t^2)\right)S(\epsilon)\times$$

$$\times \exp\left\{-\left(\sqrt{\frac{\epsilon}{\beta}t^2-\delta}-M_0\right)^2\right\}\epsilon d\epsilon, \qquad (12)$$

where $S_{T_0} = 2E_T^2/T_i^2F(M)$; $t = \cos\theta$, $\epsilon_* = \max(1,\delta)$; $\epsilon = E/E_T$; $\beta = T_i/E_T$; and $\delta = Z_ie\Phi_0/T_i$.

In expression (12) above, $S(t)$ is the angular dependence of the sputtering coefficient in Eq. (8); $S(\epsilon)$ is the energy dependence of the sputtering coefficient [see Eq. (5) or Eq. (7)]; E_T is the threshold energy determined either from Eq. (6) or from the data in Table 9; Z_i is the charge of the incident ion; and Φ_0 is the Debye potential. It can be seen that in contrast to the coefficient for sputtering by a single particle, the magnitude of which depends only on the nuclear charge Z_1 of the incident particle, the true sputtering coefficient in a plasma depends also on the charge state of the incident particle - and, what is more, this dependence enters into both the parameter δ and the lower limit of energy integration, ϵ_*.

This is because the minimum energy taken on by the ion in the Debye layer field is proportional to its charge. Since the number of particles in the accelerating field is preserved, the fraction of fast particles on a plate rises exponentially with increasing δ. However, the dependence of $\bar{S}$ on δ proves to be fairly complex: on the one hand, the magnitude of $\bar{S}$ should increase owing to the increasing number of fast particles; but on the other hand, if the minimum energy acquired in the Debye layer field exceeds the threshold value for sputtering, then $\bar{S}$ must decrease, since with increasing δ the range of integration for ε in expression (12) is obviously reduced.

5. Results of the calculations and discussion

In accordance with the above discussions, expression (12) was used to calculate the double-averaged (angle and energy) sputtering coefficients for a number of materials and incident particles. The results of these calculations are shown in Tables 11 to 28, where the following notation is used: the case max = 0 corresponds to $M_0 = 0$; the case max = 1 means that allowance is made for ion acceleration up to the limit; the case FIO = 0 corresponds to $\phi = 0$; and the case FIO = 1 means that allowance is made for ion acceleration in the Debye layer. Tables 11 to 28 show data for sputtering of carbon, aluminium, titanium, iron, molybdenum and tungsten by atoms and ions of hydrogen, deuterium, tritium and helium. In Table 29 we give data for sputtering of vanadium by atoms of deuterium, tritium and helium. For the sake of comparison, Table 30 presents data for a sputtering coefficient averaged only over the incident particle energy.

These calculations enable one to assess the role of effects such as the presence of an accelerating potential, distortion of the distribution function, and allowance for the angular dependence of the sputtering coefficient, and to make recommendations as a result of which numerical calculations can be avoided. Comparing values of $\bar{S}$ calculated for different values of M_o and δ, we can easily see that the increase in the angle- and energy-averaged sputtering coefficient for $\delta \neq 0$ and $M_o \neq 0$ as compared with $\delta = 0$ and $M_o = 0$ is mainly due to allowing for the influence of the accelerating potential. Thus, for example, if the angular dependence is taken into account in sputtering of tungsten by deuterium atoms at $T_e = 100$ eV, the sputtering coefficient is increased by roughly a factor of three, whereas allowance for the potential (i.e. sputtering of tungsten by the deuterium ion) leads to an increase in sputtering by a factor of 35. The significance of allowing for the angular dependence $S(\theta)$ is demonstrated in Fig. 2, which shows the ratio between a sputtering coefficient which is both angle- and energy-averaged and a coefficient averaged only for energy (for the case $\delta = 0$, $M_o = 0$). It can be seen that this ratio increases with temperature, and this is to be expected, since as the temperature rises the contribution of high-energy particles for which (in accordance with expression (8)) an increase in the sputtering coefficient at grazing incidence is substantial. Thus we can say that, even though for energies < 200 eV the dependence of the sputtering coefficient on the angle of incidence is weak, nevertheless in determining the distribution-function-averaged sputtering coefficient, allowance for the angular dependence is important even at low temperatures (in tungsten sputtering by deuterium atoms the coefficient is increased by a factor of 2.5 even at $T = 10$ eV). Cook and co-workers [11] have drawn attention to the importance of taking the angular dependence of the sputtering coefficient into account. Figure 3 shows the calculated sputtering coefficient averaged over the angle of incidence and over a Maxwellian distribution function, for a combination of deuterium + nickel [11], together with calculations based on Eq. (12) for $\delta = 0$ and $M_o = 0$. It can be seen that the agreement of the results of calculations, using an undistorted distribution function, with the present ones is fairly good. (The small difference is due to the fact that in Ref. [11] the averaging procedure used a weighting function equal to 1, whereas in our calculations based on Eq. (12) a weighting function v is involved).

The results of our analysis of the data show that allowance for distortion of the distribution function increases the sputtering coefficient by a factor of 1.5 to 2, an increase comparable to that resulting from taking the angular dependence into account. It is instructive to compare calculated values of the sputtering coefficient with values determined from Eq. (7) for an energy equivalent to 3.5 Z_iT_e (this is the energy acquired by the ion allowing for acceleration in the Debye sheath and in the pre-sheath). From this comparison one can see that for all "incident particle + target atom" pairs, the magnitude of S in the tables exceeds the values of S for $E = 3.5\ Z_iT_e$ by several times (the actual magnitude of the excess depends on the type of incident ion).

From the data in Tables 11 to 30, it can be seen that for T < 10 eV the sputtering coefficient is very low ($< 10^{-5}$) for some "incident particle + target atom" pairs. Similar sputtering coefficients are characteristic of sputtering by the 14 MeV neutrons [7]. However, since the neutron fluxes are far smaller than the particle fluxes from the plasma, their contribution to the sputtering yeald can be neglected even though the actual neutron sputtering coefficients may be relatively large on occasion.

Figure 4 shows the sputtering coefficient for iron by deuterium, tritium and helium atoms as a function of temperature, and Fig. 5 shows the temperature dependence of the sputtering coefficient for tungsten by deuterium, tritium and singly-charged helium ions.

Conclusions

1. In the present study, we have obtained sputtering coefficients (averaged over the incident particle energy and angle of incidence) and erosion rates for the materials and incident particles which will be characteristic of a tokamak reactor. Sputtering coefficients have been determined for carbon, aluminium, titanium, iron, molybdenum, vanadium and tungsten for sputtering by hydrogen isotopes (hydrogen, deuterium and tritium) and helium atoms and ions.

2. The influence on the sputtering coefficient of the potential difference between the wall and the plasma is demonstrated. Taking this potential difference into account, results in a substantial increase in the sputtering coefficient. The usual method of assessing the sputtering coefficient taking into account the potential difference for $E = 3.5\ Z_i T_e$ gives values that are too low.

3. Allowance for the angular distribution of incident particles is important both in the high- and low-temperature regions. This is associated with averaging over the incident particle distribution function.

4. It is shown that first wall erosion in a tokamak reactor due to sputtering by neutral atoms is substantially in excess of the value obtained without allowance for the angular dependence of the sputtering coefficient.

Table 1: Coefficients for sputtering of stainless steel by deuterium.

S (E,0)	E, eV					
	50	100	200	500	10^3	3.10^3
S_1	$1,3.10^{-4}$	$5,5.10^{-3}$	$1,5.10^{-2}$	$2,5.10^{-2}$	3.10^{-2}	$2,8.10^{-2}$
S_2	10^{-4}	$3,5.10^{-3}$	1.10^{-2}	$2,5.10^{-2}$	3.10^{-2}	2.10^{-2}
$S_{exp.}$	–	$3,5.10^{-3}$	–	$(2-2,5) \times 10^{-2}$	3.10^{-2}	$(2-3).10^{-2}$

Table 2: Coefficients for sputtering of stainless steel by helium.

S (E,0)	E, eV					
	50	100	200	500	10^3	3.10^3
S_1	6.10^{-3}	$1,8.10^{-2}$	3.10^{-2}	0,08	0,11	$1,2.10^{-2}$
S_2	8.10^{-3}	$3,5.10^{-2}$	4.10^{-2}	0,1	0,11	$1,1.10^{-2}$
$S_{exp.}$	–	–	7.10^{-2}	0,08 – 0,1	0,102	$1,1.10^{-2}$

Table 3: Coefficients for sputtering of nickel by deuterium.

S (E,0)	E, eV				
	50	100	500	10^3	3.10^3
S_1	$7,6.10^{-4}$	$4,9.10^{-3}$	$2,4.10^{-2}$	$3,1.10^{-2}$	$2,8.10^{-2}$
S_2	$1,36.10^{-3}$	$9,4.10^{-3}$	$3,3.10^{-2}$	$4,1.10^{-2}$	4.10^{-2}
$S_{exp.}$	–	6.10^{-3}	3.10^{-2}	4.10^{-2}	3.10^{-2}

Table 4: Coefficients for sputtering of nickel by helium.

S (E,0)	E, eV					
	40	50	100	500	10^3	3.10^3
S_1	$3,29.10^{-3}$	$5,6.10^{-3}$	$1,7.10^{-2}$	$7,9.10^{-2}$	0,12	0,14
S_2	$7,68.10^{-3}$	$1,5.10^{-2}$	$4,4.10^{-2}$	0,128	0,116	0,22
$S_{exp.}$	–	–	–	0,15	0,2	0,2

Table 5: Coefficients for sputtering of tungsten by helium.

S (E,0)	E, eV			
	200	500	10^3	2.10^3
S_1	$8,0.10^{-4}$	5.10^{-3}	$1,5.10^{-2}$	2.10^{-2}
S_2	$2,2.10^{-3}$	10^{-2}	$2,2.10^{-2}$	3.10^{-2}
$S_{exp.}$	-	9.10^{-3}	$2,2.10^{-2}$	3.10^{-2}

Table 6: Coefficients for sputtering of tungsten by hydrogen.

S (E,0)	E, eV				
	700	10^3	2.10^3	4.10^3	10^4
S_1	3.10^{-4}	8.10^{-4}	$1,5.10^{-3}$	$2,2.10^{-3}$	$1,7.10^{-3}$
S_2	10^{-4}	3.10^{-4}	$1,5.10^{-3}$	2.10^{-3}	$2,2.10^{-3}$
$S_{exp.}$	–	3.10^{-4}	10^{-3}	2.10^{-3}	2.10^{-3}

Table 7: Coefficients for self-sputtering of nickel.

S (E,0)	E, eV						
	40	50	70	100	200	10^3	3.10^3
S_1	$3,2.10^{-2}$	$5,7.10^{-2}$	0,1	0,18	0,44	0,22	5,5
S_2	3.10^{-3}	$2,5.10^{-2}$	8.10^{-2}	0,2	0,55	1,8	2,5
$S_{exp.}$	–	–	8.10^{-2}	0,2	0,55	1,8	3

Table 8: Coefficients for self-sputtering of titanium.

S (E,0)	E, eV							
	90	120	150	200	300	600	10^3	3.10^3
S_1	0,15	0,23	0,30	0,43	0,67	1,35	2,15	4,68
S_2	0,04	0,076	0,11	0,17	0,27	0,45	0,56	0,92
$S_{exp.}$	0,011	0,09	0,12	0,24	0,34	0,48	0,62	1

Table 9: Values of the parameters in Eq.(7).

Target	Parameter	Incident particle				Self-sputtering
		H	D	T	He	
Al	E_T, eV	67	41	35	25	25
	E_{TF}, eV	1058	1096	1134	2448	34550
	Q,at./ion	0,045	0,14	0,2	0,59	5,4
C	E_T, eV	15	25	30	65	44
	E_{TF}, eV	415	446	48	1090	5680
	Q,at./ion	0,035	0,14	0,2	0,32	1,9
Ti	E_T, eV	80	50	40	25	40
	E_{TF}, eV	2060	2100	2140	4510	$1,18.10^{5}$
	Q,at./ion	0,017	0,055	0,1	0,125	3,7
Fe	E_T, eV	68	46	40	33	40
	E_{TF}, eV	2540	2590	2630	5514	$1,74.10^{5}$
	Q,at./ion	0,41	0,12	0,21	0,53	13
Ni	E_T, eV	50	30	25	20	35
	E_{TF}, eV	2800	2850	2890	6040	$2,07.10^{5}$
	Q,at./ion	0,05	0,12	0,22	0,45	12
Mo	E_T, eV	200	135	70	48	64
	E_{TF}, eV	4720	4770	4820	9940	$5,33.10^{5}$
	Q,at./ion	$7,8.10^{-3}$	0,023	0,045	0,17	18
W	E_T, eV	458	160	140	100	80
	E_{TF}, eV	9870	9920	9980	2.10^{4}	2.10^{6}
	Q,at./ion	$7,7.10^{-3}$	0,021	0,038	0,1	37

Table 10: Values of U_0 and ρ for various targets.

Parameter	Target							
	C	Al	Ti	V	Fe	Nb	Mo	W
U_0, eV	7,4	3,4	4,9	5,3	4,3	7,6	7,8	11,1
ρ, g/cm^3	1,6	2,7	4,5	5,96	7,86	8,4	10,2	19,3

Table 11: Coefficients for sputtering by hydrogen max = 0.00, Fi0 = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	9.26e-06	1.21e-16	1.63e-13	5.32e-35	0.00e+00	3.16e-14
5.0	1.36e-04	1.28e-11	3.44e-09	5.35e-23	0.00e+00	5.81e-10
6.0	2.82e-04	2.52e-10	4.50e-08	5.90e-20	0.00e+00	7.32e-09
7.0	4.83e-04	2.19e-09	2.93e-07	9.16e-18	2.10e-34	4.63e-08
8.0	7.35e-04	1.14e-08	1.22e-06	4.16e-16	9.68e-31	1.89e-07
9.0	1.03e-03	4.17e-08	3.77e-06	8.26e-15	7.01e-28	5.74e-07
10.0	1.36e-03	1.20e-07	9.42e-06	9.20e-14	1.39e-25	1.42e-06
15.0	3.30e-03	3.16e-06	1.64e-04	1.46e-10	1.26e-18	2.35e-05
20.0	5.40e-03	1.78e-05	7.48e-04	6.57e-09	4.39e-15	1.04e-04
25.0	7.44e-03	5.31e-05	1.95e-03	6.92e-08	6.36e-13	2.67e-04
30.0	9.33e-03	1.13e-04	3.81e-03	3.47e-07	1.85e-11	5.12e-04
40.0	1.26e-02	3.06e-04	9.21e-03	2.80e-06	1.36e-09	1.21e-03
50.0	1.54e-02	5.77e-04	1.62e-02	1.03e-05	1.93e-08	2.09e-03
60.0	1.77e-02	9.01e-04	2.41e-02	2.55e-05	1.18e-07	3.06e-03
70.0	1.96e-02	1.26e-03	3.25e-02	4.99e-05	4.44e-07	4.06e-03
80.0	2.12e-02	1.63e-03	4.10e-02	8.36e-05	1.23e-06	5.06e-03
90.0	2.26e-02	2.00e-03	4.95e-02	1.26e-04	2.74e-06	6.04e-03
100.0	2.38e-02	2.38e-03	5.78e-02	1.77e-04	5.28e-06	6.98e-03
150.0	2.77e-02	4.13e-03	9.54e-02	5.23e-04	4.13e-05	1.10e-02
200.0	2.97e-02	5.58e-03	1.26e-01	9.45e-04	1.25e-04	1.40e-02
250.0	3.08e-02	6.77e-03	1.50e-01	1.38e-03	2.51e-04	1.63e-02
300.0	3.13e-02	7.74e-03	1.70e-01	1.81e-03	4.11e-04	1.80e-02
400.0	3.16e-02	9.20e-03	2.01e-01	2.58e-03	7.87e-04	2.03e-02
500.0	3.13e-02	1.02e-02	2.22e-01	3.24e-03	1.19e-03	2.17e-02
1000.0	2.83e-02	1.24e-02	2.68e-01	5.33e-03	3.03e-03	2.34e-02
2000.0	2.33e-02	1.27e-02	2.76e-01	6.87e-03	5.22e-03	2.16e-02
3000.0	2.02e-02	1.21e-02	2.65e-01	7.30e-03	6.31e-03	1.95e-02

Table 12: Coefficients for sputtering by deuterium max = 0.00, Fi0 = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	6.54e-07	1.56e-11	1.15e-10	6.83e-25	1.08e-28	1.08e-09
5.0	3.95e-05	2.91e-08	1.24e-07	1.16e-16	5.18e-19	5.85e-07
6.0	1.17e-04	2.07e-07	7.70e-07	1.45e-14	1.50e-16	3.04e-06
7.0	2.61e-04	8.64e-07	2.92e-06	4.76e-13	8.97e-15	1.01e-05
8.0	4.84e-04	2.58e-06	8.10e-06	6.71e-12	1.99e-13	2.55e-05
9.0	7.94e-04	6.16e-06	1.82e-05	5.37e-11	2.26e-12	5.32e-05
10.0	1.19e-03	1.25e-05	3.53e-05	2.88e-10	1.61e-11	9.68e-05
15.0	4.30e-03	1.15e-04	2.82e-04	5.07e-08	6.64e-09	6.36e-04
20.0	8.67e-03	3.79e-04	8.63e-04	7.54e-07	1.52e-07	1.75e-03
25.0	1.36e-02	8.08e-04	1.76e-03	4.06e-06	1.07e-06	3.35e-03
30.0	1.87e-02	1.38e-03	2.91e-03	1.29e-05	4.08e-06	5.26e-03
40.0	2.85e-02	2.79e-03	5.68e-03	5.88e-05	2.33e-05	9.60e-03
50.0	3.74e-02	4.40e-03	8.75e-03	1.53e-04	7.01e-05	1.41e-02
60.0	4.53e-02	6.07e-03	1.19e-02	2.99e-04	1.51e-04	1.85e-02
70.0	5.22e-02	7.74e-03	1.50e-02	4.91e-04	2.66e-04	2.27e-02
80.0	5.83e-02	9.36e-03	1.80e-02	7.23e-04	4.15e-04	2.66e-02
90.0	6.36e-02	1.09e-02	2.08e-02	9.87e-04	5.92e-04	3.02e-02
100.0	6.83e-02	1.24e-02	2.35e-02	1.27e-03	7.94e-04	3.36e-02
150.0	8.50e-02	1.87e-02	3.51e-02	2.91e-03	2.04e-03	4.68e-02
200.0	9.46e-02	2.36e-02	4.39e-02	4.59e-03	3.46e-03	5.58e-02
250.0	1.00e-01	2.73e-02	5.07e-02	6.19e-03	4.88e-03	6.22e-02
300.0	1.04e-01	3.02e-02	5.62e-02	7.64e-03	6.25e-03	6.67e-02
400.0	1.07e-01	3.45e-02	6.42e-02	1.01e-02	8.74e-03	7.26e-02
500.0	1.08e-01	3.74e-02	6.97e-02	1.22e-02	1.09e-02	7.58e-02
1000.0	1.01e-01	4.30e-02	8.12e-02	1.83e-02	1.83e-02	7.79e-02
2000.0	8.59e-02	4.29e-02	8.24e-02	2.25e-02	2.51e-02	7.01e-02
3000.0	7.51e-02	4.05e-02	7.86e-02	2.35e-02	2.81e-02	6.27e-02

Table 13: Coefficients for sputtering by tritium max = 0.00, FiO = 0

T, eV	Target					
	C	TI	Fe	Mo	W	Al
3.0	1.31e-07	9.90e-10	1.73e-09	8.44e-15	1.84e-25	1.31e-08
5.0	1.50e-05	4.74e-07	8.28e-07	2.35e-10	6.13e-17	3.14e-06
6.0	5.19e-05	2.38e-06	4.17e-06	3.31e-09	9.09e-15	1.32e-05
7.0	1.29e-04	7.79e-06	1.36e-05	2.26e-08	3.36e-13	3.80e-05
8.0	2.58e-04	1.93e-05	3.38e-05	9.82e-08	5.20e-12	8.56e-05
9.0	4.47e-04	3.98e-05	6.97e-05	3.13e-07	4.47e-11	1.63e-04
10.0	7.00e-04	7.18e-05	1.26e-04	8.03e-07	2.54e-10	2.77e-04
15.0	2.83e-03	4.61e-04	8.08e-04	1.52e-05	5.34e-08	1.46e-03
20.0	5.92e-03	1.26e-03	2.21e-03	7.25e-05	8.70e-07	3.60e-03
25.0	9.36e-03	2.40e-03	4.22e-03	1.95e-04	4.96e-06	6.40e-03
30.0	1.28e-02	3.78e-03	6.64e-03	3.90e-04	1.65e-05	9.60e-03
40.0	1.91e-02	6.94e-03	1.22e-02	9.76e-04	7.90e-05	1.65e-02
50.0	2.43e-02	1.03e-02	1.81e-02	1.76e-03	2.13e-04	2.33e-02
60.0	2.86e-02	1.36e-02	2.40e-02	2.67e-03	4.26e-04	2.98e-02
70.0	3.21e-02	1.68e-02	2.97e-02	3.66e-03	7.15e-04	3.59e-02
80.0	3.48e-02	1.98e-02	3.51e-02	4.68e-03	1.07e-03	4.14e-02
90.0	3.71e-02	2.27e-02	4.02e-02	5.72e-03	1.48e-03	4.65e-02
100.0	3.89e-02	2.54e-02	4.50e-02	6.75e-03	1.94e-03	5.12e-02
150.0	4.40e-02	3.66e-02	6.52e-02	1.16e-02	4.61e-03	6.94e-02
200.0	4.56e-02	4.48e-02	8.03e-02	1.58e-02	7.50e-03	8.15e-02
250.0	4.58e-02	5.12e-02	9.19e-02	1.94e-02	1.03e-02	9.00e-02
300.0	4.54e-02	5.61e-02	1.01e-01	2.25e-02	1.30e-02	9.60e-02
400.0	4.37e-02	6.32e-02	1.15e-01	2.75e-02	1.78e-02	1.04e-01
500.0	4.18e-02	6.79e-02	1.24e-01	3.14e-02	2.19e-02	1.08e-01
1000.0	3.40e-02	7.69e-02	1.43e-01	4.21e-02	3.59e-02	1.10e-01
2000.0	2.54e-02	7.61e-02	1.45e-01	4.86e-02	4.90e-02	9.89e-02

Table 14: Coefficient for sputtering by helium max = 0.00, FiO = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	2.89e-13	1.52e-07	2.69e-08	3.57e-11	2.06e-19	8.24e-07
5.0	4.08e-09	9.36e-06	4.98e-06	5.13e-08	3.25e-13	5.02e-05
6.0	4.83e-08	2.80e-05	1.97e-05	3.42e-07	1.26e-11	1.49e-04
7.0	2.92e-07	6.28e-05	5.42e-05	1.37e-06	1.79e-10	3.34e-04
8.0	1.15e-06	1.17e-04	1.18e-04	3.97e-06	1.34e-09	6.23e-04
9.0	3.40e-06	1.94e-04	2.20e-04	9.24e-06	6.57e-09	1.02e-03
10.0	8.23e-06	2.92e-04	3.66e-04	1.84e-05	2.38e-08	1.54e-03
15.0	1.29e-04	1.09e-03	1.83e-03	1.61e-04	1.28e-06	5.65e-03
20.0	5.57e-04	2.25e-03	4.43e-03	5.21e-04	1.05e-05	1.16e-02
25.0	1.41e-03	3.60e-03	7.84e-03	1.10e-03	3.96e-05	1.84e-02
30.0	2.68e-03	5.05e-03	1.17e-02	1.88e-03	9.95e-05	2.56e-02
40.0	6.29e-03	7.98e-03	2.03e-02	3.82e-03	3.35e-04	3.99e-02
50.0	1.09e-02	1.08e-02	2.90e-02	6.08e-03	7.27e-04	5.35e-02
60.0	1.59e-02	1.35e-02	3.75e-02	8.48e-03	1.26e-03	6.60e-02
70.0	2.12e-02	1.59e-02	4.56e-02	1.09e-02	1.90e-03	7.75e-02
80.0	2.66e-02	1.82e-02	5.34e-02	1.33e-02	2.62e-03	8.79e-02
90.0	3.18e-02	2.04e-02	6.07e-02	1.57e-02	3.41e-03	9.75e-02
100.0	3.69e-02	2.24e-02	6.75e-02	1.80e-02	4.24e-03	1.06e-01
150.0	5.93e-02	3.05e-02	9.67e-02	2.86e-02	8.66e-03	1.41e-01
200.0	7.67e-02	3.67e-02	1.19e-01	3.74e-02	1.31e-02	1.66e-01
250.0	9.03e-02	4.16e-02	1.37e-01	4.49e-02	1.72e-02	1.84e-01
300.0	1.01e-01	4.55e-02	1.52e-01	5.14e-02	2.10e-02	1.99e-01
400.0	1.16e-01	5.16e-02	1.76e-01	6.22e-02	2.78e-02	2.19e-01
500.0	1.26e-01	5.61e-02	1.93e-01	7.08e-02	3.37e-02	2.32e-01
1000.0	1.44e-01	6.71e-02	2.39e-01	9.74e-02	5.42e-02	2.55e-01
2000.0	1.41e-01	7.20e-02	2.64e-01	1.20e-01	7.59e-02	2.50e-01

Table 15: Coefficients for sputtering by hydrogen max = 0.00, Fi0 = 1

T, eV	Target					
	C	TI	Fe	Mo	W	Al
3.0	2.05e-04	5.90e-15	8.49e-12	3.16e-33	0.00e+00	1.61e-12
5.0	1.59e-03	5.33e-10	1.52e-07	2.76e-21	0.00e+00	2.48e-08
6.0	2.49e-03	9.95e-09	1.83e-06	3.05e-18	0.00e+00	2.86e-07
7.0	3.38e-03	7.98e-08	1.10e-05	4.24e-16	1.20e-32	1.67e-06
8.0	4.20e-03	3.82e-07	4.25e-05	1.80e-14	5.52e-29	6.33e-06
9.0	4.96e-03	1.32e-06	1.22e-04	3.55e-13	3.48e-26	1.78e-05
10.0	5.65e-03	3.52e-06	2.84e-04	3.95e-12	6.78e-24	4.10e-05
15.0	8.25e-03	6.79e-05	3.50e-03	5.05e-09	5.93e-17	4.79e-04
20.0	9.87e-03	2.85e-04	1.14e-02	1.91e-07	1.77e-13	1.50e-03
25.0	1.09e-02	6.32e-04	2.16e-02	1.75e-06	2.43e-11	2.78e-03
30.0	1.16e-02	1.03e-03	3.23e-02	7.64e-06	6.16e-10	4.06e-03
40.0	1.23e-02	1.81e-03	5.17e-02	4.76e-05	4.01e-08	6.28e-03
50.0	1.26e-02	2.49e-03	6.78e-02	1.37e-04	4.94e-07	8.02e-03
60.0	1.26e-02	3.05e-03	8.10e-02	2.67e-04	2.66e-06	9.35e-03
70.0	1.25e-02	3.52e-03	9.18e-02	4.16e-04	8.86e-06	1.04e-02
80.0	1.23e-02	3.90e-03	1.01e-01	5.69e-04	2.18e-05	1.12e-02
90.0	1.21e-02	4.22e-03	1.08e-01	7.19e-04	4.36e-05	1.18e-02
100.0	1.19e-02	4.49e-03	1.14e-01	8.62e-04	7.54e-05	1.22e-02
150.0	1.07e-02	5.31e-03	1.34e-01	1.44e-03	3.49e-04	1.33e-02
200.0	9.63e-03	5.67e-03	1.43e-01	1.84e-03	6.80e-04	1.35e-02
250.0	8.77e-03	5.80e-03	1.47e-01	2.11e-03	9.84e-04	1.32e-02
300.0	8.07e-03	5.82e-03	1.48e-01	2.29e-03	1.24e-03	1.28e-02
400.0	6.99e-03	5.70e-03	1.46e-01	2.52e-03	1.64e-03	1.20e-02
500.0	6.19e-03	5.49e-03	1.42e-01	2.63e-03	1.93e-03	1.12e-02
1000.0	4.07e-03	4.46e-03	1.17e-01	2.60e-03	2.51e-03	8.28e-03
2000.0	2.54e-03	3.24e-03	8.69e-02	2.18e-03	2.55e-03	5.63e-03
3000.0	1.89e-03	2.58e-03	7.00e-02	1.85e-03	2.36e-03	4.35e-03

Table 16: Coefficients for sputtering by deuterium max = 0.00, Fi0 = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	2.21e-05	7.25e-10	5.64e-09	3.83e-23	6.10e-27	4.98e-08
5.0	8.83e-04	1.08e-06	4.99e-06	5.66e-15	2.77e-17	2.11e-05
6.0	2.15e-03	6.91e-06	2.77e-05	6.89e-13	6.87e-15	9.76e-05
7.0	3.95e-03	2.61e-05	9.50e-05	2.23e-11	4.00e-13	2.91e-04
8.0	6.05e-03	7.06e-05	2.39e-04	2.84e-10	8.82e-12	6.56e-04
9.0	8.30e-03	1.53e-04	4.87e-04	2.13e-09	9.31e-11	1.22e-03
10.0	1.06e-02	2.82e-04	8.54e-04	1.12e-08	6.09e-10	1.99e-03
15.0	2.06e-02	1.63e-03	4.17e-03	1.56e-06	2.06e-07	7.63e-03
20.0	2.80e-02	3.52e-03	8.40e-03	1.88e-05	3.91e-06	1.37e-02
25.0	3.33e-02	5.41e-03	1.25e-02	8.36e-05	2.30e-05	1.91e-02
30.0	3.71e-02	7.12e-03	1.61e-02	2.22e-04	7.44e-05	2.36e-02
40.0	4.18e-02	9.94e-03	2.20e-02	7.05e-04	3.11e-04	3.05e-02
50.0	4.42e-02	1.21e-02	2.66e-02	1.32e-03	6.92e-04	3.53e-02
60.0	4.54e-02	1.38e-02	3.01e-02	1.95e-03	1.13e-03	3.88e-02
70.0	4.58e-02	1.51e-02	3.30e-02	2.55e-03	1.59e-03	4.13e-02
80.0	4.58e-02	1.62e-02	3.53e-02	3.11e-03	2.03e-03	4.31e-02
90.0	4.55e-02	1.70e-02	3.72e-02	3.61e-03	2.44e-03	4.44e-02
100.0	4.50e-02	1.77e-02	3.87e-02	4.06e-03	2.83e-03	4.54e-02
150.0	4.16e-02	1.97e-02	4.34e-02	5.73e-03	4.37e-03	4.70e-02
200.0	3.81e-02	2.04e-02	4.53e-02	6.77e-03	5.44e-03	4.63e-02
250.0	3.51e-02	2.05e-02	4.59e-02	7.44e-03	6.21e-03	4.48e-02
300.0	3.25e-02	2.04e-02	4.59e-02	7.88e-03	6.78e-03	4.31e-02
400.0	2.84e-02	1.97e-02	4.48e-02	8.37e-03	7.56e-03	3.98e-02
500.0	2.53e-02	1.88e-02	4.32e-02	8.56e-03	8.03e-03	3.68e-02
1000.0	1.69e-02	1.50e-02	3.55e-02	8.16e-03	8.67e-03	2.69e-02
2000.0	1.06e-02	1.08e-02	2.61e-02	6.71e-03	8.02e-03	1.82e-02
3000.0	7.95e-03	8.58e-03	2.10e-02	5.66e-03	7.19e-03	1.40e-02

Table 17: Coefficients for sputtering by tritium max = 0.00, Fi0 = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	5.13e-06	4.57e-08	8.49e-08	4.34e-13	1.01e-23	5.99e-07
5.0	4.13e-04	1.67e-05	3.17e-05	1.01e-08	2.97e-15	1.09e-04
6.0	1.20e-03	7.44e-05	1.42e-04	1.32e-07	4.18e-13	4.03e-04
7.0	2.51e-03	2.16e-04	4.14e-04	8.18e-07	1.54e-11	1.02e-03
8.0	4.23e-03	4.76e-04	9.18e-04	3.30e-06	2.18e-10	2.02e-03
9.0	6.15e-03	8.74e-04	1.69e-03	9.70e-06	1.72e-09	3.39e-03
10.0	8.13e-03	1.40e-03	2.73e-03	2.31e-05	9.44e-09	5.04e-03
15.0	1.63e-02	5.20e-03	1.02e-02	3.06e-04	1.57e-06	1.49e-02
20.0	2.10e-02	9.32e-03	1.84e-02	1.04e-03	2.08e-05	2.42e-02
25.0	2.35e-02	1.30e-02	2.58e-02	2.04e-03	9.76e-05	3.20e-02
30.0	2.48e-02	1.62e-02	3.22e-02	3.09e-03	2.70e-04	3.84e-02
40.0	2.53e-02	2.12e-02	4.25e-02	5.10e-03	9.09e-04	4.79e-02
50.0	2.48e-02	2.50e-02	5.02e-02	6.82e-03	1.77e-03	5.44e-02
60.0	2.38e-02	2.78e-02	5.62e-02	8.27e-03	2.69e-03	5.90e-02
70.0	2.28e-02	3.01e-02	6.10e-02	9.50e-03	3.58e-03	6.23e-02
80.0	2.18e-02	3.18e-02	6.48e-02	1.05e-02	4.42e-03	6.47e-02
90.0	2.09e-02	3.32e-02	6.79e-02	1.14e-02	5.19e-03	6.64e-02
100.0	2.00e-02	3.43e-02	7.04e-02	1.22e-02	5.91e-03	6.76e-02
150.0	1.64e-02	3.75e-02	7.81e-02	1.49e-02	8.70e-03	6.94e-02
200.0	1.39e-02	3.85e-02	8.11e-02	1.65e-02	1.06e-02	6.81e-02
250.0	1.22e-02	3.85e-02	8.20e-02	1.74e-02	1.19e-02	6.58e-02
300.0	1.08e-02	3.81e-02	8.17e-02	1.79e-02	1.29e-02	6.32e-02
400.0	8.93e-03	3.66e-02	7.96e-02	1.84e-02	1.43e-02	5.82e-02
500.0	7.64e-03	3.49e-02	7.68e-02	1.85e-02	1.51e-02	5.38e-02
1000.0	4.57e-03	2.77e-02	6.28e-02	1.69e-02	1.61e-02	3.94e-02
2000.0	2.66e-03	1.99e-02	4.62e-02	1.36e-02	1.48e-02	2.66e-02

Table 18: Coefficients for sputtering by helium max = 0.00, Fi0 = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	5.10e-11	1.86e-05	4.13e-06	6.01e-09	3.90e-17	1.03e-04
5.0	5.85e-07	6.61e-04	5.23e-04	6.40e-06	5.25e-11	3.65e-03
6.0	6.24e-06	1.46e-03	1.69e-03	3.70e-05	1.97e-09	8.03e-03
7.0	3.37e-05	2.44e-03	3.72e-03	1.28e-04	2.49e-08	1.34e-02
8.0	1.19e-04	3.51e-03	6.44e-03	3.20e-04	1.75e-07	1.92e-02
9.0	3.15e-04	4.62e-03	9.61e-03	6.40e-04	7.97e-07	2.52e-02
10.0	6.82e-04	5.70e-03	1.30e-02	1.09e-03	2.66e-06	3.10e-02
15.0	5.85e-03	1.06e-02	3.05e-02	4.46e-03	9.93e-05	5.67e-02
20.0	1.42e-02	1.45e-02	4.57e-02	8.29e-03	5.57e-04	7.66e-02
25.0	2.27e-02	1.75e-02	5.84e-02	1.19e-02	1.41e-03	9.19e-02
30.0	3.03e-02	2.01e-02	6.91e-02	1.50e-02	2.47e-03	1.04e-01
40.0	4.26e-02	2.39e-02	8.59e-02	2.03e-02	4.72e-03	1.22e-01
50.0	5.15e-02	2.67e-02	9.85e-02	2.45e-02	6.84e-03	1.35e-01
60.0	5.80e-02	2.89e-02	1.08e-01	2.80e-02	8.75e-03	1.44e-01
70.0	6.27e-02	3.06e-02	1.16e-01	3.08e-02	1.04e-02	1.51e-01
80.0	6.63e-02	3.21e-02	1.23e-01	3.33e-02	1.19e-02	1.57e-01
90.0	6.88e-02	3.32e-02	1.29e-01	3.53e-02	1.33e-02	1.61e-01
100.0	7.07e-02	3.42e-02	1.33e-01	3.72e-02	1.45e-02	1.64e-01
150.0	7.41e-02	3.72e-02	1.49e-01	4.36e-02	1.91e-02	1.72e-01
200.0	7.31e-02	3.86e-02	1.57e-01	4.76e-02	2.22e-02	1.72e-01
250.0	7.07e-02	3.91e-02	1.61e-01	5.02e-02	2.44e-02	1.70e-01
300.0	6.80e-02	3.92e-02	1.63e-01	5.19e-02	2.61e-02	1.66e-01
400.0	6.25e-02	3.87e-02	1.63e-01	5.40e-02	2.85e-02	1.57e-01
500.0	5.77e-02	3.77e-02	1.61e-01	5.50e-02	3.01e-02	1.49e-01
1000.0	4.18e-02	3.21e-02	1.42e-01	5.36e-02	3.30e-02	1.16e-01
2000.0	2.79e-02	2.45e-02	1.12e-01	4.63e-02	3.22e-02	8.20e-02

Table 19: Coefficients for sputtering by helium (He^{++}) max = 0.00, FiO = 1

T, eV	Target					
	C	TI	Fe	Mo	W	Al
3.0	7.64e-09	6.72e-04	3.49e-04	7.45e-07	7.03e-15	3.76e-03
5.0	5.88e-05	4.07e-03	7.98e-03	3.60e-04	7.45e-09	2.24e-02
6.0	4.63e-04	5.91e-03	1.38e-02	1.10e-03	2.35e-07	3.24e-02
7.0	1.64e-03	7.65e-03	1.99e-02	2.14e-03	2.70e-06	4.17e-02
8.0	3.59e-03	9.26e-03	2.59e-02	3.34e-03	1.61e-05	5.02e-02
9.0	6.05e-03	1.07e-02	3.15e-02	4.62e-03	6.03e-05	5.79e-02
10.0	8.81e-03	1.21e-02	3.69e-02	5.91e-03	1.59e-04	6.49e-02
15.0	2.30e-02	1.74e-02	5.90e-02	1.19e-02	1.44e-03	9.20e-02
20.0	3.48e-02	2.12e-02	7.52e-02	1.68e-02	3.26e-03	1.10e-01
25.0	4.37e-02	2.40e-02	8.76e-02	2.08e-02	5.10e-03	1.23e-01
30.0	5.04e-02	2.61e-02	9.73e-02	2.40e-02	6.80e-03	1.33e-01
40.0	5.93e-02	2.93e-02	1.12e-01	2.91e-02	9.71e-03	1.46e-01
50.0	6.45e-02	3.14e-02	1.22e-01	3.29e-02	1.21e-02	1.54e-01
60.0	6.75e-02	3.30e-02	1.30e-01	3.58e-02	1.40e-02	1.59e-01
70.0	6.91e-02	3.42e-02	1.36e-01	3.82e-02	1.57e-02	1.63e-01
80.0	6.98e-02	3.51e-02	1.40e-01	4.01e-02	1.71e-02	1.65e-01
90.0	6.99e-02	3.57e-02	1.44e-01	4.18e-02	1.83e-02	1.66e-01
100.0	6.97e-02	3.63e-02	1.47e-01	4.32e-02	1.93e-02	1.66e-01
150.0	6.60e-02	3.73e-02	1.55e-01	4.77e-02	2.32e-02	1.63e-01
200.0	6.13e-02	3.72e-02	1.57e-01	5.00e-02	2.55e-02	1.56e-01
250.0	5.69e-02	3.65e-02	1.56e-01	5.13e-02	2.71e-02	1.48e-01
300.0	5.31e-02	3.56e-02	1.53e-01	5.18e-02	2.83e-02	1.41e-01
400.0	4.68e-02	3.36e-02	1.47e-01	5.18e-02	2.97e-02	1.28e-01
500.0	4.19e-02	3.17e-02	1.41e-01	5.11e-02	3.04e-02	1.17e-01
1000.0	2.83e-02	2.46e-02	1.13e-01	4.51e-02	3.04e-02	8.43e-02
2000.0	1.80e-02	1.74e-02	8.18e-02	3.55e-02	2.69e-02	5.63e-02

Table 20: Coefficients for sputtering by hydrogen max = 1.00, FiO = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	9.10e-05	1.04e-13	8.35e-11	7.65e-30	0.00e+00	1.48e-11
5.0	6.88e-04	1.62e-09	3.08e-07	2.84e-19	0.00e+00	4.82e-08
6.0	1.17e-03	1.83e-08	2.44e-06	1.20e-16	1.07e-33	3.71e-07
7.0	1.74e-03	1.04e-07	1.08e-05	8.93e-15	2.40e-29	1.61e-06
8.0	2.35e-03	3.89e-07	3.35e-05	2.26e-13	4.29e-26	4.87e-06
9.0	3.00e-03	1.09e-06	8.11e-05	2.78e-12	1.43e-23	1.16e-05
10.0	3.65e-03	2.50e-06	1.65e-04	2.08e-11	1.47e-21	2.34e-05
15.0	6.82e-03	3.16e-05	1.48e-03	8.87e-09	1.53e-15	2.01e-04
20.0	9.54e-03	1.18e-04	4.63e-03	1.90e-07	1.52e-12	6.13e-04
25.0	1.18e-02	2.67e-04	9.44e-03	1.22e-06	9.63e-11	1.23e-03
30.0	1.37e-02	4.68e-04	1.54e-02	4.31e-06	1.54e-09	1.97e-03
40.0	1.65e-02	9.71e-04	2.92e-02	2.16e-05	5.04e-08	3.65e-03
50.0	1.85e-02	1.53e-03	4.38e-02	5.84e-05	4.19e-07	5.36e-03
60.0	2.00e-02	2.11e-03	5.80e-02	1.15e-04	1.75e-06	6.98e-03
70.0	2.11e-02	2.66e-03	7.15e-02	1.90e-04	4.93e-06	8.47e-03
80.0	2.19e-02	3.19e-03	8.40e-02	2.79e-04	1.08e-05	9.81e-03
90.0	2.25e-02	3.68e-03	9.56e-02	3.78e-04	2.01e-05	1.10e-02
100.0	2.30e-02	4.14e-03	1.06e-01	4.85e-04	3.32e-05	1.21e-02
150.0	2.40e-02	5.98e-03	1.48e-01	1.06e-03	1.57e-04	1.60e-02
200.0	2.39e-02	7.23e-03	1.76e-01	1.60e-03	3.57e-04	1.84e-02
250.0	2.35e-02	8.11e-03	1.96e-01	2.09e-03	5.96e-04	1.98e-02
300.0	2.29e-02	8.75e-03	2.10e-01	2.50e-03	8.51e-04	2.07e-02
400.0	2.17e-02	9.54e-03	2.29e-01	3.16e-03	1.35e-03	2.14e-02
500.0	2.05e-02	9.97e-03	2.39e-01	3.65e-03	1.81e-03	2.16e-02
1000.0	1.62e-02	1.02e-02	2.45e-01	4.81e-03	3.37e-03	1.99e-02
2000.0	1.19e-02	9.05e-03	2.20e-01	5.18e-03	4.62e-03	1.61e-02
3000.0	9.66e-03	8.01e-03	1.96e-01	5.03e-03	5.00e-03	1.36e-02

Table 21: Coefficients for sputtering by deuterium max = 1.00, Fi0 = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	1.64e-05	2.52e-09	1.65e-08	8.10e-21	3.26e-24	1.05e-07
5.0	3.91e-04	1.11e-06	4.54e-06	9.92e-14	8.64e-16	1.59e-05
6.0	8.91e-04	5.23e-06	1.90e-05	5.81e-12	1.08e-13	5.73e-05
7.0	1.62e-03	1.60e-05	5.34e-05	1.06e-10	3.40e-12	1.45e-04
8.0	2.57e-03	3.74e-05	1.17e-04	9.48e-10	4.51e-11	2.94e-04
9.0	3.70e-03	7.31e-05	2.18e-04	5.21e-09	3.39e-10	5.14e-04
10.0	4.97e-03	1.26e-04	3.60e-04	2.05e-08	1.70e-09	8.06e-04
15.0	1.25e-02	6.71e-04	1.71e-03	1.29e-06	2.26e-07	3.27e-03
20.0	2.05e-02	1.62e-03	3.89e-03	1.07e-05	2.72e-06	6.84e-03
25.0	2.80e-02	2.82e-03	6.54e-03	3.94e-05	1.25e-05	1.09e-02
30.0	3.47e-02	4.15e-03	9.39e-03	9.57e-05	3.51e-05	1.50e-02
40.0	4.57e-02	6.88e-03	1.51e-02	3.00e-04	1.33e-04	2.28e-02
50.0	5.42e-02	9.48e-03	2.04e-02	6.12e-04	3.06e-04	2.97e-02
60.0	6.08e-02	1.19e-02	2.53e-02	1.00e-03	5.43e-04	3.56e-02
70.0	6.59e-02	1.40e-02	2.97e-02	1.44e-03	8.28e-04	4.07e-02
80.0	7.00e-02	1.59e-02	3.36e-02	1.91e-03	1.15e-03	4.51e-02
90.0	7.32e-02	1.77e-02	3.71e-02	2.39e-03	1.49e-03	4.89e-02
100.0	7.58e-02	1.92e-02	4.02e-02	2.87e-03	1.85e-03	5.22e-02
150.0	8.28e-02	2.51e-02	5.20e-02	5.12e-03	3.65e-03	6.33e-02
200.0	8.48e-02	2.88e-02	5.96e-02	7.02e-03	5.31e-03	6.91e-02
250.0	8.47e-02	3.13e-02	6.48e-02	8.57e-03	6.75e-03	7.23e-02
300.0	8.37e-02	3.30e-02	6.84e-02	9.85e-03	8.00e-03	7.40e-02
400.0	8.05e-02	3.49e-02	7.28e-02	1.18e-02	1.00e-02	7.49e-02
500.0	7.70e-02	3.59e-02	7.50e-02	1.31e-02	1.16e-02	7.42e-02
1000.0	6.26e-02	3.53e-02	7.52e-02	1.62e-02	1.59e-02	6.60e-02
2000.0	4.68e-02	3.08e-02	6.66e-02	1.68e-02	1.85e-02	5.25e-02
3000.0	3.83e-02	2.70e-02	5.91e-02	1.61e-02	1.89e-02	4.41e-02

Table 22: Coefficients for sputtering by tritium max = 1.00, Fi0 = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	5.11e-06	8.79e-08	1.70e-07	4.44e-12	2.48e-21	8.78e-07
5.0	2.03e-04	1.20e-05	2.31e-05	2.10e-08	5.64e-14	6.62e-05
6.0	5.17e-04	4.23e-05	8.13e-05	1.78e-07	3.85e-12	2.01e-04
7.0	1.02e-03	1.05e-04	2.02e-04	8.28e-07	7.88e-11	4.49e-04
8.0	1.69e-03	2.11e-04	4.05e-04	2.65e-06	7.62e-10	8.29e-04
9.0	2.53e-03	3.65e-04	7.00e-04	6.59e-06	4.47e-09	1.35e-03
10.0	3.49e-03	5.70e-04	1.09e-03	1.38e-05	1.85e-08	2.00e-03
15.0	9.25e-03	2.28e-03	4.36e-03	1.32e-04	1.36e-06	6.79e-03
20.0	1.51e-02	4.76e-03	9.11e-03	4.32e-04	1.23e-05	1.30e-02
25.0	2.02e-02	7.58e-03	1.45e-02	9.04e-04	4.75e-05	1.96e-02
30.0	2.45e-02	1.05e-02	2.01e-02	1.51e-03	1.19e-04	2.61e-02
40.0	3.08e-02	1.61e-02	3.09e-02	2.95e-03	3.92e-04	3.79e-02
50.0	3.49e-02	2.12e-02	4.07e-02	4.51e-03	8.27e-04	4.79e-02
60.0	3.75e-02	2.57e-02	4.94e-02	6.08e-03	1.38e-03	5.64e-02
70.0	3.93e-02	2.96e-02	5.71e-02	7.60e-03	2.03e-03	6.36e-02
80.0	4.03e-02	3.31e-02	6.39e-02	9.05e-03	2.72e-03	6.97e-02
90.0	4.10e-02	3.62e-02	7.00e-02	1.04e-02	3.45e-03	7.50e-02
100.0	4.13e-02	3.90e-02	7.54e-02	1.17e-02	4.19e-03	7.95e-02
150.0	4.06e-02	4.91e-02	9.56e-02	1.69e-02	7.81e-03	9.44e-02
200.0	3.87e-02	5.53e-02	1.08e-01	2.08e-02	1.10e-02	1.02e-01
250.0	3.65e-02	5.94e-02	1.17e-01	2.38e-02	1.37e-02	1.06e-01
300.0	3.45e-02	6.21e-02	1.23e-01	2.60e-02	1.61e-02	1.08e-01
400.0	3.11e-02	6.52e-02	1.30e-01	2.93e-02	1.99e-02	1.09e-01
500.0	2.83e-02	6.66e-02	1.34e-01	3.15e-02	2.28e-02	1.08e-01
1000.0	2.01e-02	6.48e-02	1.33e-01	3.58e-02	3.07e-02	9.54e-02
2000.0	1.34e-02	5.61e-02	1.18e-01	3.56e-02	3.53e-02	7.58e-02
3000.0	1.04e-02	4.92e-02	1.04e-01	3.36e-02	3.61e-02	6.36e-02

Table 23: Coefficients for sputtering by helium max = 1.00, FiO = 0

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	1.44e-10	5.39e-06	1.94e-06	6.47e-09	6.18e-16	2.99e-05
5.0	3.68e-07	1.30e-04	1.17e-04	2.26e-06	1.07e-10	7.12e-04
6.0	2.67e-06	2.97e-04	3.35e-04	1.01e-05	2.20e-09	1.62e-03
7.0	1.11e-05	5.45e-04	7.24e-04	2.97e-05	1.92e-08	2.96e-03
8.0	3.26e-05	8.67e-04	1.30e-03	6.75e-05	9.85e-08	4.70e-03
9.0	7.60e-05	1.26e-03	2.07e-03	1.29e-04	3.53e-07	6.78e-03
10.0	1.50e-04	1.70e-03	3.03e-03	2.18e-04	9.87e-07	9.15e-03
15.0	1.22e-03	4.43e-03	9.92e-03	1.12e-03	2.27e-05	2.35e-02
20.0	3.63e-03	7.46e-03	1.88e-02	2.66e-03	1.15e-04	3.92e-02
25.0	7.16e-03	1.04e-02	2.83e-02	4.61e-03	3.13e-04	5.43e-02
30.0	1.14e-02	1.32e-02	3.78e-02	6.78e-03	6.26e-04	6.85e-02
40.0	2.09e-02	1.83e-02	5.55e-02	1.13e-02	1.54e-03	9.32e-02
50.0	3.06e-02	2.26e-02	7.14e-02	1.57e-02	2.73e-03	1.14e-01
60.0	3.98e-02	2.63e-02	8.54e-02	1.99e-02	4.08e-03	1.31e-01
70.0	4.83e-02	2.95e-02	9.78e-02	2.38e-02	5.50e-03	1.46e-01
80.0	5.60e-02	3.23e-02	1.09e-01	2.74e-02	6.94e-03	1.59e-01
90.0	6.29e-02	3.48e-02	1.19e-01	3.08e-02	8.38e-03	1.70e-01
100.0	6.92e-02	3.71e-02	1.28e-01	3.39e-02	9.80e-03	1.80e-01
150.0	9.25e-02	4.55e-02	1.63e-01	4.65e-02	1.63e-02	2.14e-01
200.0	1.07e-01	5.11e-02	1.86e-01	5.58e-02	2.17e-02	2.35e-01
250.0	1.16e-01	5.51e-02	2.04e-01	6.30e-02	2.62e-02	2.48e-01
300.0	1.21e-01	5.81e-02	2.17e-01	6.88e-02	3.01e-02	2.57e-01
400.0	1.28e-01	6.20e-02	2.35e-01	7.77e-02	3.64e-02	2.66e-01
500.0	1.30e-01	6.44e-02	2.47e-01	8.40e-02	4.14e-02	2.69e-01
1000.0	1.23e-01	6.73e-02	2.67e-01	9.98e-02	5.59e-02	2.59e-01
2000.0	1.03e-01	6.32e-02	2.58e-01	1.06e-01	6.73e-02	2.23e-01
3000.0	8.90e-02	5.81e-02	2.41e-01	1.05e-01	7.13e-02	1.95e-01

Table 24: Coefficients for sputtering by hydrogen max = 1.00, FiO = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	7.64e-04	2.93e-12	2.18e-09	3.01e-28	0.00e+00	3.85e-10
5.0	3.34e-03	3.47e-08	6.02e-06	9.46e-18	3.48e-38	9.33e-07
6.0	4.69e-03	3.50e-07	4.23e-05	3.71e-15	4.39e-32	6.33e-06
7.0	5.93e-03	1.79e-06	1.68e-04	2.59e-13	9.41e-28	2.45e-05
8.0	7.04e-03	6.06e-06	4.67e-04	6.14e-12	1.61e-24	6.69e-05
9.0	8.03e-03	1.55e-05	1.03e-03	7.14e-11	5.18e-22	1.45e-04
10.0	8.91e-03	3.25e-05	1.91e-03	5.04e-10	5.15e-20	2.66e-04
15.0	1.20e-02	2.84e-04	1.16e-02	1.68e-07	4.56e-14	1.54e-03
20.0	1.39e-02	7.88e-04	2.70e-02	2.90e-06	3.96e-11	3.47e-03
25.0	1.49e-02	1.40e-03	4.35e-02	1.56e-05	2.22e-09	5.45e-03
30.0	1.56e-02	2.01e-03	5.90e-02	4.66e-05	3.17e-08	7.24e-03
40.0	1.62e-02	3.11e-03	8.56e-02	1.76e-04	8.53e-07	1.01e-02
50.0	1.62e-02	4.00e-03	1.06e-01	3.75e-04	5.95e-06	1.22e-02
60.0	1.60e-02	4.70e-03	1.23e-01	6.05e-04	2.13e-05	1.38e-02
70.0	1.57e-02	5.26e-03	1.36e-01	8.40e-04	5.19e-05	1.49e-02
80.0	1.54e-02	5.71e-03	1.46e-01	1.06e-03	1.00e-04	1.57e-02
90.0	1.50e-02	6.08e-03	1.55e-01	1.27e-03	1.65e-04	1.63e-02
100.0	1.46e-02	6.38e-03	1.62e-01	1.47e-03	2.44e-04	1.68e-02
150.0	1.29e-02	7.22e-03	1.83e-01	2.21e-03	7.36e-04	1.75e-02
200.0	1.15e-02	7.50e-03	1.90e-01	2.67e-03	1.22e-03	1.73e-02
250.0	1.04e-02	7.55e-03	1.92e-01	2.97e-03	1.62e-03	1.67e-02
300.0	9.51e-03	7.47e-03	1.91e-01	3.16e-03	1.95e-03	1.60e-02
400.0	8.17e-03	7.18e-03	1.85e-01	3.37e-03	2.44e-03	1.47e-02
500.0	7.20e-03	6.83e-03	1.77e-01	3.45e-03	2.76e-03	1.36e-02
1000.0	4.66e-03	5.36e-03	1.42e-01	3.25e-03	3.32e-03	9.82e-03
2000.0	2.88e-03	3.81e-03	1.03e-01	2.63e-03	3.20e-03	6.55e-03
3000.0	2.13e-03	3.01e-03	8.20e-02	2.20e-03	2.89e-03	5.03e-03

Table 25: Coefficients for sputtering by deuterium max = 1.00, FiO = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	2.21e-04	5.56e-08	3.50e-07	2.81e-19	1.20e-22	2.06e-06
5.0	3.28e-03	1.75e-05	6.80e-05	2.80e-12	2.63e-14	2.17e-04
6.0	6.17e-03	7.12e-05	2.46e-04	1.50e-10	3.03e-12	6.72e-04
7.0	9.51e-03	1.91e-04	6.08e-04	2.54e-09	8.82e-11	1.48e-03
8.0	1.30e-02	3.97e-04	1.18e-03	2.09e-08	1.09e-09	2.65e-03
9.0	1.64e-02	6.95e-04	1.97e-03	1.07e-07	7.66e-09	4.11e-03
10.0	1.97e-02	1.08e-03	2.94e-03	3.91e-07	3.62e-08	5.80e-03
15.0	3.30e-02	3.77e-03	9.19e-03	1.83e-05	3.62e-06	1.53e-02
20.0	4.20e-02	6.73e-03	1.56e-02	1.19e-04	3.44e-05	2.41e-02
25.0	4.79e-02	9.40e-03	2.13e-02	3.52e-04	1.29e-04	3.12e-02
30.0	5.20e-02	1.17e-02	2.62e-02	7.08e-04	3.04e-04	3.69e-02
40.0	5.65e-02	1.53e-02	3.39e-02	1.63e-03	8.51e-04	4.52e-02
50.0	5.85e-02	1.80e-02	3.95e-02	2.60e-03	1.53e-03	5.07e-02
60.0	5.90e-02	2.00e-02	4.38e-02	3.51e-03	2.22e-03	5.45e-02
70.0	5.88e-02	2.15e-02	4.72e-02	4.34e-03	2.88e-03	5.70e-02
80.0	5.82e-02	2.27e-02	4.98e-02	5.07e-03	3.50e-03	5.88e-02
90.0	5.73e-02	2.37e-02	5.19e-02	5.71e-03	4.06e-03	5.99e-02
100.0	5.63e-02	2.44e-02	5.36e-02	6.28e-03	4.57e-03	6.06e-02
150.0	5.08e-02	2.63e-02	5.83e-02	8.30e-03	6.54e-03	6.08e-02
200.0	4.59e-02	2.66e-02	5.97e-02	9.48e-03	7.85e-03	5.88e-02
250.0	4.19e-02	2.64e-02	5.96e-02	1.02e-02	8.75e-03	5.61e-02
300.0	3.85e-02	2.59e-02	5.89e-02	1.06e-02	9.41e-03	5.35e-02
400.0	3.33e-02	2.46e-02	5.66e-02	1.10e-02	1.02e-02	4.86e-02
500.0	2.95e-02	2.32e-02	5.40e-02	1.11e-02	1.07e-02	4.45e-02
1000.0	1.94e-02	1.80e-02	4.29e-02	1.01e-02	1.11e-02	3.18e-02
2000.0	1.21e-02	1.27e-02	3.08e-02	8.05e-03	9.87e-03	2.11e-02
3000.0	8.98e-03	9.98e-03	2.45e-02	6.70e-03	8.69e-03	1.62e-02

Table 26: Coefficients for sputtering by tritium max = 1.00, FiO = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	7.92e-05	1.70e-06	3.31e-06	1.17e-10	8.71e-20	1.57e-05
5.0	2.00e-03	1.60e-04	3.12e-04	4.15e-07	1.62e-12	7.99e-04
6.0	4.22e-03	4.82e-04	9.42e-04	3.10e-06	1.01e-10	2.06e-03
7.0	6.98e-03	1.04e-03	2.04e-03	1.29e-05	1.91e-09	3.99e-03
8.0	9.93e-03	1.84e-03	3.61e-03	3.71e-05	1.71e-08	6.46e-03
9.0	1.28e-02	2.83e-03	5.57e-03	8.39e-05	9.31e-08	9.31e-03
10.0	1.55e-02	3.97e-03	7.81e-03	1.60e-04	3.59e-07	1.24e-02
15.0	2.51e-02	1.04e-02	2.05e-02	1.04e-03	1.97e-05	2.77e-02
20.0	2.98e-02	1.63e-02	3.25e-02	2.51e-03	1.38e-04	4.05e-02
25.0	3.19e-02	2.13e-02	4.26e-02	4.15e-03	4.31e-04	5.06e-02
30.0	3.25e-02	2.54e-02	5.10e-02	5.73e-03	9.00e-04	5.85e-02
40.0	3.21e-02	3.18e-02	6.41e-02	8.52e-03	2.17e-03	6.99e-02
50.0	3.07e-02	3.63e-02	7.37e-02	1.08e-02	3.57e-03	7.72e-02
60.0	2.92e-02	3.97e-02	8.08e-02	1.27e-02	4.93e-03	8.22e-02
70.0	2.76e-02	4.22e-02	8.64e-02	1.42e-02	6.19e-03	8.55e-02
80.0	2.62e-02	4.42e-02	9.08e-02	1.55e-02	7.33e-03	8.77e-02
90.0	2.49e-02	4.57e-02	9.42e-02	1.66e-02	8.36e-03	8.91e-02
100.0	2.37e-02	4.68e-02	9.70e-02	1.75e-02	9.29e-03	8.99e-02
150.0	1.91e-02	4.97e-02	1.04e-01	2.06e-02	1.28e-02	8.96e-02
200.0	1.61e-02	5.00e-02	1.07e-01	2.23e-02	1.51e-02	8.63e-02
250.0	1.40e-02	4.94e-02	1.06e-01	2.32e-02	1.67e-02	8.23e-02
300.0	1.24e-02	4.83e-02	1.05e-01	2.36e-02	1.78e-02	7.83e-02
400.0	1.02e-02	4.57e-02	1.00e-01	2.38e-02	1.92e-02	7.11e-02
500.0	8.66e-03	4.31e-02	9.57e-02	2.36e-02	2.00e-02	6.52e-02
1000.0	5.14e-03	3.32e-02	7.60e-02	2.08e-02	2.05e-02	4.66e-02
2000.0	2.96e-03	2.34e-02	5.46e-02	1.63e-02	1.82e-02	3.09e-02
3000.0	2.13e-03	1.84e-02	4.35e-02	1.35e-02	1.60e-02	2.37e-02

Table 27: Coefficients for sputtering by helium max = 1.00, FiO = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	9.19e-09	1.53e-04	7.35e-05	3.33e-07	5.12e-14	8.52e-04
5.0	1.58e-05	1.95e-03	2.55e-03	7.31e-05	6.46e-09	1.08e-02
6.0	9.61e-05	3.47e-03	5.83e-03	2.67e-04	1.16e-07	1.91e-02
7.0	3.41e-04	5.13e-03	1.02e-02	6.55e-04	8.89e-07	2.81e-02
8.0	8.62e-04	6.82e-03	1.53e-02	1.26e-03	4.04e-06	3.72e-02
9.0	1.74e-03	8.48e-03	2.07e-02	2.06e-03	1.29e-05	4.61e-02
10.0	3.02e-03	1.01e-02	2.61e-02	3.01e-03	3.24e-05	5.46e-02
15.0	1.38e-02	1.69e-02	5.18e-02	8.71e-03	4.66e-04	9.01e-02
20.0	2.69e-02	2.21e-02	7.29e-02	1.44e-02	1.60e-03	1.16e-01
25.0	3.88e-02	2.61e-02	8.99e-02	1.94e-02	3.17e-03	1.36e-01
30.0	4.89e-02	2.93e-02	1.04e-01	2.37e-02	4.88e-03	1.51e-01
40.0	6.42e-02	3.42e-02	1.26e-01	3.07e-02	8.23e-03	1.74e-01
50.0	7.48e-02	3.77e-02	1.42e-01	3.62e-02	1.12e-02	1.89e-01
60.0	8.21e-02	4.04e-02	1.54e-01	4.06e-02	1.38e-02	2.00e-01
70.0	8.72e-02	4.25e-02	1.64e-01	4.43e-02	1.61e-02	2.08e-01
80.0	9.08e-02	4.42e-02	1.72e-01	4.73e-02	1.80e-02	2.14e-01
90.0	9.32e-02	4.56e-02	1.79e-01	4.99e-02	1.98e-02	2.18e-01
100.0	9.48e-02	4.67e-02	1.84e-01	5.22e-02	2.14e-02	2.21e-01
150.0	9.63e-02	5.00e-02	2.02e-01	6.01e-02	2.72e-02	2.27e-01
200.0	9.33e-02	5.12e-02	2.10e-01	6.47e-02	3.10e-02	2.24e-01
250.0	8.91e-02	5.14e-02	2.14e-01	6.76e-02	3.38e-02	2.19e-01
300.0	8.49e-02	5.11e-02	2.15e-01	6.95e-02	3.58e-02	2.12e-01
400.0	7.70e-02	4.98e-02	2.13e-01	7.15e-02	3.86e-02	1.99e-01
500.0	7.05e-02	4.81e-02	2.08e-01	7.21e-02	4.04e-02	1.86e-01
1000.0	5.00e-02	3.98e-02	1.78e-01	6.83e-02	4.32e-02	1.41e-01
2000.0	3.30e-02	2.97e-02	1.37e-01	5.74e-02	4.10e-02	9.86e-02
3000.0	2.52e-02	2.41e-02	1.13e-01	4.93e-02	3.75e-02	7.73e-02

Table 28: Coefficients for sputtering by helium (He^{++}) max = 1.00, FiO = 1

T, eV	Target					
	C	Ti	Fe	Mo	W	Al
3.0	4.81e-07	1.54e-03	1.44e-03	1.22e-05	3.86e-12	8.62e-03
5.0	4.14e-04	6.77e-03	1.50e-02	1.03e-03	3.10e-07	3.73e-02
6.0	1.76e-03	9.39e-03	2.38e-02	2.41e-03	4.44e-06	5.13e-02
7.0	4.32e-03	1.18e-02	3.26e-02	4.11e-03	2.73e-05	6.42e-02
8.0	7.79e-03	1.40e-02	4.10e-02	5.96e-03	9.86e-05	7.57e-02
9.0	1.18e-02	1.60e-02	4.89e-02	7.85e-03	2.50e-04	8.61e-02
10.0	1.60e-02	1.78e-02	5.63e-02	9.72e-03	4.96e-04	9.55e-02
15.0	3.60e-02	2.49e-02	8.61e-02	1.81e-02	2.70e-03	1.31e-01
20.0	5.15e-02	2.98e-02	1.08e-01	2.47e-02	5.41e-03	1.54e-01
25.0	6.29e-02	3.34e-02	1.24e-01	3.00e-02	8.01e-03	1.71e-01
30.0	7.12e-02	3.62e-02	1.36e-01	3.43e-02	1.03e-02	1.83e-01
40.0	8.19e-02	4.02e-02	1.55e-01	4.09e-02	1.43e-02	1.99e-01
50.0	8.78e-02	4.30e-02	1.68e-01	4.58e-02	1.74e-02	2.09e-01
60.0	9.08e-02	4.49e-02	1.78e-01	4.96e-02	2.00e-02	2.15e-01
70.0	9.23e-02	4.63e-02	1.85e-01	5.26e-02	2.22e-02	2.18e-01
80.0	9.26e-02	4.73e-02	1.91e-01	5.51e-02	2.40e-02	2.20e-01
90.0	9.23e-02	4.81e-02	1.95e-01	5.72e-02	2.56e-02	2.21e-01
100.0	9.16e-02	4.87e-02	1.99e-01	5.89e-02	2.69e-02	2.20e-01
150.0	8.54e-02	4.96e-02	2.07e-01	6.45e-02	3.18e-02	2.13e-01
200.0	7.87e-02	4.90e-02	2.08e-01	6.72e-02	3.48e-02	2.02e-01
250.0	7.26e-02	4.78e-02	2.05e-01	6.84e-02	3.68e-02	1.92e-01
300.0	6.74e-02	4.64e-02	2.01e-01	6.88e-02	3.82e-02	1.81e-01
400.0	5.91e-02	4.36e-02	1.92e-01	6.84e-02	3.98e-02	1.64e-01
500.0	5.28e-02	4.09e-02	1.82e-01	6.71e-02	4.06e-02	1.49e-01
1000.0	3.53e-02	3.13e-02	1.44e-01	5.82e-02	3.98e-02	1.06e-01
2000.0	2.23e-02	2.19e-02	1.03e-01	4.50e-02	3.46e-02	7.03e-02
3000.0	1.67e-02	1.72e-02	8.20e-02	3.71e-02	3.02e-02	5.39e-02

Table 29: Coefficients for sputtering of vanadium by deuterium, tritium and helium atoms

T, eV	Incident particle		
	D	T	He
3	2,33E-9	1,E-8	5,95E-7
5	1,04E-6	1,63E-5	3,25E-5
6	4,86E-6	5,65E-5	9,08E-5
7	1,47E-5	1,20E-4	1,91E-4
8	3,42E-5	2,40E-4	3,38E-4
9	6,62E-5	4,10E-4	5,32E-4
10	1,13E-4	6,25E-4	7,75E-4
15	5,87E-4	2,34E-4	2,49E-3
20	1,41E-3	4,79E-3	4,82E-3
25	2,46E-3	7,60E-3	7,41E-3
30	3,66E-3	1,07E-2	1,03E-2
40	6,24E-3	1,71E-2	1,61E-2
50	8,90E-3	2,34E-2	2,21E-2
60	1,15E-2	2,95E-2	2,80E-2
70	1,42E-2	3,54E-2	3,38E-2
80	1,65E-2	4,10E-2	3,95E-2
90	1,88E-2	4,64E-2	4,51E-2
100	2,10E-2	5,14E-2	5,05E-2
150	3,04E-2	7,31E-2	7,52E-2
200	3,77E-2	8,97E-2	9,62E-2
250	4,33E-2	1,03E-1	1,14E-1
300	4,77E-2	1,13E-1	1,29E-1
400	5,39E-2	1,27E-1	1,54E-1
500	5,79E-2	1,36E-1	1,72E-1
1000	6,32E-2	1,48E-1	2,10E-1
2000	5,78E-2	1,36E-1	2,20E-1
3000	5,11E-2	1,20E-1	2,10E-1

Table 30: Sputtering coefficients averaged only over the incident particle energy

T, eV	Incident particle + target atom			
	D^0 + Fe	D^0 + W	He^* + Fe	He^* + W
3	$1{,}38.10^{-11}$	–	$3{,}3.10^{-8}$	–
5	$8{,}4.10^{-8}$	–	$6{,}1.10^{-6}$	–
6	$1{,}8.10^{-7}$	–	$2{,}4.10^{-5}$	$1{,}03.10^{-11}$
7	$7{,}46.10^{-7}$	–	$6{,}5.10^{-5}$	$1{,}44.10^{-10}$
8	$2{,}22.10^{-7}$	–	$1{,}4.10^{-4}$	$1{,}08.10^{-9}$
9	$5{,}27.10^{-6}$	–	$2{,}6.10^{-4}$	$5{,}26.10^{-9}$
10	$2{,}33.10^{-5}$	$6{,}4.10^{-12}$	$4{,}3.10^{-3}$	$1{,}98.10^{-8}$
15	$1{,}82.10^{-4}$	$2{,}62.10^{-9}$	$2{,}1.10^{-3}$	$1{,}0.10^{-6}$
20	$5{,}47.10^{-4}$	$5{,}95.10^{-8}$	$5{,}0.10^{-3}$	$8{,}07.10^{-6}$
25	$1{,}1.10^{-3}$	$4{,}12.10^{-7}$	$8{,}7.10^{-3}$	$2{,}98.10^{-5}$
30	$1{,}8.10^{-3}$	$1{,}56.10^{-6}$	$1{,}28.10^{-2}$	$7{,}37.10^{-5}$
40	$3{,}43.10^{-3}$	$8{,}34.10^{-6}$	$2{,}15.10^{-2}$	$2{,}42.10^{-4}$
50	$5{,}19.10^{-3}$	$2{,}58.10^{-5}$	$3{,}02.10^{-2}$	$5{,}14.10^{-4}$
60	$6{,}95.10^{-3}$	$5{,}48.10^{-5}$	$3{,}83.10^{-2}$	$8{,}72.10^{-4}$
70	$8{,}65.10^{-3}$	$9{,}57.10^{-5}$	$4{,}59.10^{-2}$	$1{,}29.10^{-3}$
80	$1{,}03.10^{-2}$	$1{,}47.10^{-4}$	$5{,}3.10^{-2}$	$1{,}76.10^{-3}$
90	$1{,}18.10^{-2}$	$2{,}08.10^{-4}$	$5{,}95.10^{-2}$	$2{,}25.10^{-3}$
100	$1{,}32.10^{-2}$	$2{,}76.10^{-4}$	$6{,}55.10^{-2}$	$2{,}77.10^{-3}$
150	$1{,}34.10^{-2}$	$6{,}82.10^{-4}$	$9{,}05.10^{-2}$	$5{,}36.10^{-3}$
200	$1{,}65.10^{-2}$	$1{,}12.10^{-3}$	0,107	$7{,}76.10^{-3}$
250	$1{,}88.10^{-2}$	$1{,}54.10^{-3}$	0,12	$9{,}9.10^{-3}$
300	$2{,}83.10^{-2}$	$1{,}93.10^{-3}$	0,13	$1{,}18.10^{-2}$
400	$3{,}15.10^{-2}$	$2{,}61.10^{-3}$	0,145	$1{,}49.10^{-2}$
500	$3{,}35.10^{-2}$	$3.11.10^{-3}$	0,156	$1{,}74.10^{-2}$
1000	$3{,}65.10^{-2}$	$3{,}84.10^{-3}$	0,178	$2{,}49.10^{-2}$
2000	$3{,}47.10^{-2}$	$6{,}06.10^{-3}$	0,182	$3{,}11.10^{-2}$
3000	$3{,}19.10^{-2}$	$6{,}48.10^{-2}$	0,175	$3{,}35.10^{-2}$

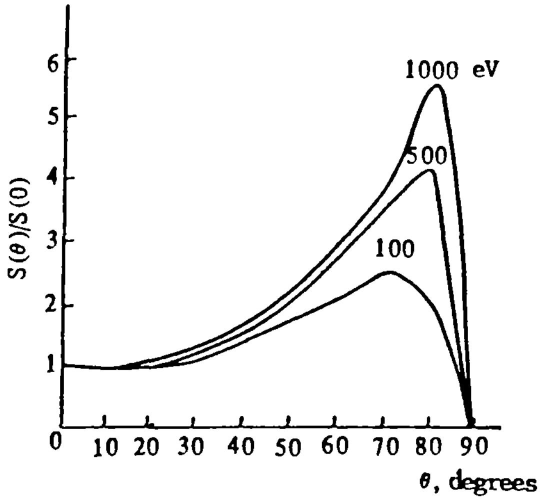

Fig. 1: Angular dependence of the coefficient for iron sputtering by deuterium.

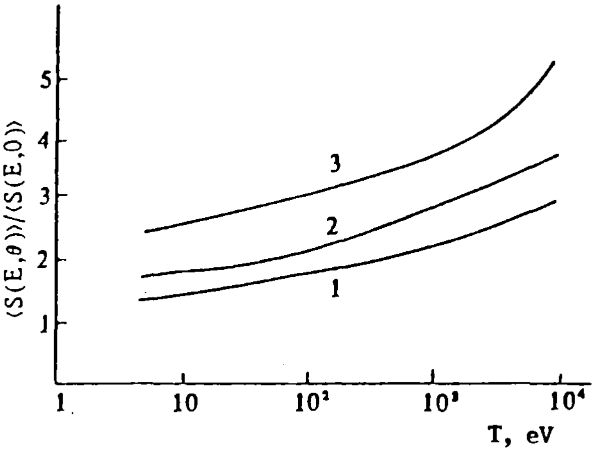

Fig. 2: Ratio of angle- and energy-averaged sputtering coefficient to energy-averaged sputtering coefficient: 1 - deuterium + iron; 2 - deuterium + vanadium; 3 - deuterium + tungsten.

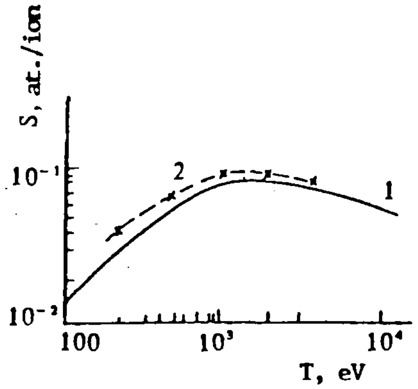

Fig. 3: Dependence of the angle- and energy-averaged sputtering coefficient on the temperature of nickel sputtering by deuterium: 1 - results from Ref. [11]; 2 - present results.

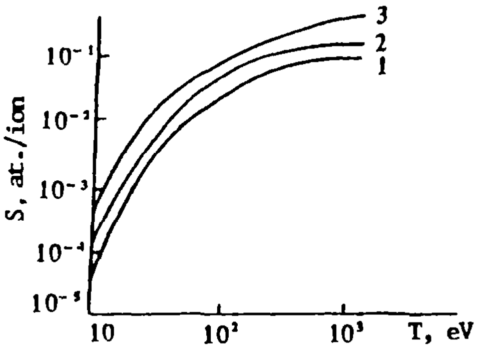

Fig. 4: Temperature dependence of the coefficient for iron sputtering by deuterium, tritium and helium atoms: 1 - deuterium; 2 - tritium; 3 - helium.

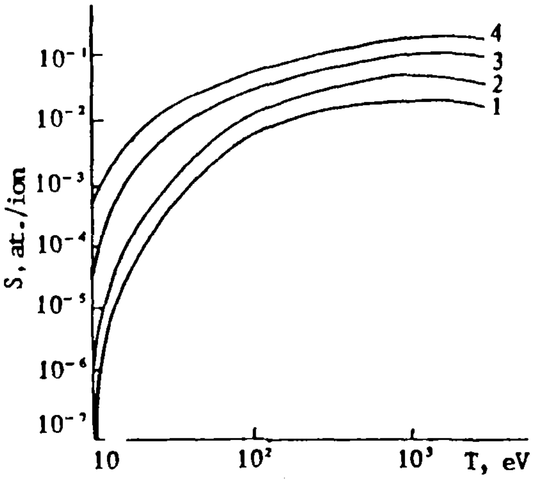

Fig. 5: Temperature dependence of the coefficient for tungsten sputtering by deuterium, tritium and singly and doubly charged helium ions:
1 - deuterium; 2 - tritium; 3 - singly-charged helium;
4 - doubly-charged helium.