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LUCAS HEIGHTS RESEARCH LABORATORIES

SPUTLIB - A LIBRARY OF MAXWELLIAN-AVERAGED SPUTTERING COEFFICIENTS

by

J.L. COOK
E.K. ROSE

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ABSTRACT

A general law of sputtering coefficients as a function of hydrogen and helium ion energies that are incident on metallic walls is given. The average over a Maxwellian spectrum is carried out analytically. A library of such coefficients is presented in the ADL-1 format.

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BOLTZMANN STATISTICS; COMPILED DATA; DEUTERON BEAMS; ENERGY DEPENDENCE; EV RANGE 100-1000; HELIUM 3 BEAMS; HELIUM 4 BEAMS; KEV RANGE; METALS; PLASMA; PROTON BEAMS; SCALING LAWS; SPUTTERING; TRITON BEAMS

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1. INTRODUCTION

Many conceptual design studies of fusion reactor performance, such as the INTOR project, are being carried out around the world. A recent review paper by Hershman and Sigmar [1981] gives full details of the effect of impurities in plasmas, and another by Ashby and Hughes [1981] uses the radiation loss evaluation for impurities calculated by Post et al. [1977], together with transport codes, to reach the conclusion that in INTOR, the temperature radial profile will collapse inwards from the wall. Ashby and Hughes claim that the plasma temperature near the wall will be about 200 eV, a temperature at which impurities, particularly those from heavy metals, have quite large radiation losses. It is not clear what wall reflective properties were considered for such losses, but Ashby and Hughes point out that sputtering from the walls and limiters is the main source of impurities which have considerable power rate coefficients.

A compilation of sputtering coefficients for the hydrogen and helium isotopes was carried out by Thomas et al. [1979]. In the same year, McCracken and Stott [1979] reviewed the semi-empirical theory of sputtering, but unfortunately it can be shown that their quoted spectral law and scaling coefficients do not fit the data at all well, and predict no maximum in the spectral curve, which occurs in almost all of the data around 1 keV. We have used all available data from Thomas et al. [1979] to fit the spectrum and discover the appropriate scaling rules.

2. SEMI-EMPIRICAL LAWS

The Thomas et al. evaluations were chosen to fit the elements Be, C, Ti, Fe, Co, Ni, Cu, Nb, Mo, W, Au and U to the rational function

$$S(E) = A(m_1,m_2)\ \frac{(E - E_T)}{(E + B)^2} \quad , \qquad E \geq E_T \quad , \tag{1}$$

where S(E) is the sputtering coefficient for incident ion beam energy E,

$$\text{(i)} \quad E_T = \frac{E_S}{\gamma(1-\gamma)} \quad , \qquad \text{(ii)} \quad \gamma = 4\ \frac{m_1 m_2}{(m_1 + m_2)^2} \quad , \tag{2}$$

m_1 and m_2 are the atomic masses of the elements in the wall and incident beam, respectively, and $A(m_1,m_2)$ is the scaling coefficient. The threshold energy

can be obtained directly from the sublimation energy of the wall material, defined as E_S, which in turn can be obtained from the relation

$$E_S = 0.0435\ L_H \quad (eV) \quad , \tag{3}$$

where L_H is the latent heat of sublimation, tabulated in the Metals Reference Book [Smithells 1976]. If the latent heat is not tabulated, the following rough approximations can be used:

$$E_S \approx 2.8 \times 10^{-3}\ M_p \quad \text{or} \quad 1.48 \times 10^{-3}\ B_p \quad , \tag{4}$$

where M_p is the melting point and B_p is the boiling point in K. We have used the second correlation only for graphite and silicon.

It was not possible to find sufficient data to check whether E_T (from equation 2(i)) is the experimental threshold, so we have assumed the theoretical value and computed the constants A and B from the fits to the equation

$$\sqrt{\frac{E - E_T}{S(E)}} = a_0 + a_1 E \tag{5}$$

in which

$$A = \frac{1}{a_1^2} \quad , \quad B = \frac{a_0}{a_1} \quad .$$

The maximum of the spectrum occurs when

$$E_{max} = B + 2E_T \quad , \tag{6}$$

and the width is so broad that the fits are very insensitive to B. We observed the correlation

$$\bar{E}_{max} = b_0 + b_1 \sqrt{Z_1} \quad , \tag{7}$$

where Z_1 is the atomic number of the element in the wall and, with 5 per cent error weighting, obtained the values

$$b_0 = -2.5429 \quad , \quad b_1 = 0.7879 \quad .$$

A rough correlation of $\overline{E}_{max}$ with m_1 could just as well be found, but for interpolation purposes, equation (7) suffices.

We note that the scaling factor $A(m_1,m_2)$ in equation (1) can be well approximated by the law

$$A(m_1,m_2) = A(m_1,1)\, e^{\overline{c}(m_2 - 1)} \quad , \tag{8}$$

where $\overline{c}$ is an average value over m_1, m_2. For this average, we used the Thomas et al. data for Ti, Fe, Ni, Mo and Au to find

$$\overline{c} = 1.0 \tag{9}$$

Thomas et al. reported old experimental values for S(E) by Kenknight and Wehner [1964] for eighteen elements with 2.33 and 3.5 keV incident H^+ ions. Thomas et al. warned that the quoted error of 3 per cent was unrealistic and differed from more recent measurements by factors of two. However, their graphs show quite definite regions:

$$\begin{aligned} &\text{(i)} \quad 22 \leq Z_1 \leq 29, \ \text{(ii)} \quad 41 \leq Z_1 \leq 47, \quad \text{and} \\ &\text{(iii)} \quad 74 \leq Z_1 \leq 79 \end{aligned} \tag{10}$$

where the scaling law

$$A(m_1,1) = e^{c_0 + c_1 m_1} \tag{11}$$

holds. For a least squares fit over region (i) for five atoms, we obtain

$$c_{01} = -11.392 \quad , \quad c_{11} = 0.15362 \quad . \tag{12}$$

Assuming the same slope in region (ii) we found from the accurate Mo data that

$$c_{02} = -18.187 \quad , \quad c_{12} = c_{11} \tag{13}$$

and similarly, for region (iii), using the Au information,

$$c_{03} = -31.409 , \quad c_{13} = c_{11} . \tag{14}$$

3. DETAILS OF THE DATA

As with the ADL-1 library [Clancy et al. 1981], the philosophy on which the necessary sputtering coefficient data library was based is that all experimental information in the library and the fitted law (1) constants should be used only for interpolation and extrapolation when the information is otherwise unavailable. The best fits for E_S, E_T, γ,A and B are displayed in Table 1. The predicted values of A and B for Al, Si, Sc, V, Cr, Zn, Zr, Rh, Ag and Ta are shown in Table 2. The elements Al, Zr and Ta were normalised to the measured value of $A(m_1,1)$.

The Thomas et al. [1979] compilation shows tables and plots for the sputtering of incident H^+, D^+, T^+, He_3^+ and He_4^+ ion beams from the elements Be, C, Ti, Fe, Co, Ni, Cu, Nb, Mo, W, Au and U, although sometimes the information is very scanty indeed. The fitted spectra of these elements are given in Figures 1 to 12 on a log-log scale. It is to be noted that at very low energies, the deviation from the experimental values is the largest; we believe that this is both because S(E) is very small in this region and because the predicted values of E_T could be in error. The data here are very sensitive to the value of E_T.

McCracken and Stott [1979] also give a general curve of $\bar{S}(T)$, the average value of S(E) over a Maxwellian ion energy distribution, which is appropriate for plasmas. Because of their spectral law, the necessary integral cannot be evaluated analytically. The form of equation (1) can be averaged analytically.

4. MAXWELLIAN-AVERAGED SPUTTERING COEFFICIENTS

The integral which has to be evaluated is

$$\bar{S}(T) = \frac{2}{\sqrt{\pi}} T^{-\frac{3}{2}} \int_{E_T}^{\infty} dE \; S(E) \; E^{\frac{1}{2}} e^{-E/T} , \tag{15}$$

where T is the temperature of the plasma in keV. This can be written

$$\bar{S}(T) = \frac{2}{\sqrt{\pi}} T^{-\frac{3}{2}} \left\{ \int_0^\infty dE\ S(E)\ E^{\frac{1}{2}} e^{-E/T} - \int_0^{E_T} dE\ S(E)\ E^{\frac{1}{2}}\ e^{-E/T} \right\} \quad (16)$$

$$= I_1 - I_2 \quad .$$

Substituting equation (1) into equation (16), we find [after Gradshteyn and Ryzhik 1965] that

$$\int_0^\infty dE\ S(E)\ E^{\frac{1}{2}} e^{-E/T} = A[I_1^1 - E_T\ I_2^1] \quad (17)$$

in which

$$I_1^1 = 4\,\Gamma(5/2)\ \mu^{-\frac{1}{2}} e^{\frac{z^2}{4}}\ D_{-4}(z) \quad , \quad (18)$$

$$I_2^1 = 2^{\frac{3}{2}}\Gamma\ (3/2)\ B^{-\frac{1}{2}} e^{\frac{z^2}{4}}\ D_{-3}(z) \quad . \quad (19)$$

In these equations

$$\mu = \frac{1}{T} \quad , \quad z = \sqrt{\frac{2B}{T}} \quad , \quad (20)$$

while $D_\nu(z)$ is the parabolic cylinder function. This function was tabulated by Abramowitz and Stegun [1965] for $0 \leq z \leq 5$, and can be computed from the recurrence relation [Erdélyi et al. 1953].

$$D_{\nu-1}(z) = \frac{1}{\nu} \left\{ z\ D_\nu(z) - D_{\nu+1}(z) \right\} \quad , \quad (21)$$

using the first two cases

$$D_{-1}(z) = \sqrt{\frac{\pi}{2}}\ e^{\frac{z^2}{4}}\ \mathrm{erfc}\left(\frac{z}{\sqrt{2}}\right) \quad , \quad (22)$$

$$D_{-2}(z) = z\ D_{-1}(z) - e^{\frac{z^2}{4}} \quad , \quad \mathrm{erfc}(x) = \frac{2}{\sqrt{\pi}} \int_x^\infty e^{-t^2}\ dt \quad . \quad (23)$$

For very low temperature, the asymptotic series

$$e^{\frac{z^2}{4}} D_\nu(z) = z^\nu \left[1 - \frac{\nu(\nu-1)}{2z^2} + \frac{\nu(\nu-1)(\nu-2)(\nu-3)}{2!(2z^2)^2} \right] \qquad (24)$$

can be used; higher terms can be found in Erdélyi et al. [1953].

The second integral in equation (16) can be approximated very well by expanding both the exponential term and the denominator into Taylor series and integrating term by term. From this

$$I_2 \approx \frac{A}{B^2} \sum_{n=0}^{\infty} \frac{(-1)^n}{n!} E_T^{\frac{5}{2}} \left(\frac{E_T}{T}\right)^n \left[\left(1 + \frac{2E_T}{B}\right)\left(n + \frac{5}{2}\right)^{-1} - \right.$$

$$\left. - \left(n+\frac{3}{2}\right)^{-1} - \frac{2E_T}{B}\left(n + \frac{7}{2}\right)^{-1} \right] \qquad (25)$$

with a maximum error of around 1 per cent close to threshold.

5. CONCLUSIONS

It is considered that the above theory will predict sputtering coefficients for hydrogen and helium ions impinging on metals to reasonable accuracy.

The library listing appears in Table 3 for all elements in ADL-1, using the same keV temperature grid as in that library. The library format is self-explanatory.

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TABLE 1

FITTED VALUES OF SPUTTERING LAW PARAMETERS

Element	m_2	E_s(eV)	$E_T=E_s/\gamma(1-\gamma)$ (keV)	γ	A (keV)	B (keV)
4BE +	1	3.44	1.490D-02	3.619D-01	4.335D-01	5.150D+00
4BE +	2	3.44	1.430D-02	5.972D-01	7.050D-02	2.025D-01
4BE +	3	3.44	1.847D-02	7.524D-01	5.054D-01	1.837D-01
12C +	1	7.42	3.635D-02	2.857D-01	1.672D-02	4.360D-01
12C +	2	7.42	2.968D-02	4.919D-01	3.373D-01	3.209D-01
12C +	4	7.42	3.956D-02	7.499D-01	6.868D-01	1.585D+00
22TI +	1	4.88	6.576D-02	8.073D-02	1.703D-02	9.681D-01
22TI +	2	4.88	3.728D-02	1.549D-01	4.275D-02	1.009D+00
22TI +	3	4.88	2.813D-02	2.234D-01	1.209D-01	1.268D+00
22TI +	4	4.88	2.396D-02	2.847D-01	3.395D-01	1.024D+00
26FE +	1	4.14	6.507D-02	6.829D-02	5.223D-02	1.278D+00
26FE +	2	4.14	3.617D-02	1.319D-01	1.224D-01	1.056D+00
26FE +	3	4.14	2.676D-02	1.913D-01	2.497D-01	1.128D+00
26FE +	4	4.14	2.237D-02	2.452D-01	1.071D+00	1.751D+00
27CO +	1	4.42	7.158D-02	6.612D-02	1.207D-01	3.056D+00
27CO +	2	4.42	3.965D-02	1.278D-01	2.807D-01	2.192D+00
27CO +	4	4.42	2.436D-02	2.382D-01	3.748D+00	2.594D+00
28NI +	1	4.46	7.197D-02	6.638D-02	9.769D-02	1.513D+00
28NI +	2	4.46	3.988D-02	1.283D-01	2.430D-01	1.365D+00
28NI +	3	4.46	2.942D-02	1.863D-01	7.519D-01	1.797D+00
28NI +	4	4.46	2.452D-02	2.390D-01	1.972D+00	2.004D+00
29CU +	1	3.55	6.153D-02	6.147D-02	1.849D-01	6.632D-01
29CU +	2	3.55	3.383D-02	1.191D-01	5.394D-01	1.632D+00
29CU +	4	3.55	2.049D-02	2.230D-01	5.167D+00	3.298D+00
41NB +	1	7.50	1.844D-01	4.246D-02	3.266D-02	3.110D+00
41NB +	2	7.50	9.846D-02	8.307D-02	8.207D-02	3.252D+00
41NB +	4	7.50	5.626D-02	1.584D-01	3.152D+00	8.552D+00
42MO +	1	6.90	1.749D-01	4.115D-02	3.180D-02	3.877D+00
42MO +	2	6.90	9.316D-02	8.056D-02	6.546D-02	2.157D+00
42MO +	3	6.90	6.607D-02	1.185D-01	1.432D-01	2.316D+00
42MO +	3	6.90	6.607D-02	1.185D-01	3.288D-01	2.355D+00
42MO +	4	6.90	5.302D-02	1.538D-01	5.575D-01	2.273D+00
74W +	1	8.81	4.152D-01	2.169D-02	4.012D-03	2.534D+00
74W +	2	8.81	2.147D-01	4.288D-02	1.793D-01	3.219D+00
74W +	4	8.81	1.152D-01	8.341D-02	7.737D-01	5.134D+00
79AU +	1	3.94	1.985D-01	2.026D-02	3.162D-01	5.042D+00
79AU +	2	3.94	1.024D-01	4.008D-02	7.477D-01	4.139D+00
79AU +	3	3.94	7.034D-02	5.956D-02	1.252D+00	3.684D+00
79AU +	3	3.94	7.034D-02	5.956D-02	2.570D+00	4.342D+00
79AU +	4	3.94	5.474D-02	7.808D-02	2.761D+00	3.197D+00
92U +	1	4.76	2.883D-01	1.679D-02	3.627D-02	1.816D+01
92U +	4	4.76	7.826D-02	6.506D-02	1.519D+00	2.239D+01

TABLE 2

INTERPOLATED VALUES OF SPUTTERING LAW PARAMETERS

Element	m_2	E_s(eV)	$E_T=E_s/\gamma(1-\gamma)$ (keV)	γ	A (keV)	B (keV)
13AL +	1	4.09	3.421D-02	1.388D-01	4.503D-02	2.294D-01
13AL +	2	4.09	2.134D-02	2.585D-01	1.257D-01	2.551D-01
13AL +	3	4.09	1.770D-02	3.624D-01	3.461D-01	2.624D-01
13AL +	4	4.09	1.653D-02	4.500D-01	9.225D-01	2.648D-01
14SI +	1	4.68	4.039D-02	1.338D-01	8.435D-04	3.243D-01
14SI +	2	4.68	2.498D-02	2.497D-01	2.325D-03	3.551D-01
14SI +	3	4.68	2.055D-02	3.510D-01	6.380D-03	3.640D-01
14SI +	4	4.68	1.902D-02	4.367D-01	1.699D-02	3.670D-01
21SC +	1	3.91	4.986D-02	8.578D-02	1.126D-02	9.679D-01
21SC +	2	3.91	2.850D-02	1.642D-01	3.103D-02	1.011D+00
21SC +	3	3.91	2.167D-02	2.362D-01	8.515D-02	1.024D+00
21SC +	4	3.91	1.861D-02	3.003D-01	2.267D-01	1.030D+00
23V +	1	4.88	6.941D-02	7.610D-02	5.044D-02	1.097D+00
23V +	2	4.88	3.906D-02	1.463D-01	1.418D-01	1.158D+00
23V +	3	4.88	2.926D-02	2.116D-01	3.917D-01	1.177D+00
23V +	4	4.88	2.475D-02	2.702D-01	1.046D+00	1.186D+00
24CR +	1	5.36	7.763D-02	7.461D-02	3.319D-02	1.162D+00
24CR +	2	5.36	4.358D-02	1.436D-01	9.151D-02	1.230D+00
24CR +	3	5.36	3.257D-02	2.077D-01	2.511D-01	1.252D+00
24CR +	4	5.36	2.749D-02	2.655D-01	6.684D-01	1.262D+00
30ZN +	1	1.37	2.437D-02	5.980D-02	2.593D-01	1.724D+00
30ZN +	2	1.37	1.336D-02	1.160D-01	7.150D-01	1.746D+00
30ZN +	3	1.37	9.756D-03	1.690D-01	1.962D+00	1.753D+00
30ZN +	4	1.37	8.051D-03	2.174D-01	5.222D+00	1.756D+00
40ZR +	1	6.36	1.538D-01	4.323D-02	4.144D-02	2.133D+00
40ZR +	2	6.36	8.217D-02	8.454D-02	1.177D-01	2.276D+00
40ZR +	3	6.36	5.847D-02	1.242D-01	3.262D-01	2.323D+00
40ZR +	4	6.36	4.707D-02	1.611D-01	8.724D-01	2.346D+00
45RH +	1	5.78	1.565D-01	3.842D-02	9.248D-02	2.429D+00
45RH +	2	5.78	8.300D-02	7.531D-02	2.550D-01	2.576D+00
45RH +	3	5.78	5.861D-02	1.109D-01	6.996D-01	2.625D+00
45RH +	4	5.78	4.685D-02	1.442D-01	1.862D+00	2.649D+00
47AG +	1	1.78	5.037D-02	3.668D-02	1.982D-01	2.758D+00
47AG +	2	1.78	2.665D-02	7.197D-02	5.464D-01	2.805D+00
47AG +	3	1.78	1.877D-02	1.061D-01	1.499D+00	2.821D+00
47AG +	4	1.78	1.496D-02	1.380D-01	3.991D+00	2.829D+00
73TA +	1	8.13	3.773D-01	2.203D-02	1.778D-02	3.434D+00
73TA +	2	8.13	1.952D-01	4.355D-02	5.102D-02	3.798D+00
73TA +	3	8.13	1.344D-01	6.466D-02	1.418D-01	3.920D+00
73TA +	4	8.13	1.049D-01	8.469D-02	3.800D-01	3.979D+00

TABLE 3

SPUTLIB - SPUTTERING COEFFICIENT LIBRARY - NOV.81

TEMPERATURES IN KEV (45 ENTRIES)

```
*
1.000D-02 2.000D-02 3.000D-02 4.000D-02 5.000D-02 6.000D-02 7.000D-02
8.000D-02 9.000D-02 1.000D-01 2.000D-01 3.000D-01 4.000D-01 5.000D-01
6.000D-01 7.000D-01 8.000D-01 9.000D-01 1.000D+00 2.000D+00 3.000D+00
4.000D+00 5.000D+00 6.000D+00 7.000D+00 8.000D+00 9.000D+00 1.000D+01
1.200D+01 1.400D+01 1.600D+01 1.800D+01 2.000D+01 3.000D+01 4.000D+01
5.000D+01 6.000D+01 7.000D+01 8.000D+01 9.000D+01 1.000D+02 2.500D+02
5.000D+02 7.500D+02 1.000D+03
*          SPUTTERING COEFFICIENT  FOR  BE  + H+
*
1.000D-50 1.449D-04 3.206D-04 4.886D-04 6.520D-04 8.121D-04 9.692D-04
1.124D-03 1.276D-03 1.426D-03 2.817D-03 4.071D-03 5.258D-03 5.988D-03
6.811D-03 7.546D-03 8.206D-03 8.801D-03 9.338D-03 1.267D-02 1.468D-02
1.466D-02 1.485D-02 1.482D-02 1.467D-02 1.445D-02 1.419D-02 1.392D-02
1.335D-02 1.280D-02 1.227D-02 1.178D-02 1.132D-02 9.477D-03 8.172D-03
7.202D-03 6.453D-03 5.854D-03 5.364D-03 4.955D-03 4.607D-03 2.310D-03
1.298D-03 9.119D-04 7.057D-04
*          SPUTTERING COEFFICIENT  FOR  BE  + D+
*
1.000D-50 1.224D-02 2.512D-02 3.439D-02 4.136D-02 4.673D-02 5.095D-02
5.429D-02 5.696D-02 5.911D-02 6.645D-02 6.510D-02 6.196D-02 5.857D-02
5.533D-02 5.235D-02 4.965D-02 4.721D-02 4.500D-02 3.093D-02 2.384D-02
1.952D-02 1.659D-02 1.446D-02 1.284D-02 1.155D-02 1.052D-02 9.650D-03
8.810D-03 7.305D-03 6.523D-03 5.898D-03 5.384D-03 3.769D-03 2.911D-03
2.376D-03 2.009D-03 1.742D-03 1.539D-03 1.378D-03 1.249D-03 5.221D-04
2.670D-04 1.798D-04 1.357D-04
*          SPUTTERING COEFFICIENT  FOR  BE  + 4HE+
*
1.000D-50 1.000D-50 2.262D-02 1.307D-01 2.091D-01 2.682D-01 3.138D-01
3.497D-01 3.782D-01 4.011D-01 4.848D-01 4.814D-01 4.601D-01 4.354D-01
4.113D-01 3.890D-01 3.687D-01 3.503D-01 3.336D-01 2.279D-01 1.750D-01
1.429D-01 1.212D-01 1.055D-01 9.355D-02 8.413D-02 7.650D-02 7.019D-02
6.034D-02 5.299D-02 4.729D-02 4.272D-02 3.898D-02 2.724D-02 2.101D-02
1.713D-02 1.448D-02 1.255D-02 1.108D-02 9.922D-03 8.986D-03 3.751D-03
1.916D-03 1.290D-03 9.729D-04
*          SPUTTERING COEFFICIENT  FOR  C   + H+
*
1.000D-50 1.000D-50 1.000D-50 5.514D-04 1.369D-03 2.052D-03 2.633D-03
3.134D-03 3.571D-03 3.954D-03 6.110D-03 6.885D-03 7.151D-03 7.191D-03
7.122D-03 6.998D-03 6.847D-03 6.684D-03 6.516D-03 5.094D-03 4.173D-03
3.547D-03 3.094D-03 2.750D-03 2.479D-03 2.260D-03 2.078D-03 1.925D-03
1.681D-03 1.494D-03 1.347D-03 1.227D-03 1.127D-03 8.069D-04 6.315D-04
5.202D-04 4.430D-04 3.861D-04 3.425D-04 3.079D-04 2.798D-04 1.194D-04
6.173D-05 4.176D-05 3.160D-05
*          SPUTTERING COEFFICIENT  FOR  C   + D+
*
1.000D-50 1.000D-50 5.917D-04 3.639D-03 6.041D-03 7.993D-03 9.611D-03
1.097D-02 1.213D-02 1.312D-02 1.807D-02 1.933D-02 1.942D-02 1.906D-02
1.853D-02 1.794D-02 1.733D-02 1.674D-02 1.618D-02 1.200D-02 9.581D-03
8.017D-03 6.917D-03 6.097D-03 5.461D-03 4.951D-03 4.533D-03 4.184D-03
3.631D-03 3.212D-03 2.884D-03 2.618D-03 2.399D-03 1.701D-03 1.324D-03
1.086D-03 9.221D-04 8.020D-04 7.100D-04 6.373D-04 5.783D-04 2.447D-04
1.259D-04 8.500D-05 6.423D-05
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(Continued)

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*           SPUTTERING COEFFICIENT  FOR  C    + 4HE+
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1.000D-50 1.000D-50 1.000D-50 2.425D-03 6.267D-03 9.810D-03 1.314D-02
1.633D-02 1.941D-02 2.243D-02 4.206D-02 5.562D-02 6.504D-02 7.177D-02
7.667D-02 8.026D-02 8.290D-02 8.482D-02 8.621D-02 8.692D-02 8.112D-02
7.497D-02 6.942D-02 6.458D-02 6.037D-02 5.669D-02 5.345D-02 5.059D-02
4.576D-02 4.182D-02 3.856D-02 3.580D-02 3.344D-02 2.531D-02 2.050D-02
1.729D-02 1.498D-02 1.324D-02 1.188D-02 1.078D-02 9.872D-03 4.451D-03
2.366D-03 1.621D-03 1.236D-03
*           SPUTTERING COEFFICIENT  FOR  TI   + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 2.614D-04
3.991D-04 5.760D-04 7.379D-04 1.845D-03 2.454D-03 2.821D-03 3.059D-03
3.195D-03 3.285D-03 3.338D-03 3.365D-03 3.373D-03 3.107D-03 2.758D-03
2.466D-03 2.229D-03 2.035D-03 1.874D-03 1.739D-03 1.622D-03 1.522D-03
1.356D-03 1.225D-03 1.119D-03 1.030D-03 9.556D-04 7.062D-04 5.635D-04
4.705D-04 4.046D-04 3.555D-04 3.173D-04 2.867D-04 2.617D-04 1.152D-04
6.048D-05 4.121D-05 3.131D-05
*           SPUTTERING COEFFICIENT  FOR  TI   + D+
*
1.000D-50 1.000D-50 1.000D-50 4.342D-04 9.786D-04 1.484D-03 1.969D-03
2.223D-03 2.578D-03 2.908D-03 5.240D-03 6.556D-03 7.352D-03 7.847D-03
8.155D-03 8.340D-03 8.443D-03 8.488D-03 8.493D-03 7.763D-03 6.881D-03
6.150D-03 5.559D-03 5.076D-03 4.675D-03 4.337D-03 4.048D-03 3.798D-03
3.385D-03 3.059D-03 2.794D-03 2.574D-03 2.387D-03 1.765D-03 1.409D-03
1.177D-03 1.013D-03 8.897D-04 7.943D-04 7.179D-04 6.553D-04 2.887D-04
1.516D-04 1.033D-04 7.852D-05
*           SPUTTERING COEFFICIENT  FOR  TI   + T+
*
1.000D-50 1.000D-50 6.658D-04 1.703D-03 2.647D-03 3.532D-03 4.377D-03
5.199D-03 6.012D-03 6.305D-03 1.109D-02 1.403D-02 1.594D-02 1.722D-02
1.809D-02 1.868D-02 1.907D-02 1.932D-02 1.946D-02 1.858D-02 1.686D-02
1.530D-02 1.399D-02 1.288D-02 1.195D-02 1.115D-02 1.045D-02 9.846D-03
8.836D-03 8.026D-03 7.362D-03 6.807D-03 6.334D-03 4.735D-03 3.806D-03
3.193D-03 2.756D-03 2.428D-03 2.173D-03 1.967D-03 1.799D-03 8.010D-04
4.230D-04 2.890D-04 2.199D-04
*           SPUTTERING COEFFICIENT  FOR  TI   + 4HE+
*
1.000D-50 1.000D-50 4.430D-03 8.598D-03 1.242D-02 1.605D-02 1.957D-02
2.135D-02 2.395D-02 2.638D-02 4.372D-02 5.356D-02 5.951D-02 6.319D-02
6.545D-02 6.678D-02 6.749D-02 6.777D-02 6.774D-02 6.169D-02 5.462D-02
4.880D-02 4.410D-02 4.027D-02 3.709D-02 3.440D-02 3.211D-02 3.012D-02
2.685D-02 2.426D-02 2.216D-02 2.041D-02 1.894D-02 1.401D-02 1.118D-02
9.339D-03 8.035D-03 7.060D-03 6.303D-03 5.697D-03 5.201D-03 2.292D-03
1.204D-03 8.204D-04 6.234D-04
*           SPUTTERING COEFFICIENT  FOR  FE   + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 5.227D-04
9.320D-04 1.326D-03 1.517D-03 3.825D-03 5.225D-03 6.144D-03 6.768D-03
7.201D-03 7.503D-03 7.712D-03 7.854D-03 7.946D-03 7.745D-03 7.083D-03
6.457D-03 5.918D-03 5.462D-03 5.073D-03 4.739D-03 4.448D-03 4.194D-03
3.769D-03 3.427D-03 3.146D-03 2.911D-03 2.710D-03 2.030D-03 1.633D-03
1.371D-03 1.184D-03 1.044D-03 9.343D-04 8.462D-04 7.738D-04 3.452D-04
1.824D-04 1.247D-04 9.489D-05
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*          SPUTTERING COEFFICIENT  FOR  FE  + D+
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1.000D-50 1.000D-50 1.000D-50 1.311D-03 2.731D-03 4.050D-03 5.313D-03
6.554D-03 6.977D-03 7.856D-03 1.414D-02 1.775D-02 1.997D-02 2.137D-02
2.226D-02 2.282D-02 2.314D-02 2.330D-02 2.334D-02 2.153D-02 1.917D-02
1.718D-02 1.557D-02 1.424D-02 1.313D-02 1.220D-02 1.139D-02 1.070D-02
9.548D-03 8.636D-03 7.894D-03 7.276D-03 6.754D-03 5.005D-03 4.001D-03
3.344D-03 2.879D-03 2.531D-03 2.260D-03 2.044D-03 1.866D-03 8.239D-04
4.332D-04 2.953D-04 2.245D-04
*          SPUTTERING COEFFICIENT  FOR  FE  + T+
*
1.000D-50 1.000D-50 2.036D-03 4.665D-03 7.061D-03 9.314D-03 1.148D-02
1.362D-02 1.450D-02 1.606D-02 2.749D-02 3.423D-02 3.845D-02 4.117D-02
4.293D-02 4.405D-02 4.473D-02 4.509D-02 4.523D-02 4.209D-02 3.769D-02
3.391D-02 3.080D-02 2.823D-02 2.608D-02 2.426D-02 2.269D-02 2.133D-02
1.907D-02 1.727D-02 1.580D-02 1.458D-02 1.355D-02 1.007D-02 8.060D-03
6.745D-03 5.812D-03 5.113D-03 4.569D-03 4.133D-03 3.776D-03 1.672D-03
8.802D-04 6.004D-04 4.566D-04
*          SPUTTERING COEFFICIENT  FOR  FE  + 4HE+
*
1.000D-50 1.000D-50 5.953D-03 1.076D-02 1.523D-02 1.946D-02 2.351D-02
2.741D-02 3.122D-02 3.494D-02 6.078D-02 7.904D-02 9.201D-02 1.015D-01
1.085D-01 1.138D-01 1.177D-01 1.207D-01 1.228D-01 1.257D-01 1.183D-01
1.101D-01 1.024D-01 9.561D-02 8.965D-02 8.440D-02 7.975D-02 7.563D-02
6.861D-02 6.287D-02 5.807D-02 5.401D-02 5.052D-02 3.844D-02 3.123D-02
2.640D-02 2.292D-02 2.028D-02 1.821D-02 1.654D-02 1.516D-02 6.872D-03
3.663D-03 2.512D-03 1.917D-03
*          SPUTTERING COEFFICIENT  FOR  CO  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
3.551D-04 5.349D-04 7.069D-04 2.206D-03 3.155D-03 3.990D-03 4.667D-03
5.222D-03 5.683D-03 6.069D-03 6.393D-03 6.668D-03 7.916D-03 8.068D-03
7.902D-03 7.634D-03 7.338D-03 7.043D-03 6.760D-03 6.494D-03 6.249D-03
5.799D-03 5.413D-03 5.077D-03 4.783D-03 4.523D-03 3.577D-03 2.975D-03
2.557D-03 2.247D-03 2.008D-03 1.818D-03 1.662D-03 1.532D-03 7.218D-04
3.925D-04 2.717D-04 2.084D-04
*          SPUTTERING COEFFICIENT  FOR  CO  + D+
*
1.000D-50 1.000D-50 1.000D-50 5.625D-04 1.419D-03 2.215D-03 2.966D-03
3.684D-03 4.374D-03 5.044D-03 1.017D-02 1.389D-02 1.668D-02 1.882D-02
2.048D-02 2.179D-02 2.283D-02 2.366D-02 2.432D-02 2.639D-02 2.563D-02
2.432D-02 2.296D-02 2.168D-02 2.051D-02 1.945D-02 1.850D-02 1.764D-02
1.614D-02 1.490D-02 1.384D-02 1.294D-02 1.215D-02 9.380D-03 7.689D-03
6.540D-03 5.704D-03 5.067D-03 4.563D-03 4.154D-03 3.816D-03 1.755D-03
9.425D-04 6.486D-04 4.958D-04
*          SPUTTERING COEFFICIENT  FOR  CO  + 4HE+
*
1.000D-50 1.000D-50 4.533D-03 8.885D-03 1.302D-02 1.701D-02 2.088D-02
2.466D-02 2.836D-02 3.198D-02 6.506D-02 9.505D-02 1.140D-01 1.334D-01
1.502D-01 1.648D-01 1.775D-01 1.887D-01 1.985D-01 2.532D-01 2.704D-01
2.739D-01 2.715D-01 2.663D-01 2.599D-01 2.530D-01 2.460D-01 2.391D-01
2.260D-01 2.139D-01 2.031D-01 1.932D-01 1.843D-01 1.502D-01 1.274D-01
1.110D-01 9.853D-02 8.876D-02 8.086D-02 7.433D-02 6.883D-02 3.352D-02
1.855D-02 1.294D-02 9.970D-03
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*          SPUTTERING COEFFICIENT  FOR  NI  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
9.341D-04 1.478D-03 2.002D-03 5.303D-03 7.504D-03 9.013D-03 1.008D-02
1.086D-02 1.143D-02 1.185D-02 1.216D-02 1.238D-02 1.256D-02 1.172D-02
1.083D-02 1.002D-02 9.316D-03 8.703D-03 8.169D-03 7.699D-03 7.284D-03
6.583D-03 6.014D-03 5.541D-03 5.143D-03 4.801D-03 3.629D-03 2.936D-03
2.475D-03 2.144D-03 1.894D-03 1.698D-03 1.541D-03 1.411D-03 6.351D-04
3.372D-04 2.309D-04 1.760D-04
*          SPUTTERING COEFFICIENT  FOR  NI  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.041D-03 2.841D-03 4.498D-03 6.059D-03
7.556D-03 9.018D-03 1.046D-02 1.875D-02 2.441D-02 2.819D-02 3.078D-02
3.260D-02 3.387D-02 3.475D-02 3.536D-02 3.575D-02 3.488D-02 3.199D-02
2.923D-02 2.684D-02 2.481D-02 2.307D-02 2.157D-02 2.027D-02 1.913D-02
1.721D-02 1.567D-02 1.440D-02 1.333D-02 1.242D-02 9.325D-03 7.514D-03
6.315D-03 5.459D-03 4.815D-03 4.312D-03 3.907D-03 3.574D-03 1.598D-03
8.460D-04 5.785D-04 4.405D-04
*          SPUTTERING COEFFICIENT  FOR  NI  + T+
*
1.000D-50 1.000D-50 1.819D-03 5.215D-03 8.327D-03 1.125D-02 1.402D-02
1.669D-02 1.928D-02 2.181D-02 3.959D-02 5.217D-02 6.118D-02 6.780D-02
7.274D-02 7.647D-02 7.930D-02 8.144D-02 8.306D-02 8.573D-02 8.110D-02
7.564D-02 7.051D-02 6.593D-02 6.189D-02 5.832D-02 5.516D-02 5.234D-02
4.754D-02 4.360D-02 4.031D-02 3.751D-02 3.510D-02 2.676D-02 2.176D-02
1.841D-02 1.599D-02 1.416D-02 1.272D-02 1.155D-02 1.059D-02 4.811D-03
2.566D-03 1.761D-03 1.344D-03
*          SPUTTERING COEFFICIENT  FOR  NI  + 4HE+
*
1.000D-50 1.000D-50 7.140D-03 1.412D-02 2.060D-02 2.674D-02 3.261D-02
3.827D-02 4.376D-02 4.912D-02 8.890D-02 1.176D-01 1.387D-01 1.545D-01
1.666D-01 1.759D-01 1.832D-01 1.888D-01 1.932D-01 2.040D-01 1.955D-01
1.839D-01 1.725D-01 1.621D-01 1.527D-01 1.444D-01 1.369D-01 1.302D-01
1.188D-01 1.093D-01 1.013D-01 9.445D-02 8.855D-02 6.794D-02 5.549D-02
4.707D-02 4.097D-02 3.634D-02 3.268D-02 2.973D-02 2.728D-02 1.247D-02
6.675D-03 4.587D-03 3.504D-03
*          SPUTTERING COEFFICIENT  FOR  CU  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 4.862D-03
8.637D-03 1.200D-02 1.501D-02 3.393D-02 4.284D-02 4.747D-02 4.990D-02
5.109D-02 5.154D-02 5.153D-02 5.123D-02 5.073D-02 4.337D-02 3.706D-02
3.235D-02 2.874D-02 2.590D-02 2.361D-02 2.171D-02 2.012D-02 1.875D-02
1.655D-02 1.483D-02 1.345D-02 1.232D-02 1.138D-02 8.274D-03 6.539D-03
5.422D-03 4.640D-03 4.061D-03 3.613D-03 3.257D-03 2.966D-03 1.286D-03
6.695D-04 4.545D-04 3.446D-04
*          SPUTTERING COEFFICIENT  FOR  CU  + D+
*
1.000D-50 1.000D-50 1.000D-50 3.339D-03 6.085D-03 8.640D-03 1.106D-02
1.338D-02 1.563D-02 1.783D-02 3.246D-02 4.264D-02 4.976D-02 5.487D-02
5.862D-02 6.138D-02 6.343D-02 6.493D-02 6.602D-02 6.682D-02 6.252D-02
5.788D-02 5.367D-02 4.998D-02 4.676D-02 4.394D-02 4.146D-02 3.926D-02
3.554D-02 3.251D-02 2.999D-02 2.785D-02 2.603D-02 1.973D-02 1.599D-02
1.350D-02 1.170D-02 1.035D-02 9.285D-03 8.427D-03 7.720D-03 3.486D-03
1.854D-03 1.271D-03 9.690D-04
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*          SPUTTERING COEFFICIENT  FOR  CU  + 4HE+
*
1.000D-50 1.000D-50 9.731D-03 1.662D-02 2.318D-02 2.949D-02 3.560D-02
4.154D-02 4.733D-02 5.298D-02 1.046D-01 1.395D-01 1.702D-01 1.954D-01
2.163D-01 2.338D-01 2.486D-01 2.611D-01 2.717D-01 3.213D-01 3.283D-01
3.225D-01 3.124D-01 3.009D-01 2.894D-01 2.782D-01 2.677D-01 2.578D-01
2.399D-01 2.244D-01 2.108D-01 1.989D-01 1.883D-01 1.495D-01 1.247D-01
1.074D-01 9.453D-02 8.458D-02 7.662D-02 7.010D-02 6.466D-02 3.062D-02
1.670D-02 1.157D-02 8.882D-03
*          SPUTTERING COEFFICIENT  FOR  NB  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.564D-04 4.717D-04 7.300D-04 9.365D-04
1.106D-03 1.246D-03 1.364D-03 1.464D-03 1.549D-03 1.958D-03 2.038D-03
2.019D-03 1.965D-03 1.899D-03 1.829D-03 1.761D-03 1.696D-03 1.634D-03
1.523D-03 1.425D-03 1.339D-03 1.263D-03 1.196D-03 9.502D-04 7.926D-04
6.823D-04 6.005D-04 5.371D-04 4.865D-04 4.451D-04 4.105D-04 1.942D-04
1.058D-04 7.328D-05 5.624D-05
*          SPUTTERING COEFFICIENT  FOR  NB  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.645D-04 1.125D-03 1.753D-03 2.292D-03 2.732D-03
3.096D-03 3.400D-03 3.657D-03 3.876D-03 4.062D-03 4.951D-03 5.109D-03
5.044D-03 4.900D-03 4.730D-03 4.555D-03 4.384D-03 4.221D-03 4.068D-03
3.790D-03 3.547D-03 3.334D-03 3.146D-03 2.980D-03 2.369D-03 1.977D-03
1.703D-03 1.499D-03 1.342D-03 1.216D-03 1.112D-03 1.026D-03 4.862D-04
2.651D-04 1.837D-04 1.410D-04
*          SPUTTERING COEFFICIENT  FOR  NB  + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 9.210D-04 1.604D-03
2.262D-03 2.900D-03 3.524D-03 9.237D-03 1.436D-02 1.912D-02 2.366D-02
2.812D-02 3.021D-02 3.337D-02 3.629D-02 3.899D-02 5.746D-02 6.706D-02
7.231D-02 7.517D-02 7.661D-02 7.716D-02 7.715D-02 7.676D-02 7.612D-02
7.440D-02 7.240D-02 7.030D-02 6.821D-02 6.618D-02 5.728D-02 5.046D-02
4.514D-02 4.091D-02 3.745D-02 3.457D-02 3.214D-02 2.004D-02 1.564D-02
8.967D-03 6.356D-03 4.946D-03
*          SPUTTERING COEFFICIENT  FOR  MO  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.299D-04 3.482D-04 5.268D-04 6.743D-04
7.983D-04 9.040D-04 9.948D-04 1.073D-03 1.142D-03 1.505D-03 1.610D-03
1.625D-03 1.604D-03 1.567D-03 1.524D-03 1.478D-03 1.433D-03 1.389D-03
1.306D-03 1.232D-03 1.165D-03 1.105D-03 1.051D-03 8.489D-04 7.154D-04
6.203D-04 5.489D-04 4.931D-04 4.482D-04 4.112D-04 3.802D-04 1.830D-04
1.006D-04 7.000D-05 5.385D-05
*          SPUTTERING COEFFICIENT  FOR  MO  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 3.447D-04 1.753D-03 2.731D-03 3.454D-03 4.036D-03
4.436D-03 4.776D-03 5.046D-03 5.263D-03 5.437D-03 6.029D-03 5.897D-03
5.615D-03 5.311D-03 5.022D-03 4.755D-03 4.513D-03 4.294D-03 4.096D-03
3.752D-03 3.464D-03 3.219D-03 3.010D-03 2.827D-03 2.184D-03 1.791D-03
1.524D-03 1.329D-03 1.181D-03 1.063D-03 9.683D-04 8.894D-04 4.092D-04
2.198D-04 1.513D-04 1.156D-04
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*           SPUTTERING COEFFICIENT  FOR  MC  + T+
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1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 4.991D-04
8.670D-04 1.216D-03 1.550D-03 4.104D-03 5.947D-03 7.336D-03 8.412D-03
9.260D-03 9.935D-03 1.048D-02 1.092D-02 1.127D-02 1.253D-02 1.231D-02
1.177D-02 1.116D-02 1.058D-02 1.004D-02 9.541D-03 9.091D-03 8.682D-03
7.969D-03 7.370D-03 6.860D-03 6.421D-03 6.039D-03 4.683D-03 3.849D-03
3.280D-03 2.865D-03 2.547D-03 2.296D-03 2.092D-03 1.923D-03 8.882D-04
4.780D-04 2.293D-04 2.519D-04
*           SPUTTERING COEFFICIENT  FOR  MO  + T+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.115D-03
1.934D-03 2.712D-03 3.457D-03 9.173D-03 1.331D-02 1.644D-02 1.887D-02
2.079D-02 2.232D-02 2.356D-02 2.456D-02 2.538D-02 2.832D-02 2.788D-02
2.668D-02 2.533D-02 2.403D-02 2.281D-02 2.170D-02 2.069D-02 1.976D-02
1.815D-02 1.680D-02 1.564D-02 1.465D-02 1.378D-02 1.070D-02 8.797D-03
7.500D-03 6.553D-03 5.828D-03 5.255D-03 4.789D-03 4.402D-03 2.036D-03
1.096D-03 7.554D-04 5.779D-04
*           SPUTTERING COEFFICIENT  FOR  MO  + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 2.313D-03 3.797D-03
5.201D-03 6.543D-03 7.836D-03 1.776D-02 2.496D-02 3.039D-02 3.458D-02
3.786D-02 4.047D-02 4.255D-02 4.423D-02 4.558D-02 5.015D-02 4.905D-02
4.674D-02 4.426D-02 4.188D-02 3.969D-02 3.770D-02 3.590D-02 3.426D-02
3.141D-02 2.903D-02 2.700D-02 2.526D-02 2.374D-02 1.838D-02 1.509D-02
1.285D-02 1.122D-02 9.973D-03 8.986D-03 8.186D-03 7.521D-03 3.469D-03
1.865D-03 1.285D-03 9.824D-04
*           SPUTTERING COEFFICIENT  FOR  W   + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 2.990D-05
6.802D-05 9.872D-05 1.239D-04 1.448D-04 1.624D-04 2.449D-04 2.634D-04
2.635D-04 2.573D-04 2.488D-04 2.397D-04 2.306D-04 2.218D-04 2.135D-04
1.985D-04 1.853D-04 1.738D-04 1.637D-04 1.548D-04 1.221D-04 1.014D-04
8.697D-05 7.634D-05 6.814D-05 6.161D-05 5.628D-05 5.184D-05 2.429D-05
1.317D-05 9.101D-06 6.974D-06
*           SPUTTERING COEFFICIENT  FOR  W   + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.910D-04 3.323D-04 4.452D-04
5.378D-04 6.149D-04 6.799D-04 7.351D-04 7.823D-04 1.015D-03 1.068D-03
1.064D-03 1.040D-03 1.007D-03 9.727D-04 9.382D-04 9.049D-04 8.733D-04
8.153D-04 7.642D-04 7.192D-04 6.794D-04 6.440D-04 5.132D-04 4.289D-04
3.698D-04 3.258D-04 2.917D-04 2.643D-04 2.420D-04 2.232D-04 1.060D-04
5.783D-05 4.009D-05 3.078D-05
*           SPUTTERING COEFFICIENT  FOR  W   + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 4.052D-03 7.412D-03 9.809D-03 1.208D-02
1.407D-02 1.581D-02 1.735D-02 1.872D-02 1.994D-02 2.710D-02 2.980D-02
3.072D-02 3.084D-02 3.054D-02 3.004D-02 2.943D-02 2.876D-02 2.808D-02
2.674D-02 2.547D-02 2.429D-02 2.321D-02 2.222D-02 1.834D-02 1.567D-02
1.372D-02 1.223D-02 1.105D-02 1.010D-02 9.300D-03 8.628D-03 4.256D-03
2.370D-03 1.658D-03 1.280D-03
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*           SPUTTERING COEFFICIENT  FOR  AU  + H+
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1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 4.483D-04 2.030D-03 3.142D-03 4.169D-03
5.056D-03 5.831D-03 6.513D-03 7.117D-03 7.655D-03 1.081D-02 1.291D-02
1.245D-02 1.253D-02 1.243D-02 1.224D-02 1.200D-02 1.174D-02 1.147D-02
1.093D-02 1.041D-02 9.934D-03 9.493D-03 9.089D-03 7.505D-03 6.413D-03
5.616D-03 5.006D-03 4.524D-03 4.132D-03 3.806D-03 3.531D-03 1.741D-03
9.694D-04 6.782D-04 5.235D-04
*           SPUTTERING COEFFICIENT  FOR  AU  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 6.266D-03 1.099D-02 1.376D-02 1.666D-02
1.913D-02 2.126D-02 2.310D-02 2.472D-02 2.613D-02 3.377D-02 3.606D-02
3.644D-02 3.603D-02 3.526D-02 3.434D-02 3.337D-02 3.239D-02 3.143D-02
2.962D-02 2.799D-02 2.651D-02 2.519D-02 2.399D-02 1.945D-02 1.644D-02
1.428D-02 1.266D-02 1.139D-02 1.036D-02 9.514D-03 8.803D-03 4.260D-03
2.349D-03 1.636D-03 1.260D-03
*           SPUTTERING COEFFICIENT  FOR  AU  + T+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
2.539D-03 3.726D-03 4.866D-03 1.480D-02 2.206D-02 2.828D-02 3.349D-02
3.791D-02 4.168D-02 4.493D-02 4.774D-02 5.018D-02 6.287D-02 6.614D-02
6.621D-02 6.502D-02 6.330D-02 6.139D-02 5.944D-02 5.753D-02 5.569D-02
5.227D-02 4.921D-02 4.649D-02 4.407D-02 4.189D-02 3.374D-02 2.839D-02
2.459D-02 2.175D-02 1.952D-02 1.774D-02 1.627D-02 1.504D-02 7.226D-03
3.970D-03 2.760D-03 2.123D-03
*           SPUTTERING COEFFICIENT  FOR  AU  + T+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
4.255D-03 6.232D-03 8.133D-03 2.475D-02 3.942D-02 4.832D-02 5.755D-02
6.548D-02 7.234D-02 7.830D-02 8.352D-02 8.810D-02 1.132D-01 1.209D-01
1.223D-01 1.210D-01 1.185D-01 1.155D-01 1.124D-01 1.091D-01 1.060D-01
1.000D-01 9.456D-02 8.965D-02 8.522D-02 8.123D-02 6.601D-02 5.586D-02
4.859D-02 4.310D-02 3.879D-02 3.531D-02 3.244D-02 3.002D-02 1.457D-02
8.045D-03 5.607D-03 4.318D-03
*           SPUTTERING COEFFICIENT  FOR  AU  + 4HE+
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1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 5.598D-03 9.515D-03
1.324D-02 1.681D-02 2.025D-02 5.080D-02 7.092D-02 8.859D-02 1.037D-01
1.149D-01 1.249D-01 1.332D-01 1.403D-01 1.463D-01 1.742D-01 1.781D-01
1.750D-01 1.694D-01 1.631D-01 1.568D-01 1.507D-01 1.449D-01 1.395D-01
1.297D-01 1.213D-01 1.139D-01 1.074D-01 1.016D-01 8.057D-02 6.715D-02
5.778D-02 5.083D-02 4.546D-02 4.117D-02 3.766D-02 3.472D-02 1.642D-02
8.943D-03 6.194D-03 4.753D-03
*           SPUTTERING COEFFICIENT  FOR  U   + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.000D-50 9.503D-06 2.550D-05 4.019D-05
5.397D-05 6.710D-05 7.971D-05 9.194D-05 1.039D-04 1.884D-04 2.484D-04
2.914D-04 3.230D-04 3.467D-04 3.646D-04 3.783D-04 3.886D-04 3.964D-04
4.065D-04 4.114D-04 4.130D-04 4.123D-04 4.100D-04 3.883D-04 3.624D-04
3.380D-04 3.162D-04 2.970D-04 2.799D-04 2.648D-04 2.513D-04 1.458D-04
8.861D-05 6.452D-05 5.102D-05
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*           SPUTTERING COEFFICIENT  FOR  U   + 4HE+
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1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
7.617D-05 1.261D-04 1.748D-04 6.246D-04 1.042D-03 1.440D-03 1.822D-03
2.190D-03 2.546D-03 2.891D-03 3.227D-03 3.556D-03 6.107D-03 7.989D-03
9.402D-03 1.049D-02 1.133D-02 1.199D-02 1.252D-02 1.294D-02 1.327D-02
1.374D-02 1.403D-02 1.419D-02 1.426D-02 1.427D-02 1.383D-02 1.312D-02
1.238D-02 1.169D-02 1.105D-02 1.048D-02 9.970D-03 9.505D-03 5.702D-03
3.530D-03 2.592D-03 2.061D-03
*           SPUTTERING COEFFICIENT  FOR  AL  + H+
*
1.000D-50 1.000D-50 1.000D-50 3.268D-03 8.842D-03 1.318D-02 1.665D-02
1.946D-02 2.177D-02 2.369D-02 3.217D-02 3.350D-02 3.295D-02 3.181D-02
3.051D-02 2.920D-02 2.795D-02 2.678D-02 2.568D-02 1.825D-02 1.428D-02
1.179D-02 1.008D-02 8.823D-03 7.859D-03 7.094D-03 6.471D-03 5.953D-03
5.139D-03 4.528D-03 4.051D-03 3.669D-03 3.354D-03 2.359D-03 1.826D-03
1.493D-03 1.265D-03 1.098D-03 9.704D-04 8.699D-04 7.885D-04 3.311D-04
1.697D-04 1.144D-04 8.633D-05
*           SPUTTERING COEFFICIENT  FOR  AL  + D+
*
1.000D-50 1.000D-50 1.866D-02 3.256D-02 4.331D-02 5.186D-02 5.879D-02
6.448D-02 6.919D-02 7.312D-02 9.033D-02 9.229D-02 9.016D-02 8.680D-02
8.314D-02 7.954D-02 7.612D-02 7.293D-02 6.997D-02 4.989D-02 3.911D-02
3.236D-02 2.770D-02 2.428D-02 2.164D-02 1.955D-02 1.784D-02 1.642D-02
1.419D-02 1.251D-02 1.120D-02 1.015D-02 9.282D-03 6.537D-03 5.066D-03
4.145D-03 3.513D-03 3.050D-03 2.697D-03 2.418D-03 2.192D-03 9.220D-04
4.728D-04 3.188D-04 2.407D-04
*           SPUTTERING COEFFICIENT  FOR  AL  + T+
*
1.000D-50 2.711D-02 6.786D-02 1.023D-01 1.292D-01 1.507D-01 1.683D-01
1.827D-01 1.947D-01 2.047D-01 2.483D-01 2.528D-01 2.466D-01 2.373D-01
2.273D-01 2.174D-01 2.081D-01 1.994D-01 1.913D-01 1.365D-01 1.071D-01
8.868D-02 7.594D-02 6.657D-02 5.936D-02 5.363D-02 4.896D-02 4.507D-02
3.896D-02 3.436D-02 3.076D-02 2.787D-02 2.550D-02 1.796D-02 1.393D-02
1.140D-02 9.658D-03 8.387D-03 7.416D-03 6.650D-03 6.030D-03 2.537D-03
1.301D-03 8.774D-04 6.625D-04
*           SPUTTERING COEFFICIENT  FOR  AL  + 4HE+
*
1.000D-50 8.923D-02 1.936D-01 2.824D-01 3.520D-01 4.078D-01 4.533D-01
4.908D-01 5.220D-01 5.480D-01 6.614D-01 6.724D-01 6.558D-01 6.369D-01
6.042D-01 5.780D-01 5.532D-01 5.301D-01 5.086D-01 3.632D-01 2.850D-01
2.360D-01 2.021D-01 1.772D-01 1.580D-01 1.428D-01 1.303D-01 1.200D-01
1.037D-01 9.148D-02 8.192D-02 7.422D-02 6.790D-02 4.784D-02 3.709D-02
3.036D-02 2.573D-02 2.234D-02 1.976D-02 1.772D-02 1.606D-02 6.759D-03
3.467D-03 2.338D-03 1.766D-03
*           SPUTTERING COEFFICIENT  FOR  SI  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 6.676D-05 1.224D-04 1.683D-04
2.068D-04 2.395D-04 2.676D-04 4.108D-04 4.517D-04 4.599D-04 4.551D-04
4.448D-04 4.323D-04 4.190D-04 4.057D-04 3.927D-04 2.942D-04 2.359D-04
1.978D-04 1.710D-04 1.509D-04 1.352D-04 1.227D-04 1.124D-04 1.038D-04
9.013D-05 7.979D-05 7.166D-05 6.509D-05 5.967D-05 4.235D-05 3.297D-05
2.706D-05 2.299D-05 2.000D-05 1.771D-05 1.590D-05 1.443D-05 6.110D-06
3.145D-06 2.124D-06 1.605D-06
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*           SPUTTERING COEFFICIENT  FOR  SI  + D+
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1.000D-50 1.000D-50 1.430D-04 3.095D-04 4.435D-04 5.542D-04 6.472D-04
7.263D-04 7.942D-04 8.529D-04 1.156D-03 1.240D-03 1.251D-03 1.232D-03
1.202D-03 1.166D-03 1.130D-03 1.094D-03 1.059D-03 7.946D-04 6.385D-04
5.364D-04 4.641D-04 4.099D-04 3.678D-04 3.339D-04 3.061D-04 2.827D-04
2.458D-04 2.177D-04 1.956D-04 1.778D-04 1.631D-04 1.159D-04 9.032D-05
7.418D-05 6.303D-05 5.485D-05 4.859D-05 4.363D-05 3.961D-05 1.680D-05
8.653D-06 5.846D-06 4.419D-06
*           SPUTTERING COEFFICIENT  FOR  SI  + T+
*
1.000D-50 1.000D-50 6.166D-04 1.028D-03 1.363D-03 1.642D-03 1.878D-03
2.079D-03 2.253D-03 2.402D-03 3.180D-03 3.392D-03 3.414D-03 3.361D-03
3.276D-03 3.179D-03 3.080D-03 2.981D-03 2.885D-03 2.167D-03 1.743D-03
1.465D-03 1.268D-03 1.120D-03 1.005D-03 9.128D-04 8.368D-04 7.732D-04
6.722D-04 5.956D-04 5.353D-04 4.866D-04 4.463D-04 3.173D-04 2.474D-04
2.032D-04 1.727D-04 1.503D-04 1.331D-04 1.196D-04 1.085D-04 4.606D-05
2.373D-05 1.603D-05 1.212D-05
*           SPUTTERING COEFFICIENT  FOR  SI  + 4HE+
*
1.000D-50 5.217D-04 1.826D-03 2.885D-03 3.750D-03 4.473D-03 5.084D-03
5.606D-03 6.056D-03 6.446D-03 8.471D-03 9.018D-03 9.071D-03 8.927D-03
8.702D-03 8.444D-03 8.179D-03 7.917D-03 7.664D-03 5.758D-03 4.631D-03
3.893D-03 3.369D-03 2.978D-03 2.672D-03 2.427D-03 2.225D-03 2.056D-03
1.788D-03 1.584D-03 1.424D-03 1.294D-03 1.187D-03 8.441D-04 6.581D-04
5.406D-04 4.595D-04 3.999D-04 3.543D-04 3.182D-04 2.888D-04 1.226D-04
6.316D-05 4.267D-05 3.226D-05
*           SPUTTERING COEFFICIENT  FOR  SC  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 9.178D-05 2.482D-04 3.966D-04
4.727D-04 5.795D-04 6.778D-04 1.359D-03 1.736D-03 1.962D-03 2.102D-03
2.189D-03 2.241D-03 2.269D-03 2.282D-03 2.283D-03 2.084D-03 1.843D-03
1.645D-03 1.485D-03 1.355D-03 1.247D-03 1.156D-03 1.079D-03 1.011D-03
9.009D-04 8.135D-04 7.426D-04 6.837D-04 6.340D-04 4.682D-04 3.735D-04
3.117D-04 2.680D-04 2.354D-04 2.101D-04 1.899D-04 1.733D-04 7.624D-05
4.001D-05 2.725D-05 2.071D-05
*           SPUTTERING COEFFICIENT  FOR  SC  + D+
*
1.000D-50 1.000D-50 2.378D-04 6.446D-04 1.014D-03 1.362D-03 1.699D-03
1.867D-03 2.115D-03 2.344D-03 3.980D-03 4.905D-03 5.461D-03 5.805D-03
6.017D-03 6.141D-03 6.208D-03 6.234D-03 6.232D-03 5.672D-03 5.020D-03
4.483D-03 4.050D-03 3.697D-03 3.404D-03 3.157D-03 2.946D-03 2.764D-03
2.463D-03 2.225D-03 2.032D-03 1.871D-03 1.736D-03 1.283D-03 1.024D-03
8.553D-04 7.357D-04 6.464D-04 5.771D-04 5.216D-04 4.761D-04 2.697D-04
1.101D-04 7.504D-05 5.702D-05
*           SPUTTERING COEFFICIENT  FOR  SC  + T+
*
1.000D-50 1.000D-50 1.340D-03 2.365D-03 3.310D-03 4.208D-03 5.086D-03
5.521D-03 6.168D-03 6.771D-03 1.109D-02 1.354D-02 1.501D-02 1.593D-02
1.648D-02 1.681D-02 1.699D-02 1.705D-02 1.704D-02 1.550D-02 1.372D-02
1.225D-02 1.107D-02 1.011D-02 9.310D-03 8.636D-03 8.060D-03 7.561D-03
6.740D-03 6.090D-03 5.562D-03 5.123D-03 4.753D-03 3.515D-03 2.806D-03
2.343D-03 2.016D-03 1.771D-03 1.582D-03 1.429D-03 1.305D-03 5.750D-04
3.020D-04 2.058D-04 1.564D-04
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(Continued)

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*           SPUTTERING COEFFICIENT  FOR  SC   + 4HE+
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1.000D-50 1.361D-03 4.313D-03 6.945D-03 9.389D-03 1.172D-02 1.401D-02
1.514D-02 1.683D-02 1.840D-02 2.970D-02 3.612D-02 4.000D-02 4.239D-02
4.385D-02 4.471D-02 4.516D-02 4.533D-02 4.529D-02 4.119D-02 3.646D-02
3.257D-02 2.943D-02 2.687D-02 2.475D-02 2.296D-02 2.143D-02 2.010D-02
1.792D-02 1.619D-02 1.479D-02 1.362D-02 1.264D-02 9.348D-03 7.464D-03
6.234D-03 5.364D-03 4.713D-03 4.208D-03 3.803D-03 3.472D-03 1.530D-03
8.038D-04 5.478D-04 4.163D-04
*           SPUTTERING COEFFICIENT  FOR  V    + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 4.292D-04
9.777D-04 1.256D-03 1.658D-03 4.472D-03 6.087D-03 7.100D-03 7.761D-03
8.199D-03 8.489D-03 8.677D-03 8.792D-03 8.855D-03 8.381D-03 7.544D-03
6.805D-03 6.191D-03 5.680D-03 5.251D-03 4.886D-03 4.572D-03 4.299D-03
3.845D-03 3.484D-03 3.189D-03 2.943D-03 2.734D-03 2.033D-03 1.628D-03
1.363D-03 1.174D-03 1.033D-03 9.231D-04 8.351D-04 7.628D-04 3.378D-04
1.779D-04 1.213D-04 9.226D-05
*           SPUTTERING COEFFICIENT  FOR  V    + D+
*
1.000D-50 1.000D-50 1.000D-50 9.016D-04 2.319D-03 3.626D-03 4.866D-03
6.070D-03 6.651D-03 7.549D-03 1.409D-02 1.797D-02 2.044D-02 2.205D-02
2.312D-02 2.381D-02 2.426D-02 2.452D-02 2.465D-02 2.321D-02 2.089D-02
1.885D-02 1.716D-02 1.576D-02 1.458D-02 1.357D-02 1.270D-02 1.195D-02
1.070D-02 9.696D-03 8.879D-03 8.197D-03 7.619D-03 5.672D-03 4.547D-03
3.808D-03 3.283D-03 2.889D-03 2.583D-03 2.337D-03 2.135D-03 9.470D-04
4.991D-04 3.406D-04 2.590D-04
*           SPUTTERING COEFFICIENT  FOR  V    + T+
*
1.000D-50 1.000D-50 2.030D-03 5.926D-03 9.460D-03 1.277D-02 1.593D-02
1.903D-02 2.212D-02 2.284D-02 3.995D-02 5.020D-02 5.672D-02 6.099D-02
6.381D-02 6.565D-02 6.681D-02 6.749D-02 6.782D-02 6.377D-02 5.739D-02
5.181D-02 4.718D-02 4.332D-02 4.008D-02 3.732D-02 3.494D-02 3.287D-02
2.943D-02 2.668D-02 2.444D-02 2.257D-02 2.098D-02 1.562D-02 1.253D-02
1.049D-02 9.048D-03 7.964D-03 7.120D-03 6.443D-03 5.888D-03 2.612D-03
1.377D-03 9.399D-04 7.149D-04
*           SPUTTERING COEFFICIENT  FOR  V    + 4HE+
*
1.000D-50 1.000D-50 9.728D-03 1.958D-02 2.862D-02 3.712D-02 4.530D-02
5.333D-02 6.134D-02 6.319D-02 1.078D-01 1.347D-01 1.517D-01 1.629D-01
1.703D-01 1.751D-01 1.781D-01 1.799D-01 1.808D-01 1.699D-01 1.529D-01
1.380D-01 1.257D-01 1.154D-01 1.068D-01 9.945D-02 9.312D-02 8.760D-02
7.844D-02 7.113D-02 6.516D-02 6.017D-02 5.593D-02 4.167D-02 3.341D-02
2.799D-02 2.414D-02 2.125D-02 1.900D-02 1.719D-02 1.571D-02 6.972D-03
3.675D-03 2.509D-03 1.908D-03
*           SPUTTERING COEFFICIENT  FOR  CR   + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
3.330D-04 5.306D-04 7.821D-04 2.549D-03 3.579D-03 4.236D-03 4.673D-03
4.970D-03 5.172D-03 5.308D-03 5.397D-03 5.451D-03 5.245D-03 4.759D-03
4.314D-03 3.938D-03 3.623D-03 3.356D-03 3.128D-03 2.931D-03 2.759D-03
2.473D-03 2.244D-03 2.057D-03 1.900D-03 1.767D-03 1.318D-03 1.057D-03
8.862D-04 7.644D-04 6.730D-04 6.018D-04 5.447D-04 4.978D-04 2.211D-04
1.166D-04 7.959D-05 6.054D-05
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(Continued)

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*          SPUTTERING COEFFICIENT  FOR  CR  + C+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.007D-03 1.781D-03 2.509D-03
3.210D-03 3.899D-03 4.146D-03 8.100D-03 1.050D-02 1.205D-02 1.308D-02
1.378D-02 1.426D-02 1.457D-02 1.477D-02 1.489D-02 1.423D-02 1.291D-02
1.171D-02 1.069D-02 9.844D-03 9.125D-03 8.510D-03 7.978D-03 7.513D-03
6.738D-03 6.119D-03 5.611D-03 5.186D-03 4.824D-03 3.603D-03 2.994D-03
2.427D-03 2.094D-03 1.845D-03 1.650D-03 1.494D-03 1.366D-03 6.075D-04
3.207D-04 2.190D-04 1.666D-04
*          SPUTTERING COEFFICIENT  FOR  CR  + T+
*
1.000D-50 1.000D-50 1.000D-50 2.746D-03 4.816D-03 6.741D-03 8.573D-03
1.035D-02 1.211D-02 1.273D-02 2.296D-02 2.921D-02 3.328D-02 3.599D-02
3.783D-02 3.908D-02 3.990D-02 4.042D-02 4.071D-02 3.885D-02 3.523D-02
3.196D-02 2.920D-02 2.689D-02 2.493D-02 2.325D-02 2.180D-02 2.053D-02
1.842D-02 1.673D-02 1.534D-02 1.418D-02 1.320D-02 9.860D-03 7.922D-03
6.645D-03 5.735D-03 5.052D-03 4.520D-03 4.092D-03 3.741D-03 1.665D-03
8.792D-04 6.005D-04 4.570D-04
*          SPUTTERING COEFFICIENT  FOR  CR  + 4HE+
*
1.000D-50 1.000D-50 4.067D-03 9.820D-03 1.506D-02 1.998D-02 2.468D-02
2.926D-02 3.379D-02 3.538D-02 6.193D-02 7.823D-02 8.883D-02 9.592D-02
1.007D-01 1.040D-01 1.061D-01 1.074D-01 1.082D-01 1.032D-01 9.356D-02
8.488D-02 7.756D-02 7.142D-02 6.622D-02 6.177D-02 5.792D-02 5.455D-02
4.895D-02 4.446D-02 4.078D-02 3.770D-02 3.508D-02 2.622D-02 2.107D-02
1.767D-02 1.525D-02 1.344D-02 1.202D-02 1.089D-02 9.952D-03 4.431D-03
2.340D-03 1.598D-03 1.216D-03
*          SPUTTERING COEFFICIENT  FOR  ZN  + H+
*
1.000D-50 1.000D-50 1.261D-03 2.478D-03 3.604D-03 4.666D-03 5.681D-03
6.660D-03 7.611D-03 8.545D-03 1.496D-02 1.947D-02 2.267D-02 2.500D-02
2.672D-02 2.800D-02 2.896D-02 2.968D-02 3.020D-02 3.082D-02 2.898D-02
2.692D-02 2.503D-02 2.335D-02 2.189D-02 2.060D-02 1.946D-02 1.844D-02
1.672D-02 1.532D-02 1.415D-02 1.315D-02 1.230D-02 9.350D-03 7.593D-03
6.416D-03 5.568D-03 4.927D-03 4.423D-03 4.017D-03 3.681D-03 1.667D-03
8.882D-04 6.091D-04 4.646D-04
*          SPUTTERING COEFFICIENT  FOR  ZN  + D+
*
1.000D-50 3.238D-03 6.516D-03 9.561D-03 1.244D-02 1.520D-02 1.785D-02
2.041D-02 2.292D-02 2.539D-02 4.240D-02 5.444D-02 6.299D-02 6.920D-02
7.380D-02 7.723D-02 7.980D-02 8.171D-02 8.312D-02 8.463D-02 7.957D-02
7.393D-02 6.874D-02 6.414D-02 6.012D-02 5.658D-02 5.346D-02 5.068D-02
4.596D-02 4.210D-02 3.889D-02 3.616D-02 3.382D-02 2.572D-02 2.089D-02
1.766D-02 1.533D-02 1.356D-02 1.218D-02 1.106D-02 1.013D-02 4.592D-03
2.447D-03 1.678D-03 1.280D-03
*          SPUTTERING COEFFICIENT  FOR  ZN  + T+
*
1.973D-03 1.158D-02 2.026D-02 2.842D-02 3.617D-02 4.360D-02 5.077D-02
5.772D-02 6.451D-02 7.118D-02 1.173D-01 1.500D-01 1.732D-01 1.901D-01
2.026D-01 2.119D-01 2.189D-01 2.241D-01 2.279D-01 2.319D-01 2.180D-01
2.026D-01 1.884D-01 1.758D-01 1.648D-01 1.551D-01 1.465D-01 1.389D-01
1.260D-01 1.154D-01 1.066D-01 9.913D-02 9.271D-02 7.052D-02 5.728D-02
4.842D-02 4.203D-02 3.719D-02 3.339D-02 3.033D-02 2.780D-02 1.260D-02
6.713D-03 4.604D-03 3.512D-03
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            SPUTTERING COEFFICIENT  FOR  ZN  + 4HE+
*
9.163D-03 3.400D-02 5.677D-02 7.827D-02 9.876D-02 1.184D-01 1.373D-01
1.557D-01 1.737D-01 1.914D-01 3.135D-01 4.002D-01 4.617D-01 5.064D-01
5.395D-01 5.642D-01 5.827D-01 5.965D-01 6.066D-01 6.171D-01 5.801D-01
5.390D-01 5.011D-01 4.677D-01 4.384D-01 4.126D-01 3.898D-01 3.696D-01
3.352D-01 3.071D-01 2.837D-01 2.638D-01 2.467D-01 1.877D-01 1.525D-01
1.289D-01 1.119D-01 9.899D-02 8.888D-02 8.072D-02 7.398D-02 3.353D-02
1.787D-02 1.226D-02 9.350D-03
*           SPUTTERING COEFFICIENT  FOR  ZR  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 5.635D-04 1.283D-03 1.805D-03 2.200D-03
2.508D-03 2.751D-03 2.945D-03 3.102D-03 3.229D-03 3.695D-03 3.649D-03
3.492D-03 3.313D-03 3.139D-03 2.977D-03 2.828D-03 2.693D-03 2.571D-03
2.357D-03 2.178D-03 2.026D-03 1.895D-03 1.781D-03 1.377D-03 1.130D-03
9.619D-04 8.394D-04 7.458D-04 6.718D-04 6.118D-04 5.620D-04 2.588D-04
1.390D-04 9.570D-05 7.316D-05
*           SPUTTERING COEFFICIENT  FOR  ZR  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 5.790D-04 8.797D-04 3.134D-03 4.732D-03 5.929D-03 6.853D-03
7.578D-03 8.156D-03 8.619D-03 8.993D-03 9.297D-03 1.037D-02 1.120D-02
9.743D-03 9.241D-03 8.756D-03 8.305D-03 7.894D-03 7.521D-03 7.181D-03
6.589D-03 6.092D-03 5.670D-03 5.306D-03 4.989D-03 3.866D-03 3.176D-03
2.706D-03 2.363D-03 2.101D-03 1.893D-03 1.725D-03 1.585D-03 7.315D-04
3.935D-04 2.711D-04 2.073D-04
*           SPUTTERING COEFFICIENT  FOR  ZR  + T+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 8.682D-04 1.724D-03
2.531D-03 3.300D-03 4.038D-03 9.724D-03 1.385D-02 1.697D-02 1.939D-02
2.129D-02 2.281D-02 2.403D-02 2.501D-02 2.581D-02 2.861D-02 2.809D-02
2.683D-02 2.545D-02 2.411D-02 2.287D-02 2.175D-02 2.072D-02 1.979D-02
1.816D-02 1.679D-02 1.563D-02 1.463D-02 1.376D-02 1.067D-02 8.769D-03
7.473D-03 6.527D-03 5.804D-03 5.231D-03 4.766D-03 4.381D-03 2.024D-03
1.089D-03 7.503D-04 5.739D-04
*           SPUTTERING COEFFICIENT  FOR  ZR  + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 2.360D-03 4.628D-03 6.758D-03
8.782D-03 1.072D-02 1.260D-02 2.719D-02 3.790D-02 4.602D-02 5.232D-02
5.728D-02 6.124D-02 6.442D-02 6.699D-02 6.907D-02 7.636D-02 7.490D-02
7.154D-02 6.785D-02 6.429D-02 6.100D-02 5.799D-02 5.526D-02 5.278D-02
4.844D-02 4.480D-02 4.171D-02 3.904D-02 3.672D-02 2.848D-02 2.341D-02
1.995D-02 1.743D-02 1.550D-02 1.397D-02 1.273D-02 1.170D-02 5.408D-03
2.911D-03 2.006D-03 1.534D-03
*           SPUTTERING COEFFICIENT  FOR  RH  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.003D-03 2.331D-03 3.317D-03 4.080D-03
4.685D-03 5.172D-03 5.569D-03 5.895D-03 6.165D-03 7.265D-03 7.296D-03
7.058D-03 6.751D-03 6.436D-03 6.134D-03 5.853D-03 5.594D-03 5.356D-03
4.936D-03 4.579D-03 4.273D-03 4.008D-03 3.776D-03 2.946D-03 2.430D-03
2.076D-03 1.816D-03 1.617D-03 1.459D-03 1.331D-03 1.224D-03 5.685D-04
3.068D-04 2.116D-04 1.620D-04
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*           SPUTTERING COEFFICIENT  FOR  RH  + C+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 9.772D-04 1.496D-03 5.508D-03 8.414D-03 1.064D-02 1.240D-02
1.381D-02 1.495D-02 1.589D-02 1.665D-02 1.729D-02 1.985D-02 1.982D-02
1.915D-02 1.830D-02 1.745D-02 1.663D-02 1.587D-02 1.518D-02 1.453D-02
1.340D-02 1.244D-02 1.162D-02 1.091D-02 1.027D-02 8.028D-03 6.683D-03
5.668D-03 4.963D-03 4.422D-03 3.992D-03 3.642D-03 3.351D-03 1.563D-03
8.429D-04 5.817D-04 4.454D-04
*           SPUTTERING COEFFICIENT  FOR  RH  + T+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.493D-03 2.955D-03
4.337D-03 5.654D-03 6.920D-03 1.827D-02 2.446D-02 3.024D-02 3.482D-02
3.849D-02 4.148D-02 4.392D-02 4.594D-02 4.760D-02 5.427D-02 5.411D-02
5.224D-02 4.993D-02 4.760D-02 4.536D-02 4.332D-02 4.142D-02 3.967D-02
3.659D-02 3.397D-02 3.173D-02 2.978D-02 2.807D-02 2.195D-02 1.813D-02
1.551D-02 1.358D-02 1.210D-02 1.093D-02 9.969D-03 9.173D-03 4.274D-03
2.310D-03 1.595D-03 1.221D-03
*           SPUTTERING COEFFICIENT  FOR  RH  + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 4.140D-03 7.992D-03 1.162D-02
1.507D-02 1.839D-02 2.159D-02 5.477D-02 6.671D-02 8.172D-02 9.361D-02
1.032D-01 1.109D-01 1.173D-01 1.225D-01 1.269D-01 1.442D-01 1.437D-01
1.387D-01 1.326D-01 1.264D-01 1.205D-01 1.150D-01 1.100D-01 1.053D-01
9.717D-02 9.023D-02 8.427D-02 7.910D-02 7.457D-02 5.822D-02 4.819D-02
4.122D-02 3.610D-02 3.217D-02 2.905D-02 2.651D-02 2.439D-02 1.137D-02
6.147D-03 4.244D-03 3.250D-03
*           SPUTTERING COEFFICIENT  FOR  AG  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.759D-03 1.632D-03
2.177D-03 2.699D-03 3.203D-03 7.740D-03 1.036D-02 1.276D-02 1.468D-02
1.623D-02 1.750D-02 1.855D-02 1.941D-02 2.013D-02 2.313D-02 2.318D-02
2.246D-02 2.153D-02 2.057D-02 1.965D-02 1.878D-02 1.798D-02 1.724D-02
1.593D-02 1.482D-02 1.385D-02 1.302D-02 1.228D-02 9.633D-03 7.974D-03
6.829D-03 5.987D-03 5.339D-03 4.824D-03 4.404D-03 4.055D-03 1.895D-03
1.026D-03 7.091D-04 5.433D-04
*           SPUTTERING COEFFICIENT  FOR  AG  + D+
*
1.000D-50 1.000D-50 1.351D-03 2.998D-03 4.537D-03 6.012D-03 7.429D-03
8.768D-03 1.009D-02 1.137D-02 2.319D-02 3.010D-02 3.647D-02 4.157D-02
4.570D-02 4.908D-02 5.187D-02 5.418D-02 5.611D-02 6.407D-02 6.413D-02
6.211D-02 5.953D-02 5.666D-02 5.433D-02 5.194D-02 4.973D-02 4.769D-02
4.408D-02 4.100D-02 3.834D-02 3.603D-02 3.400D-02 2.668D-02 2.200D-02
1.893D-02 1.660D-02 1.480D-02 1.338D-02 1.221D-02 1.125D-02 5.261D-03
2.850D-03 1.969D-03 1.509D-03
*           SPUTTERING COEFFICIENT  FOR  AG  + 4HE+
*
1.000D-50 9.694D-03 2.144D-02 3.248D-02 4.305D-02 5.324D-02 6.311D-02
7.270D-02 8.204D-02 9.115D-02 1.755D-01 2.250D-01 2.708D-01 3.074D-01
3.371D-01 3.614D-01 3.814D-01 3.980D-01 4.119D-01 4.640D-01 4.692D-01
4.543D-01 4.354D-01 4.160D-01 3.974D-01 3.800D-01 3.638D-01 3.489D-01
3.225D-01 3.000D-01 2.806D-01 2.637D-01 2.488D-01 1.953D-01 1.618D-01
1.386D-01 1.216D-01 1.084D-01 9.799D-02 8.948D-02 8.239D-02 3.856D-02
2.089D-02 1.444D-02 1.106D-02
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*           SPUTTERING COEFFICIENT  FOR  TA  + H+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 4.615D-05 1.744D-04
2.788D-04 3.655D-04 4.387D-04 5.012D-04 5.550D-04 8.345D-04 9.171D-04
9.350D-04 9.268D-04 9.073D-04 8.830D-04 8.569D-04 8.306D-04 8.048D-04
7.564D-04 7.126D-04 6.734D-04 6.383D-04 6.067D-04 4.881D-04 4.103D-04
3.550D-04 3.137D-04 2.814D-04 2.555D-04 2.342D-04 2.164D-04 1.036D-04
5.677D-05 3.943D-05 3.030D-05
*           SPUTTERING COEFFICIENT  FOR  TA  + D+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 1.261D-04 5.012D-04 8.051D-04 1.054D-03
1.263D-03 1.440D-03 1.592D-03 1.724D-03 1.838D-03 2.440D-03 2.612D-03
2.637D-03 2.601D-03 2.541D-03 2.470D-03 2.395D-03 2.321D-03 2.249D-03
2.114D-03 1.993D-03 1.884D-03 1.787D-03 1.700D-03 1.371D-03 1.154D-03
1.000D-03 8.849D-04 7.947D-04 7.222D-04 6.625D-04 6.124D-04 2.944D-04
1.618D-04 1.125D-04 8.652D-05
*           SPUTTERING COEFFICIENT  FOR  TA  + 4HE+
*
1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50 1.000D-50
1.000D-50 1.000D-50 1.000D-50 3.432D-03 6.099D-03 7.552D-03 9.133D-03
1.047D-02 1.162D-02 1.261D-02 1.347D-02 1.422D-02 1.819D-02 1.938D-02
1.942D-02 1.913D-02 1.867D-02 1.815D-02 1.760D-02 1.705D-02 1.653D-02
1.554D-02 1.465D-02 1.386D-02 1.315D-02 1.251D-02 1.010D-02 9.515D-03
7.385D-03 6.536D-03 5.873D-03 5.339D-03 4.899D-03 4.530D-03 2.183D-03
1.201D-03 8.354D-04 6.428D-04
```

NOTE: Thomas et al. [1979] pointed out that the experiments reported are actually for BeO and not the metal. The scaling laws calculated therefore apply to Be metal in this figure.

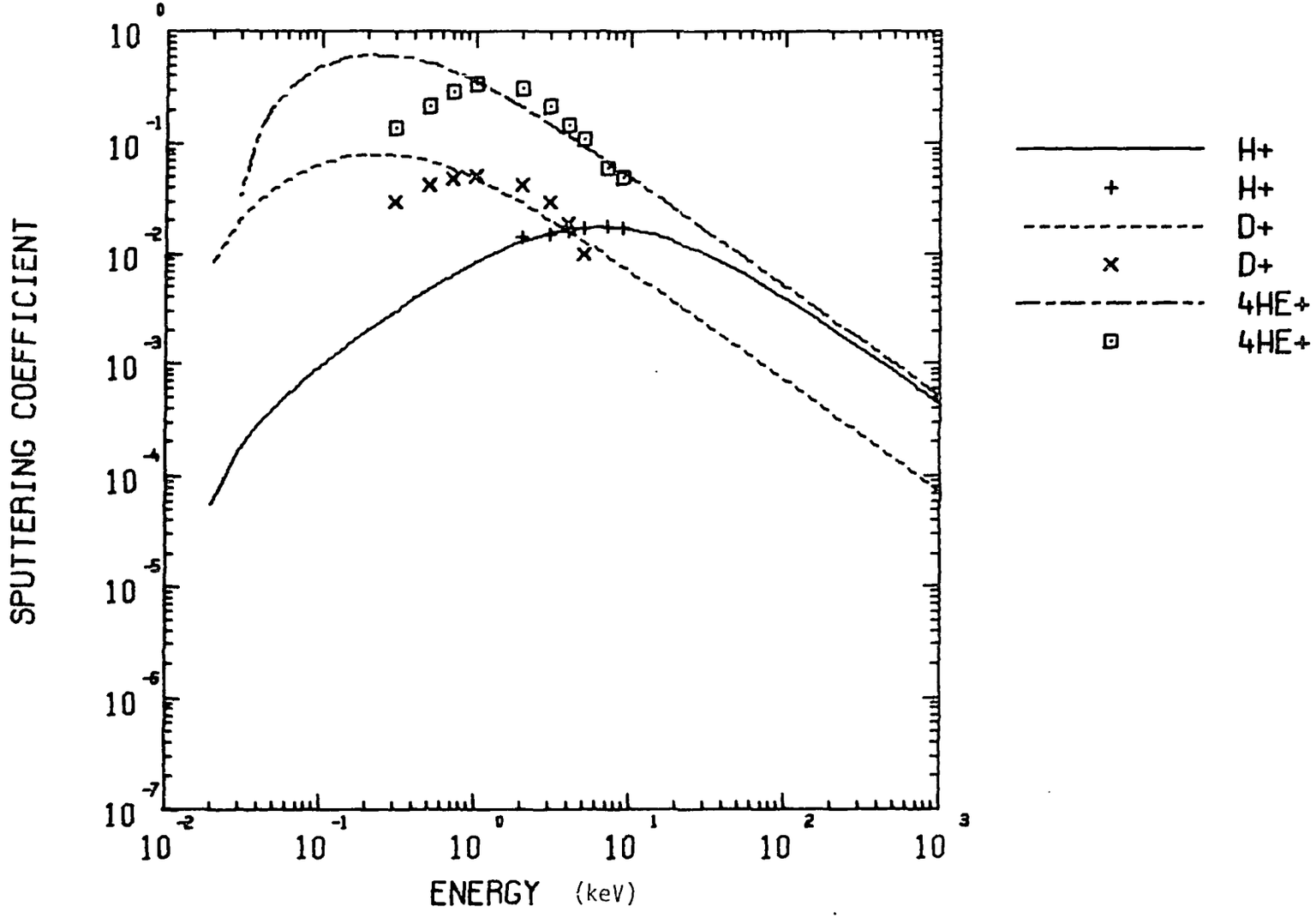

FIGURE 1. SPUTTERING COEFFICIENT FOR Be

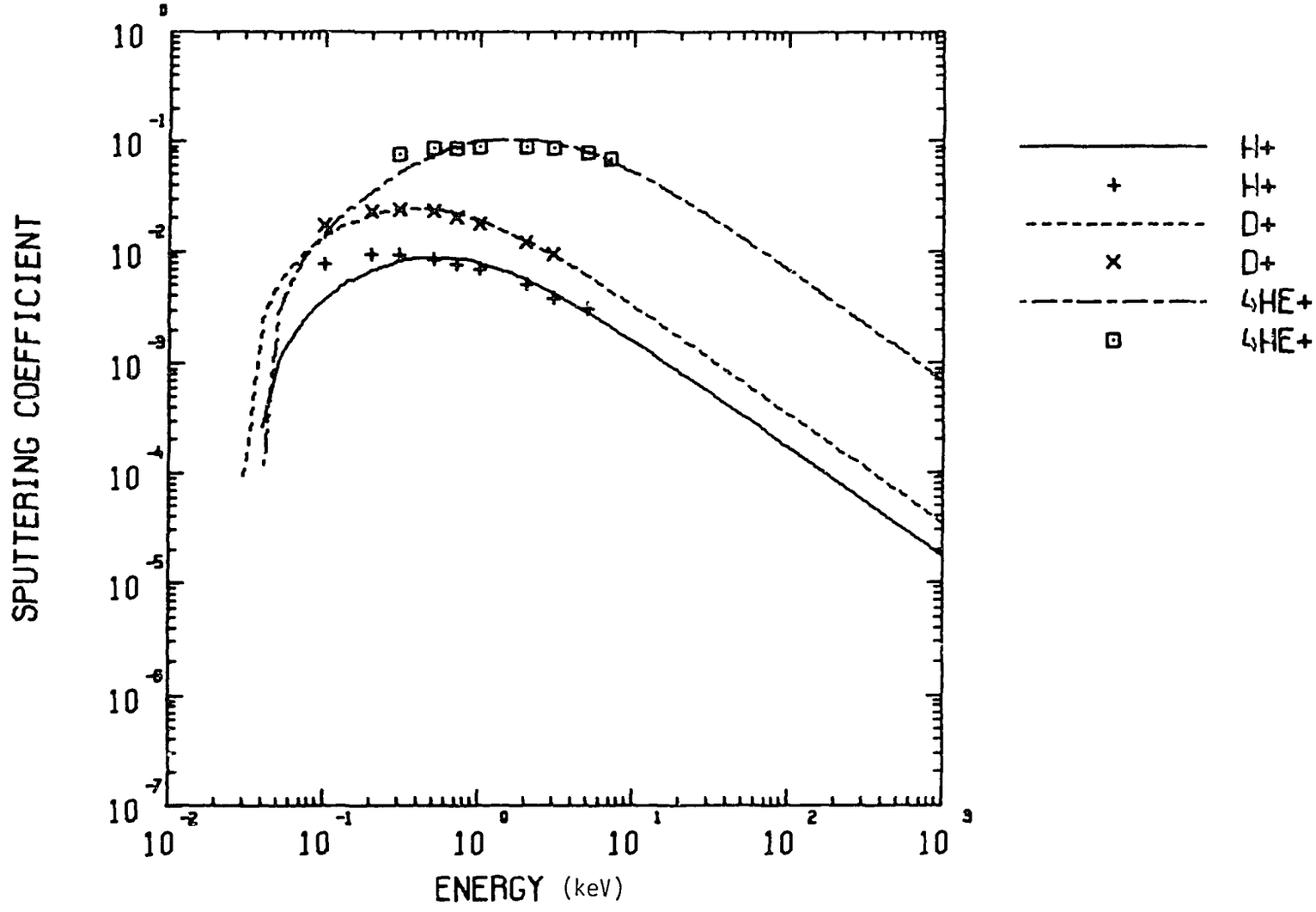

FIGURE 2. SPUTTERING COEFFICIENT FOR C

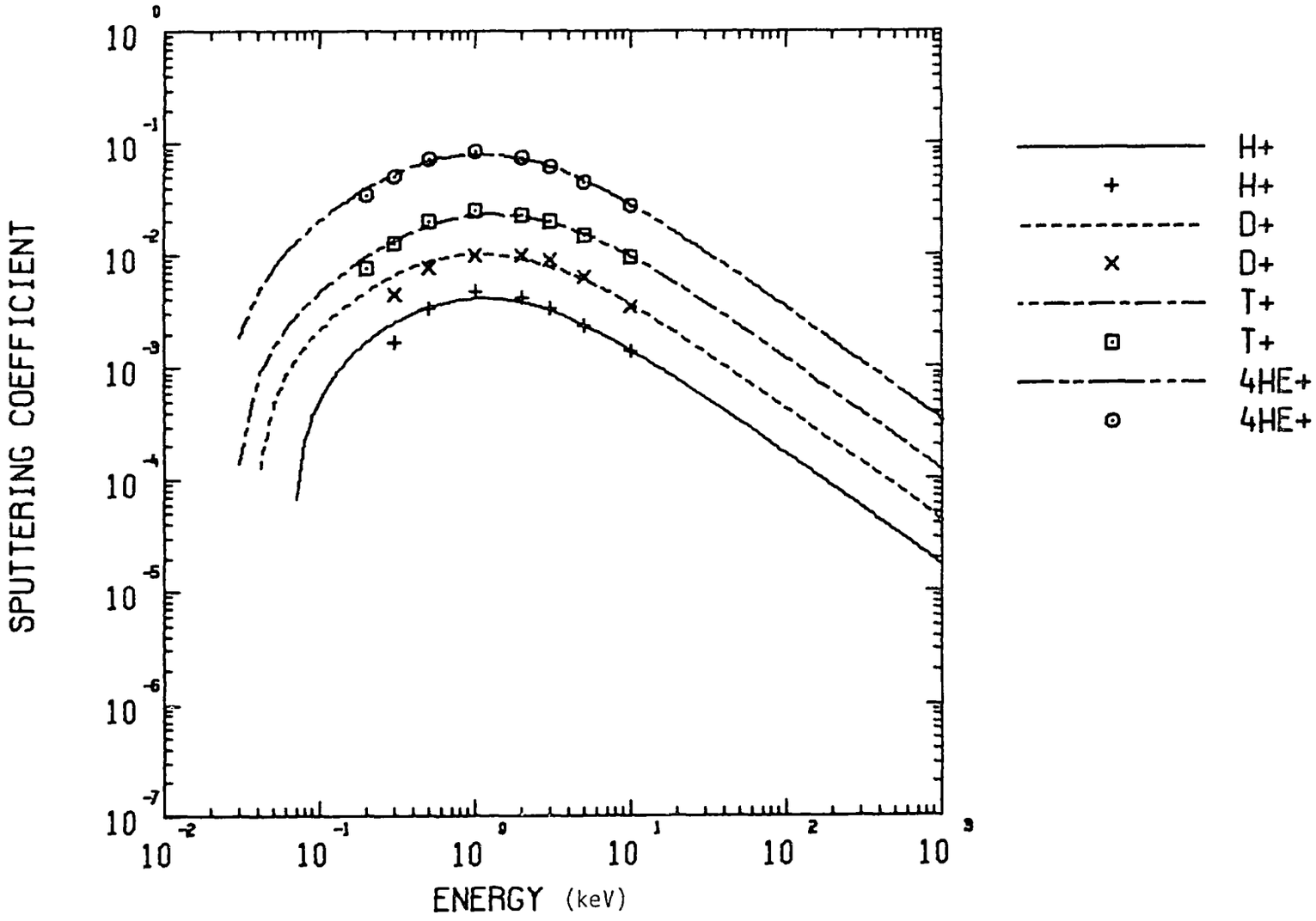

FIGURE 3. SPUTTERING COEFFICIENT FOR Ti

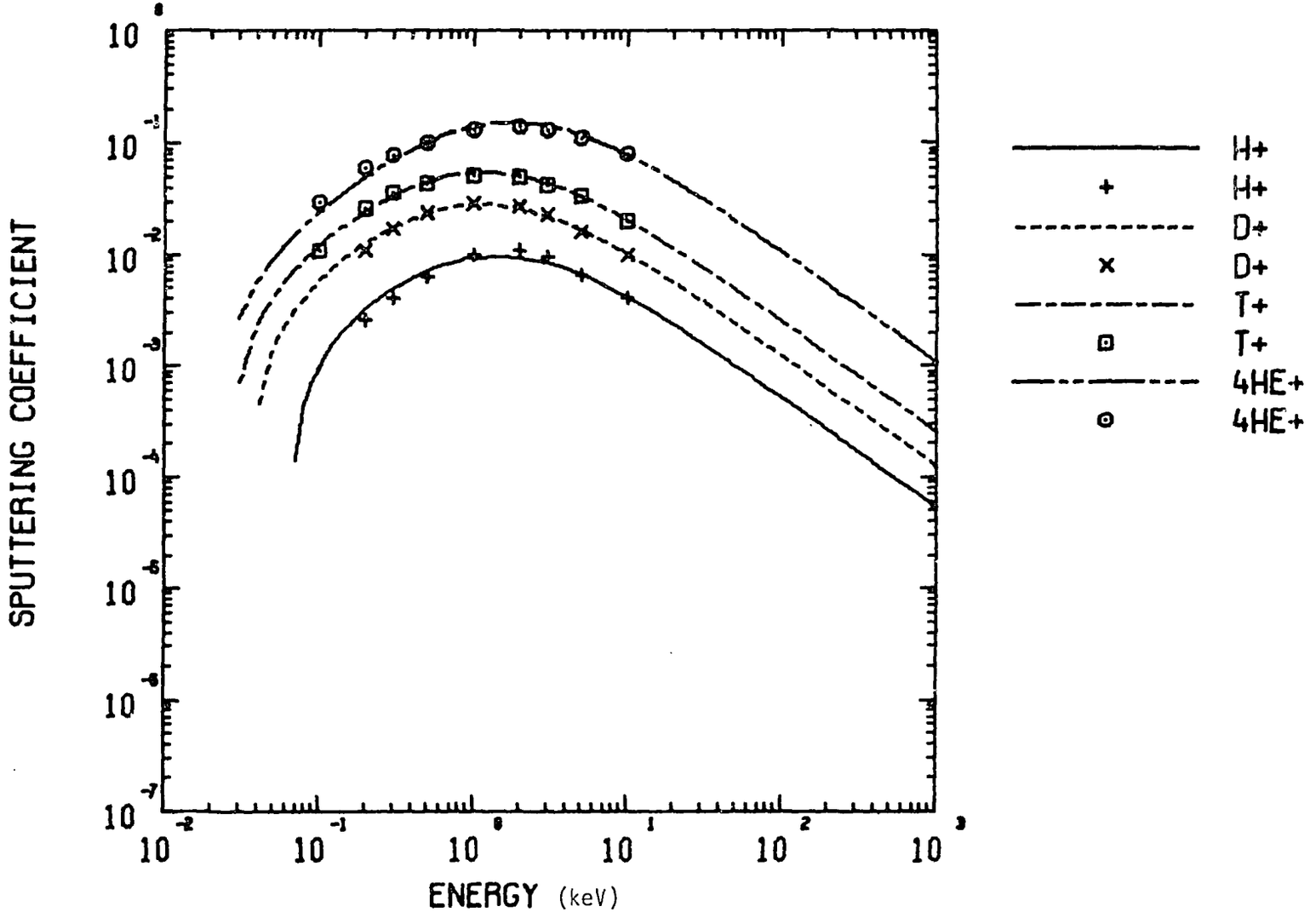

FIGURE 4. SPUTTERING COEFFICIENT FOR Fe

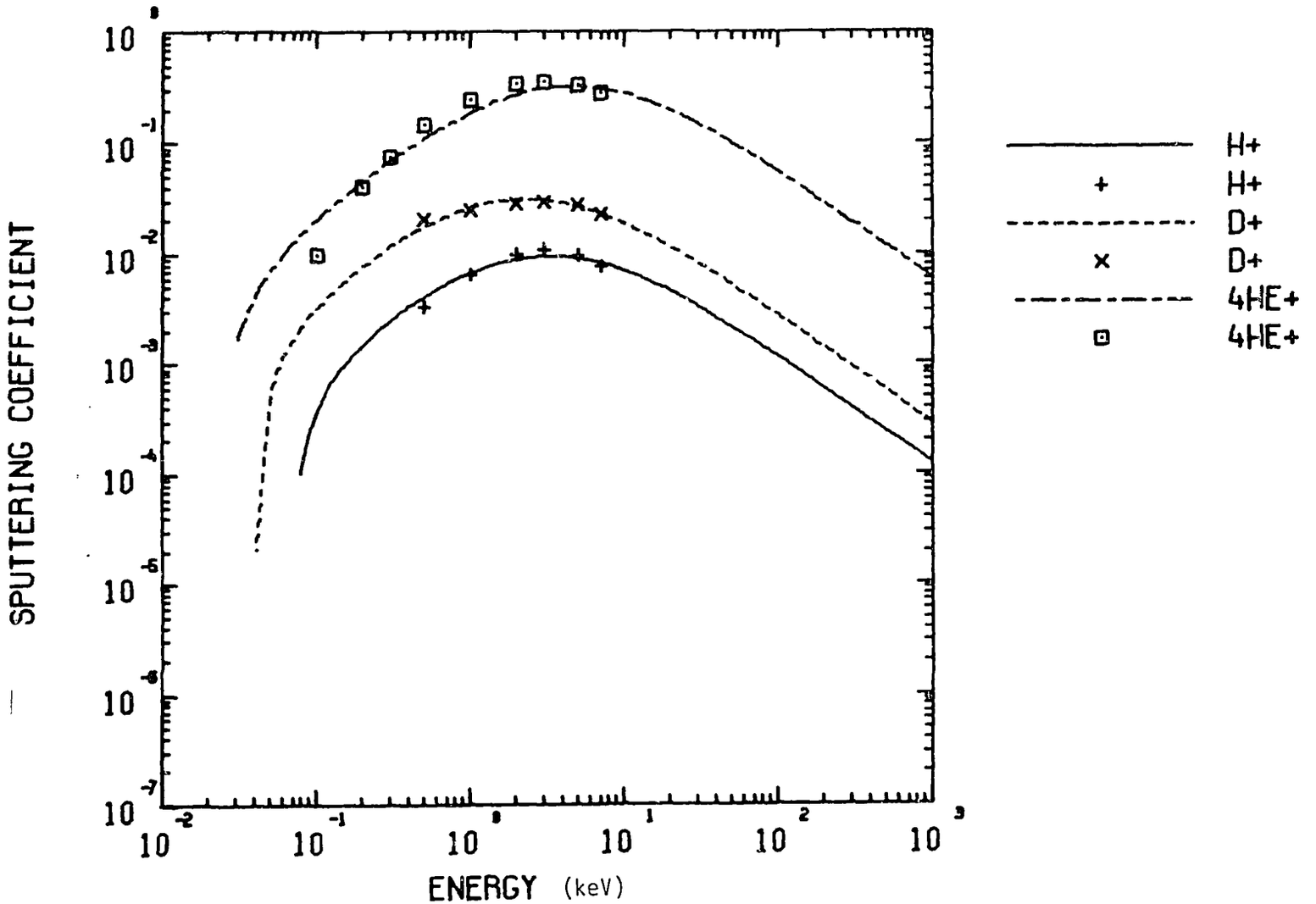

FIGURE 5. SPUTTERING COEFFICIENT FOR Co

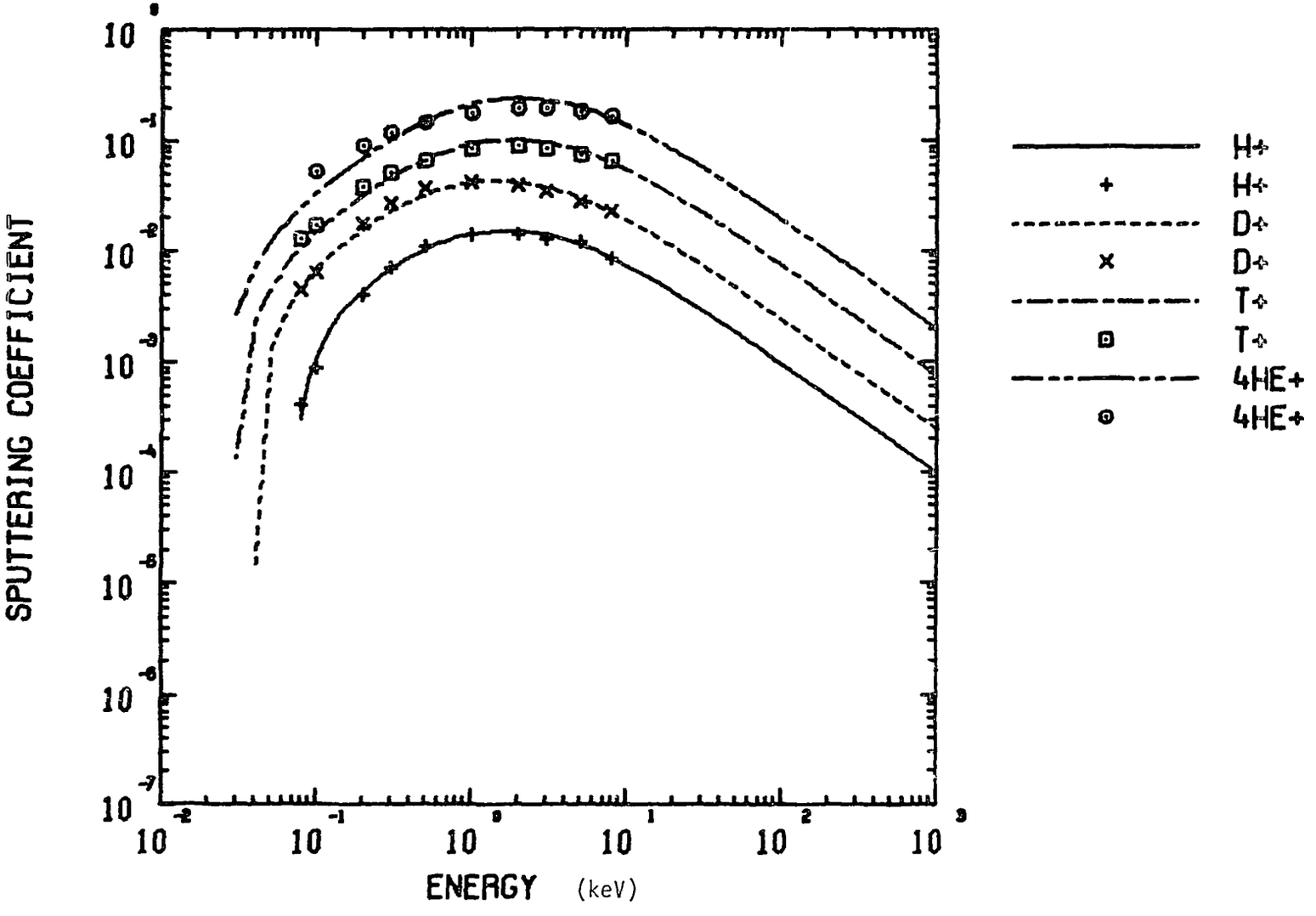

FIGURE 6. SPUTTERING COEFFICIENT FOR Ni

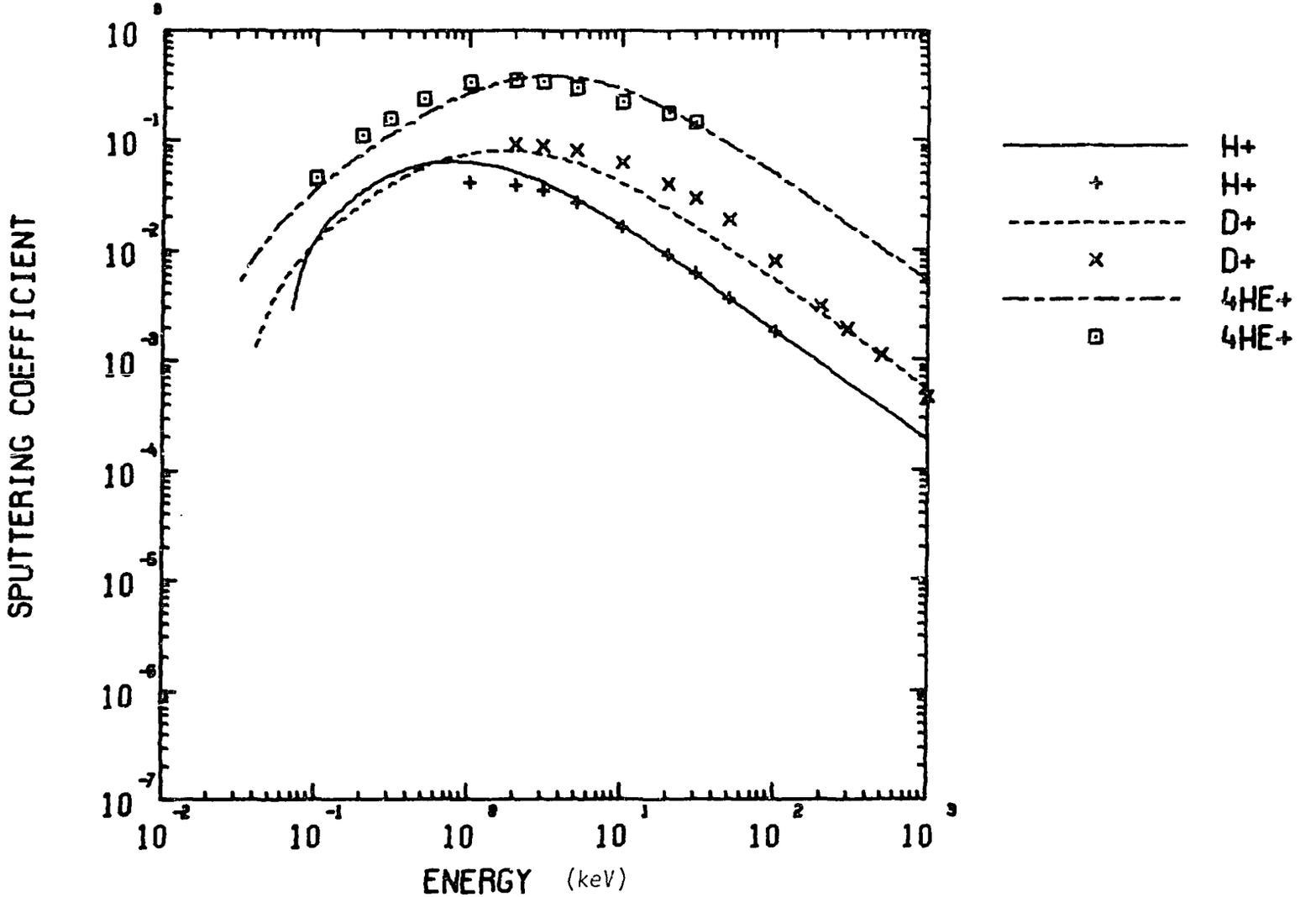

FIGURE 7. SPUTTERING COEFFICIENT FOR Cu

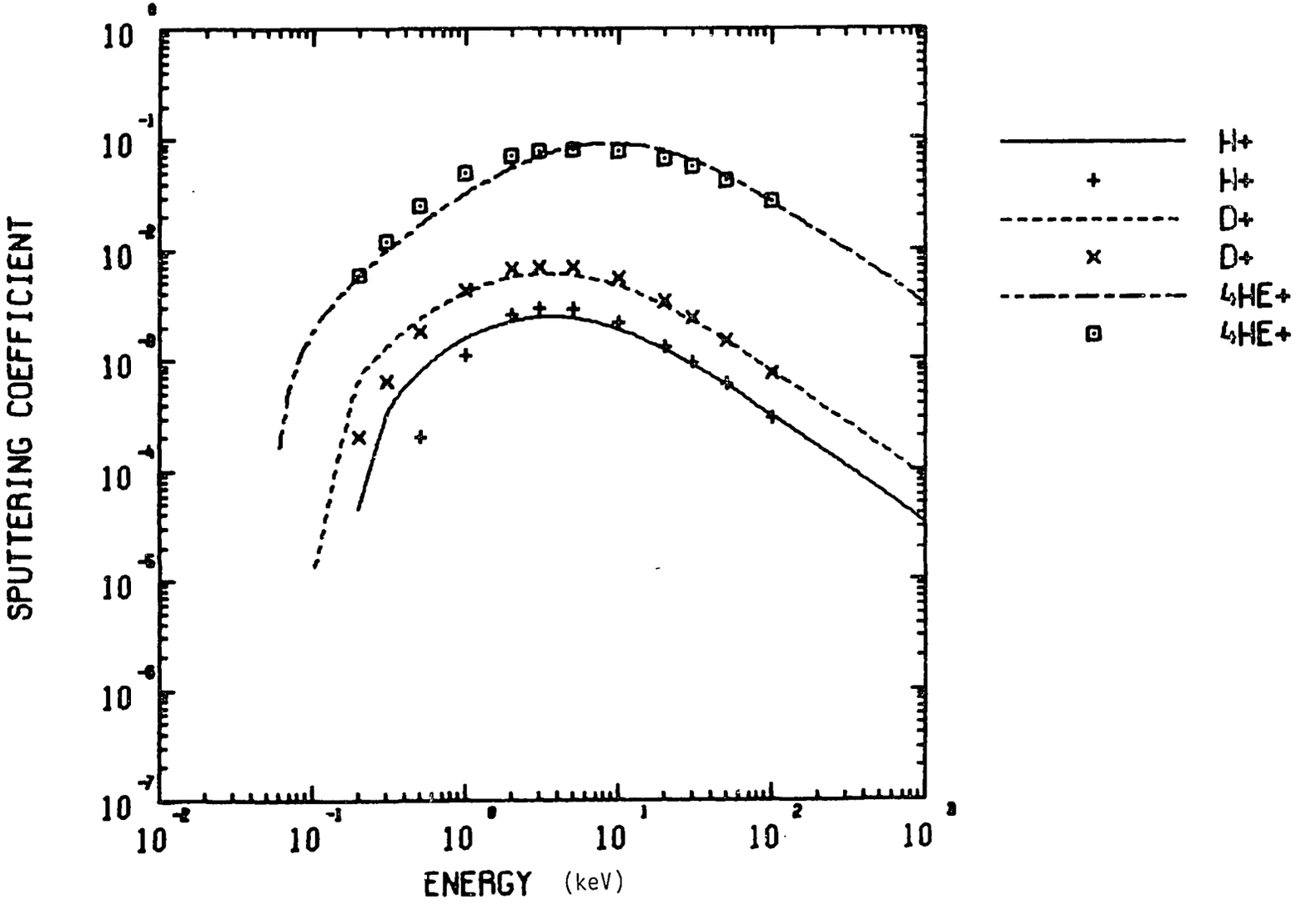

FIGURE 8. SPUTTERING COEFFICIENT FOR Nb

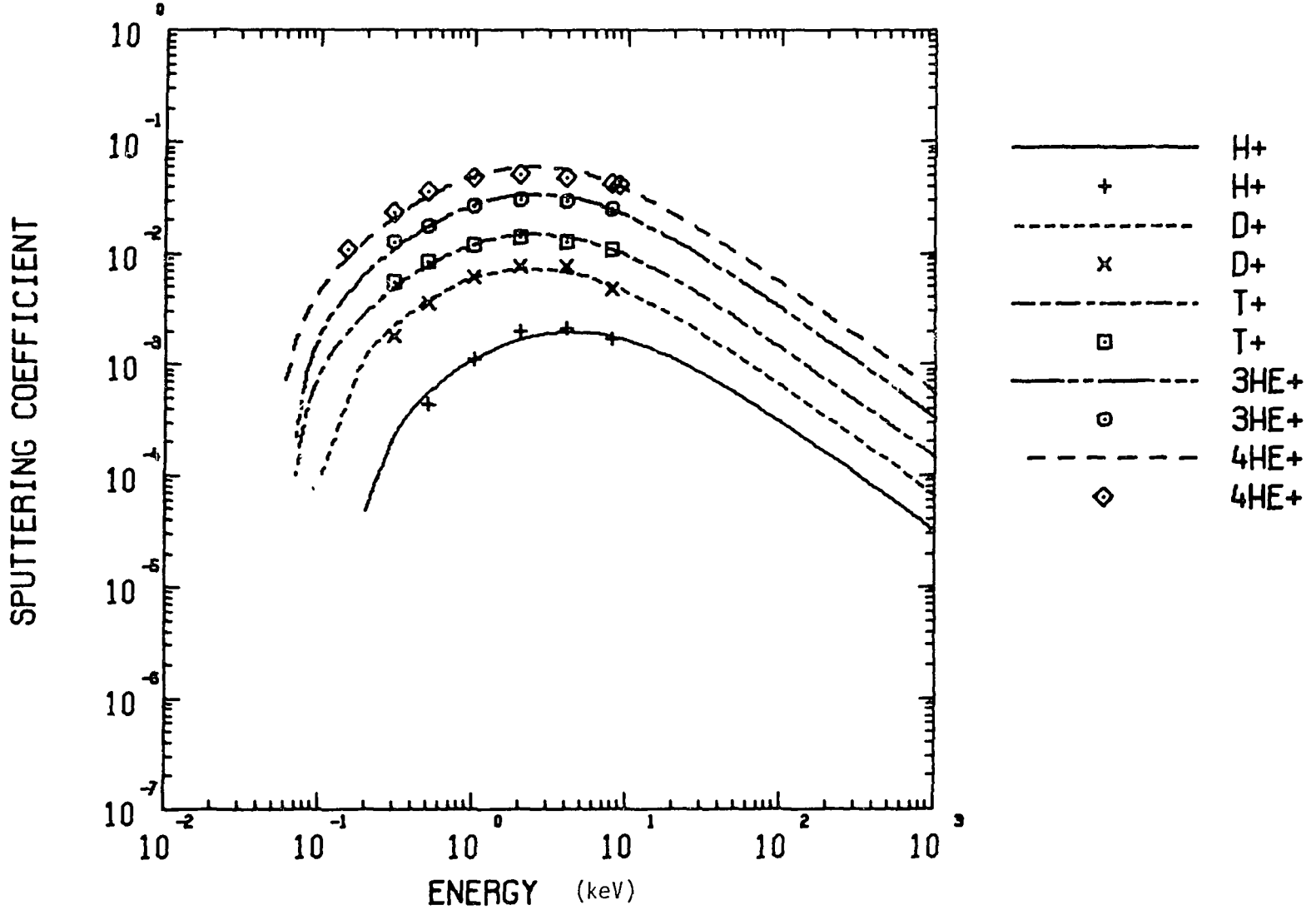

FIGURE 9. SPUTTERING COEFFICIENT FOR Mo

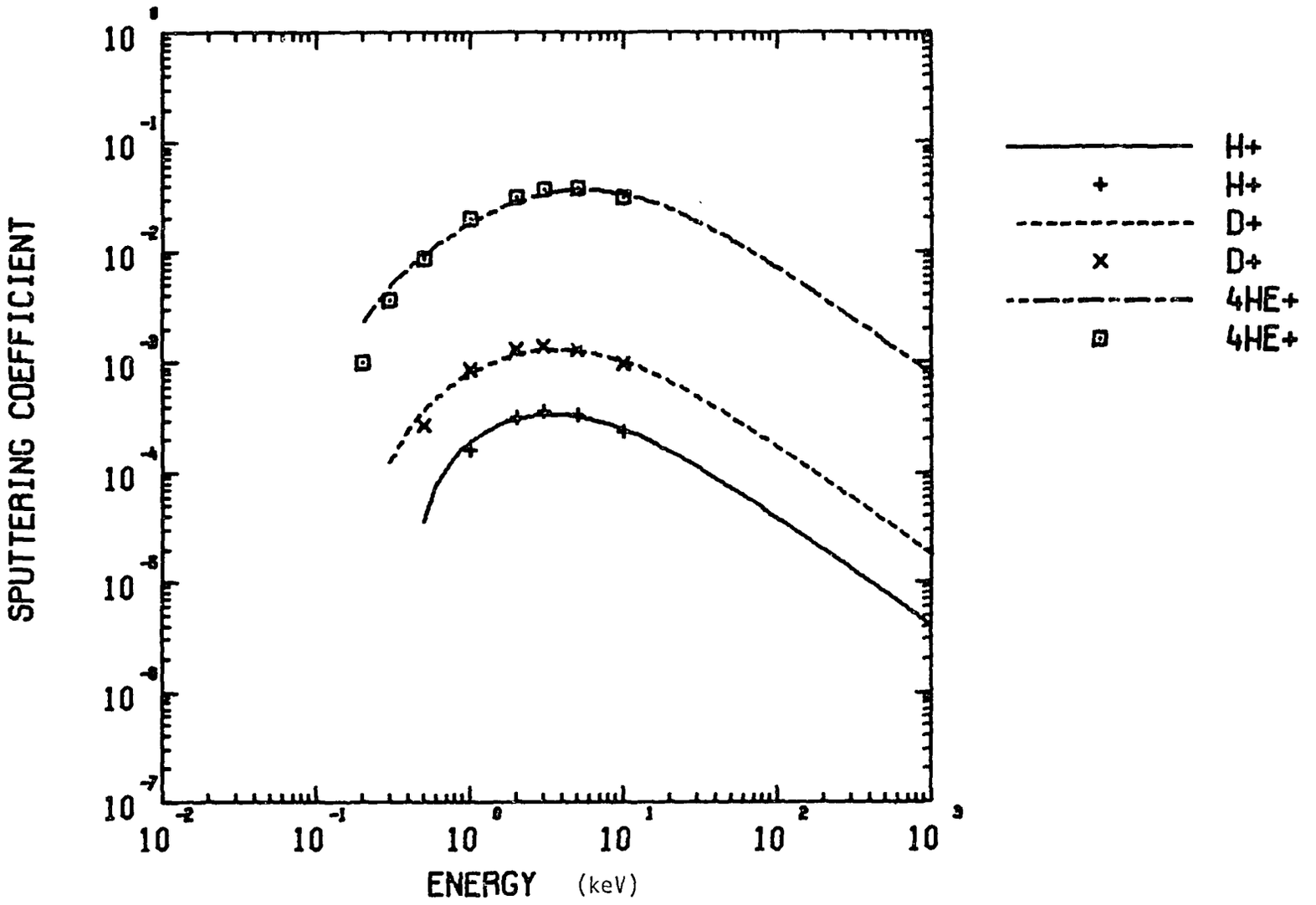

FIGURE 10. SPUTTERING COEFFICIENT FOR W

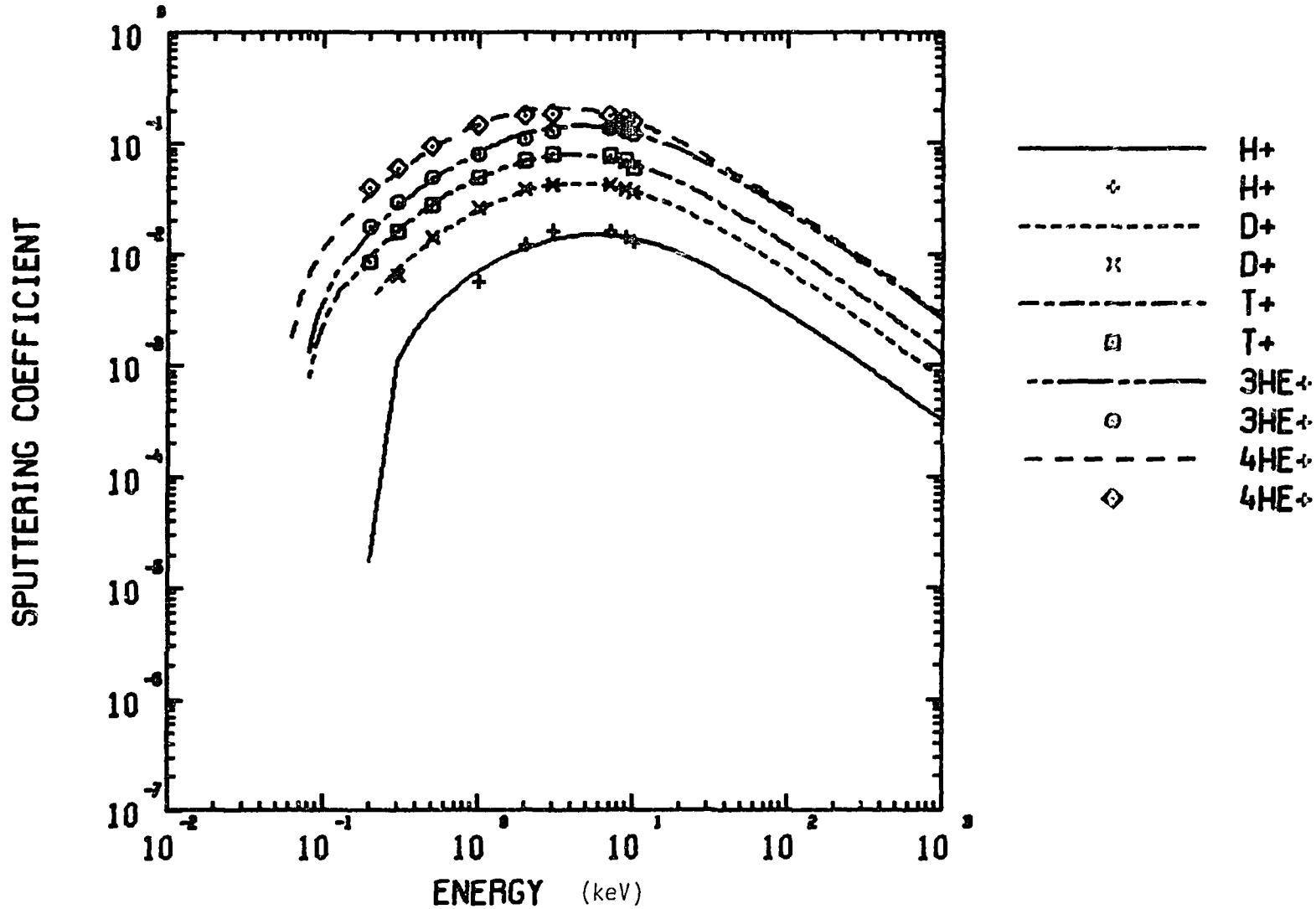

FIGURE 11. SPUTTERING COEFFICIENT FOR Au

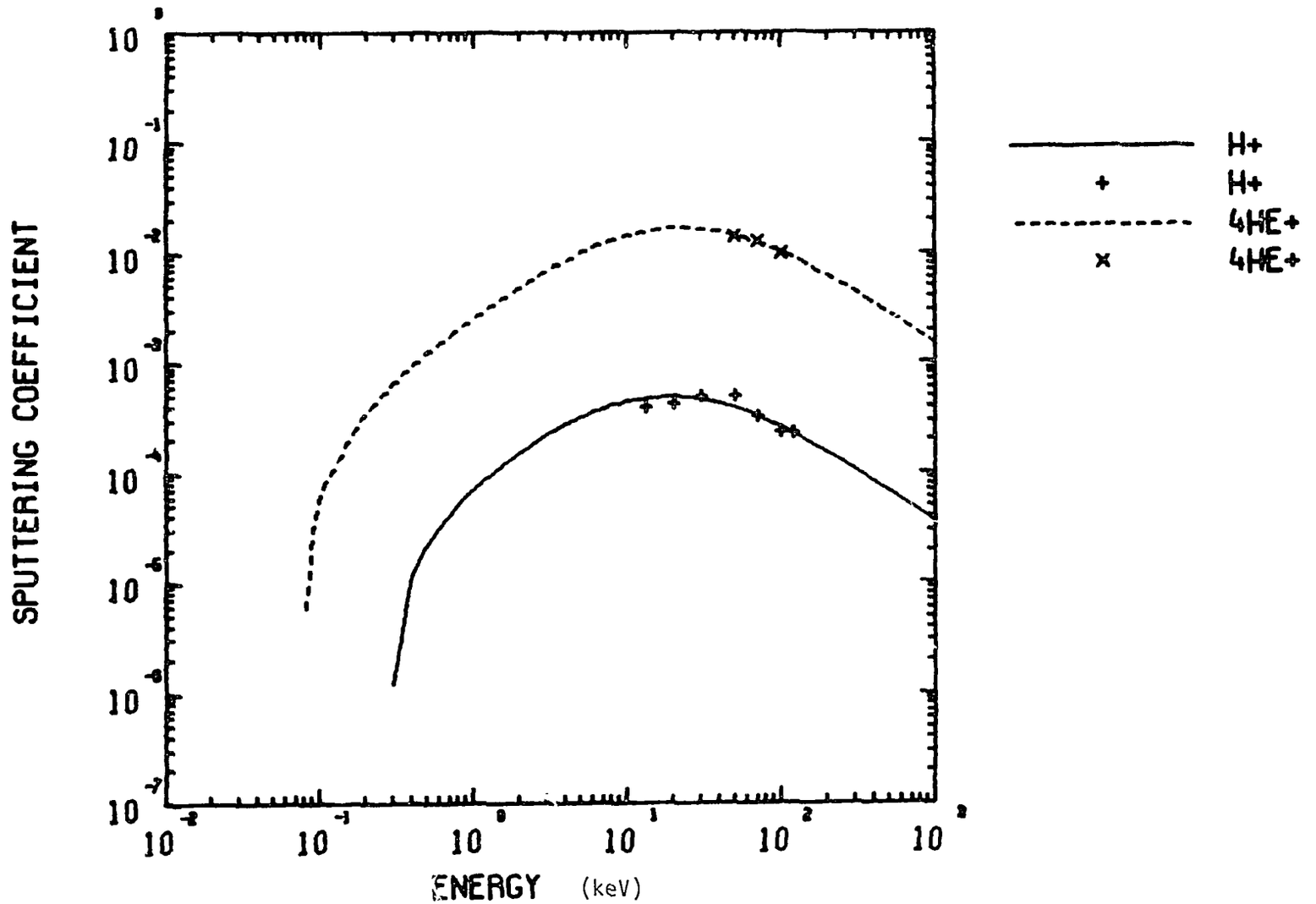

FIGURE 12. SPUTTERING COEFFICIENT FOR U