Sputtering of a tungsten surface by a flux of backscattered light atoms

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V.S. Mikhailov, D.S. Meluzova, P.Yu. Babenko, A.N. Zinoviev
Ioffe Institute, St. Petersburg, Russia
e-mail: chiro@bk.ru

Abstract

The sputtering coefficients and their angular dependences for the bombardment of tungsten with Be and Ne ions are calculated by the molecular dynamics method. In the case of Ne, there is good agreement with experiment. The data obtained for the Be-W case are needed to calculate the impurity inflow during the bombardment of the divertor material, tungsten, by Be ions in the plasma of the ITER tokamak reactor. The model is proposed that explains the universality of the behavior of the sputtering coefficients in the near-threshold region when tungsten is bombarded with light ions.

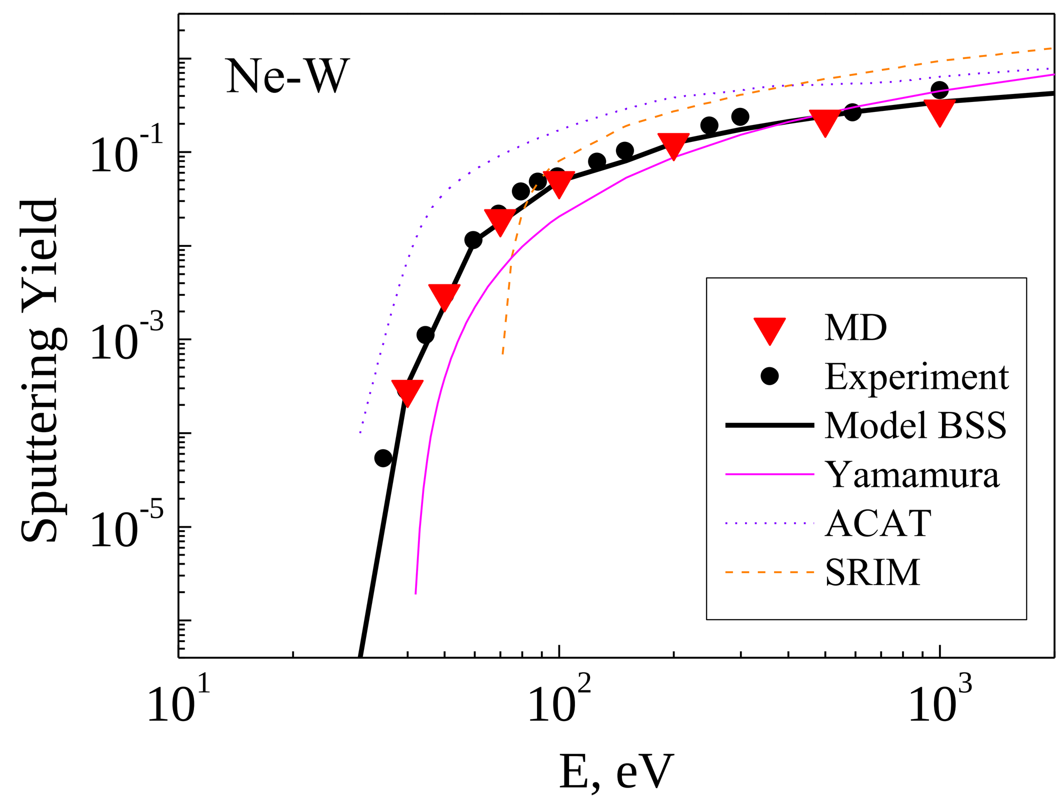

Fig. 1. Dependence of the sputtering coefficient of tungsten on the energy of bombarding neon ions.
Back Scattering Sputtering (BSS) model of surface atoms knocking out by a flux of backscattered particles.

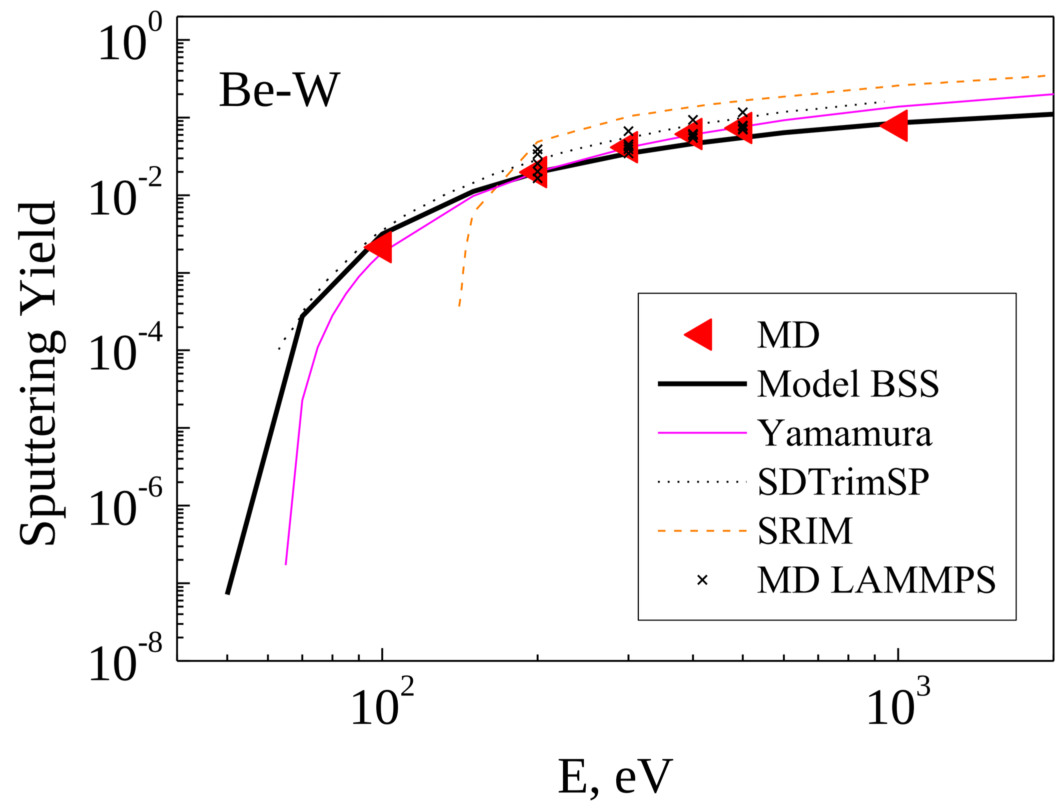

Fig. 2. Dependence of the sputtering coefficient of tungsten on the energy of beryllium ions.

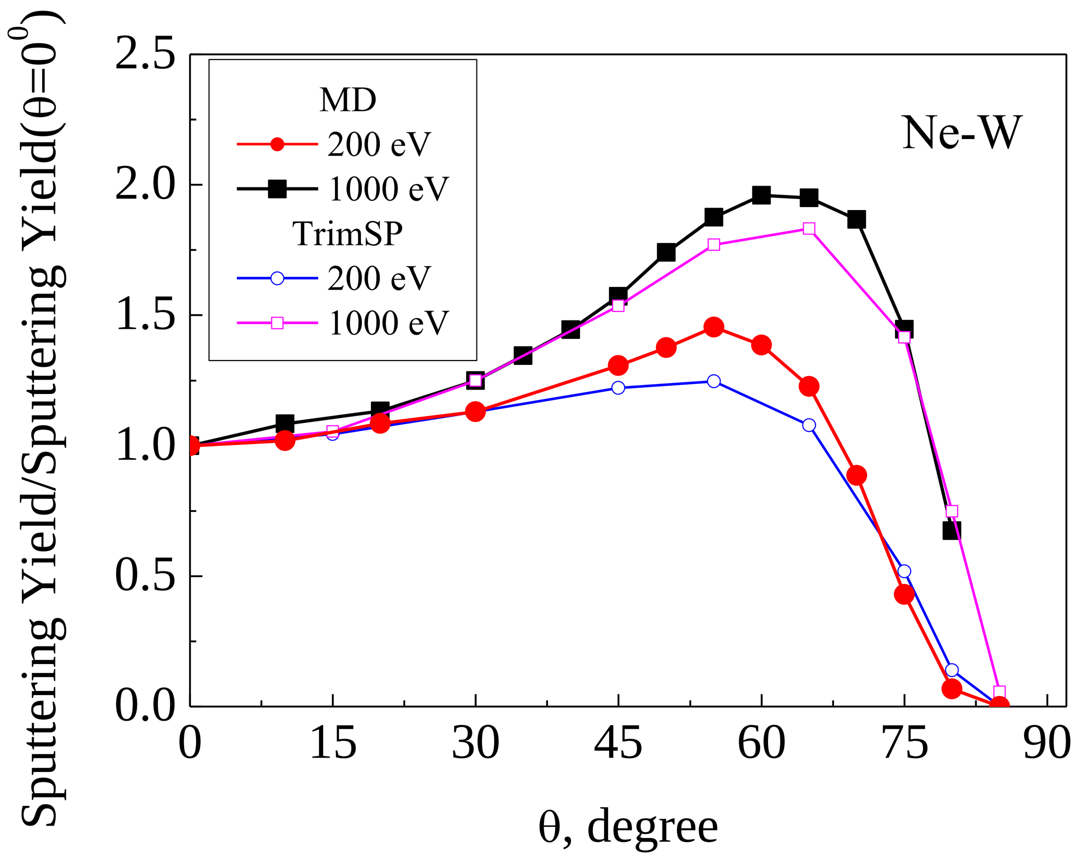

Fig. 3. Dependence of the sputtering coefficient of tungsten by neon ions on the beam incidence angle. The angle is measured from the surface normal.

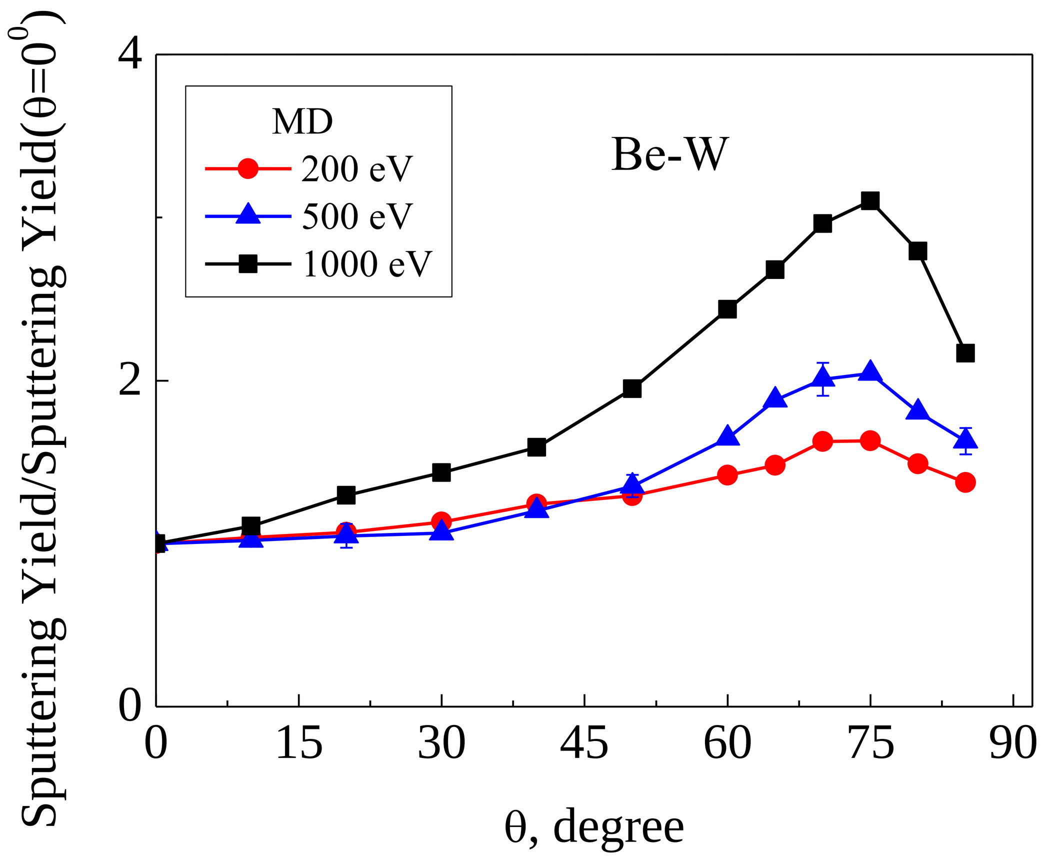

Fig. 4. Dependence of the sputtering coefficient of tungsten by beryllium ions on the beam incidence angle.

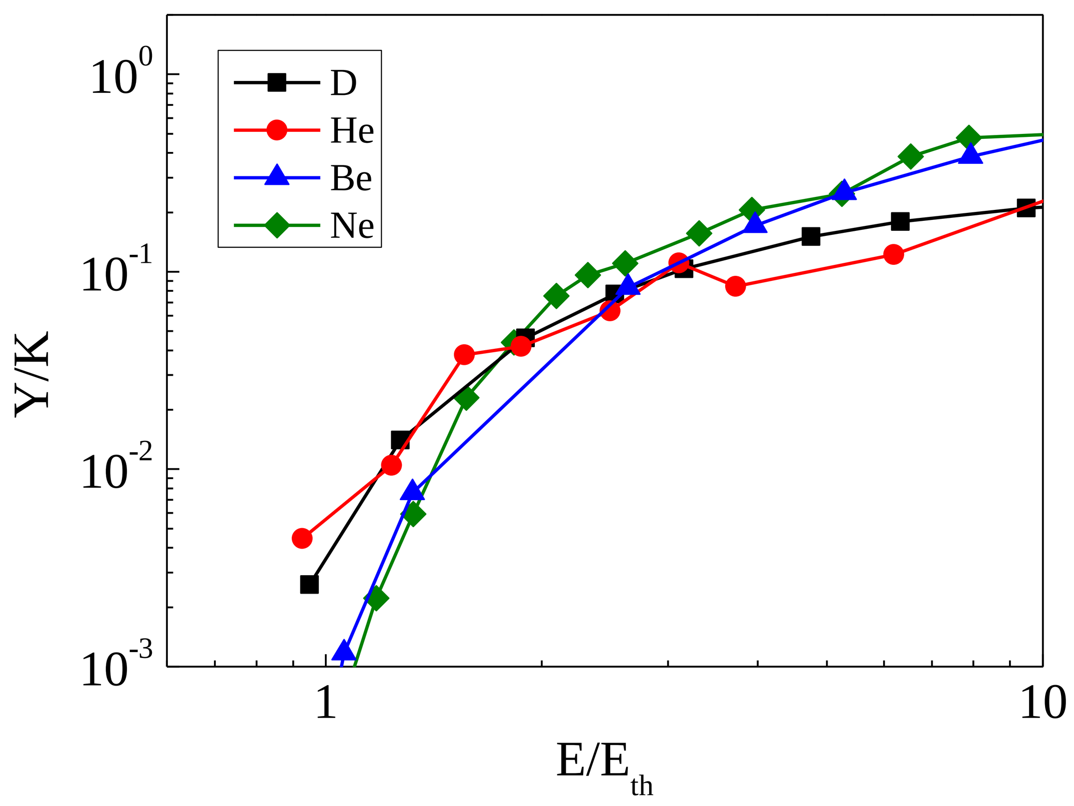

Fig. 5. Dependence of the sputtering coefficient of tungsten by various ions in the reduced coordinates.

In fig. 5 shows the dependences of the coefficients of sputtering of tungsten by ions D, He, Be, Ne. Calculated data were used for Be; in other cases, experimental data. The energy scale is normalized to the threshold energy values. For normalization on the absolute scale, the coefficient $K=\sigma(\chi_{th})/d^2$ at $E/E_{th}=4$ was used. Here $\sigma(\chi_{th})$ is the scattering cross section at an angle greater than χ_{th}. The coefficient K can be interpreted as the probability of knocking out a tungsten atom by a stream of backscattered particles.
As can be seen from Figure 5, the proposed model describes well the behavior of the sputtering coefficients in the threshold region. Attention is drawn to the fact that the curves for ions of close masses practically coincide. It is possible to extrapolate data to unexplored cases.

CONCLUSIONS

The sputtering coefficients and their angular dependences for the bombardment of tungsten with Be and Ne ions are calculated by the molecular dynamics method. In the case of Ne, there is good agreement with experiment.

The data obtained for the Be-W case are needed to calculate the impurity inflow during the bombardment of the divertor material, tungsten, by Be ions in the plasma of the ITER tokamak reactor.

The model is proposed that explains the universality of the behavior of the sputtering coefficients in the near-threshold region when tungsten is bombarded with light ions.

References

1. Ziegler J.F., Biersack J.P. SRIM – http://www.srim.org.
2. Yamamura Y., Tawara H. // At. Data Nucl. Data Tables 1996. V. 62. P. 149;
Yamamura Y., Itikawa Y., Itoh N. Angular dependence of sputtering yields of monatomic solids. IPPJ-AM report 26. Nagoya. 1983.
3. ACAT - Nakamura H., Saito S., Ito A.M. // J. Adv. Simulat. Sci. Eng. 2016. V. 3. P. 165.
4. SDTrimSP - Brezinsek S. // J. Nucl. Mater. 2015. V. 463. P. 11-21.
5. MD LAMMPS - Yang X., Hassanein A. // Appl. Surf. Sci. 2014. V. 293. P. 187.
6. Meluzova D.S. et al., // Technical Physics Letters. 2020. V.46. P.1227.