Energy Release in Be, C and W due to Irradiation with D and T Atoms

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Abstract

The distribution of the energy release over the depth of the material was calculated for hydrogen isotopes bombarding beryllium, carbon and tungsten surfaces. It was shown that for energies less than 50 keV the maximum energy release occurs near the surface. The distribution of the energy release over depth was calculated for the energy spectra of neutral particles typical for the ITER tokamak-reactor. Obtained data makes it possible to estimate the heating of the near-surface layers when the walls are bombarded by atoms leaving the plasma. The accumulation of tritium in the surface layers is predicted.

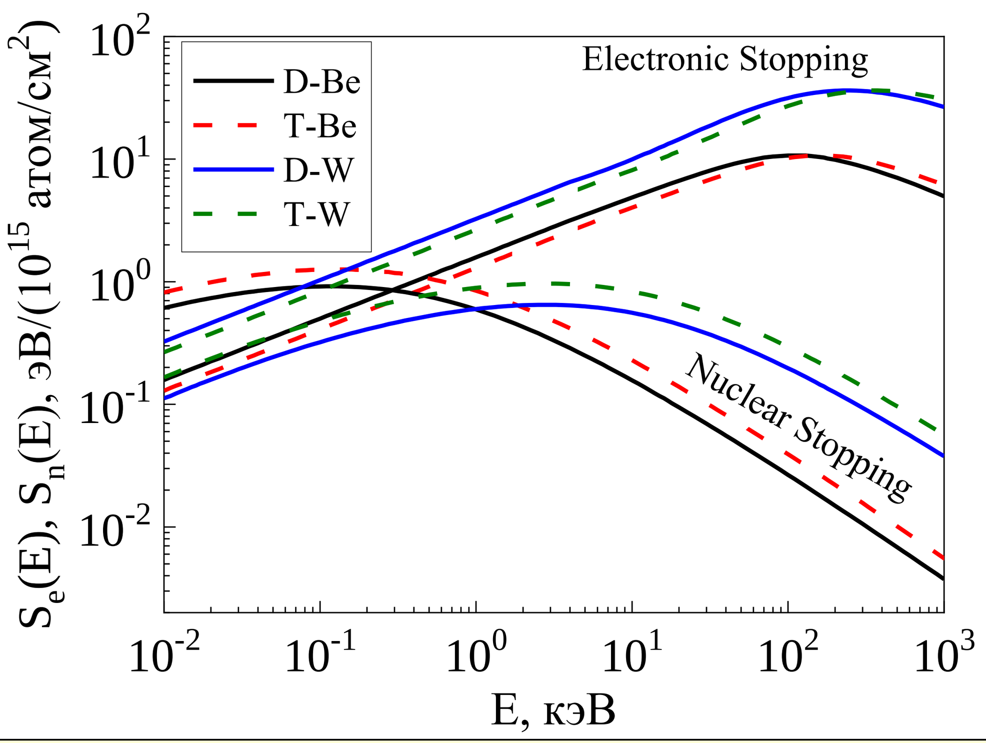


Fig. 1. Dependencies of electronic (4 upper curves) and nuclear stopping powers on collision energies of deuterium and tritium in beryllium and tungsten. From the database [1].

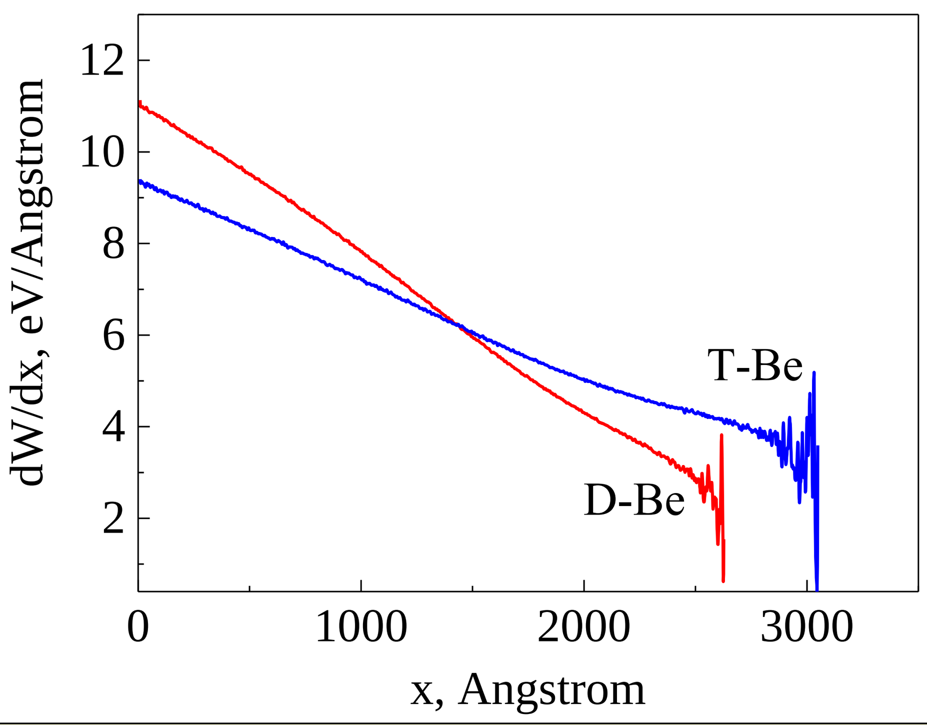
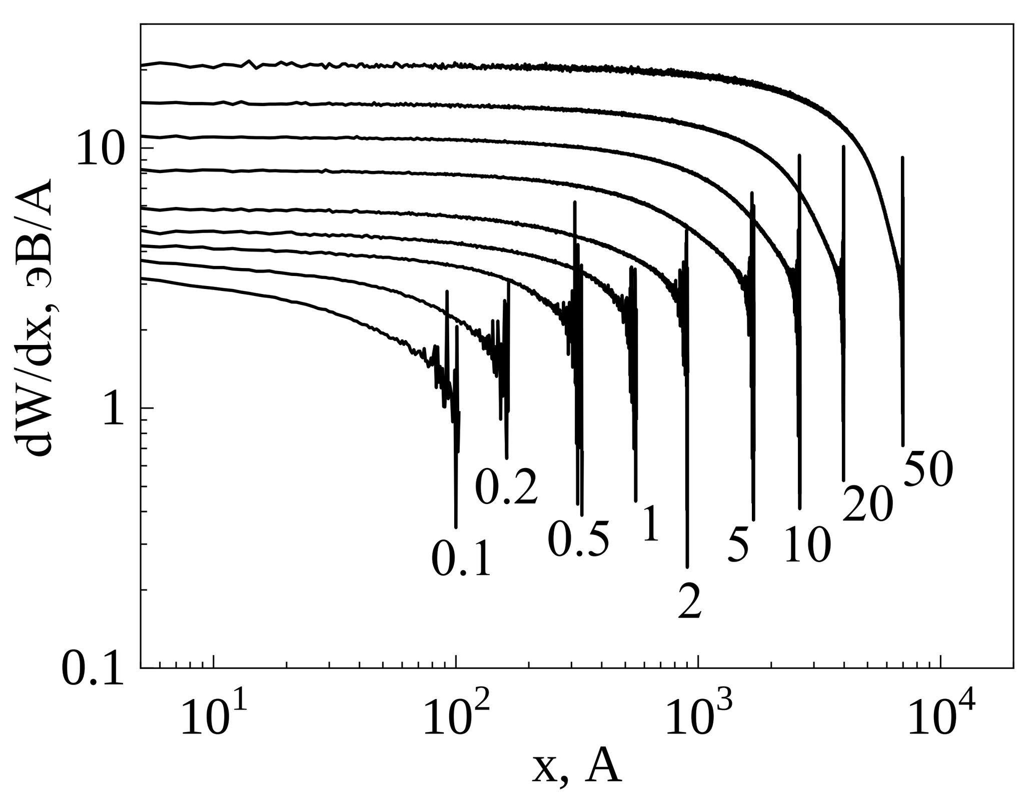
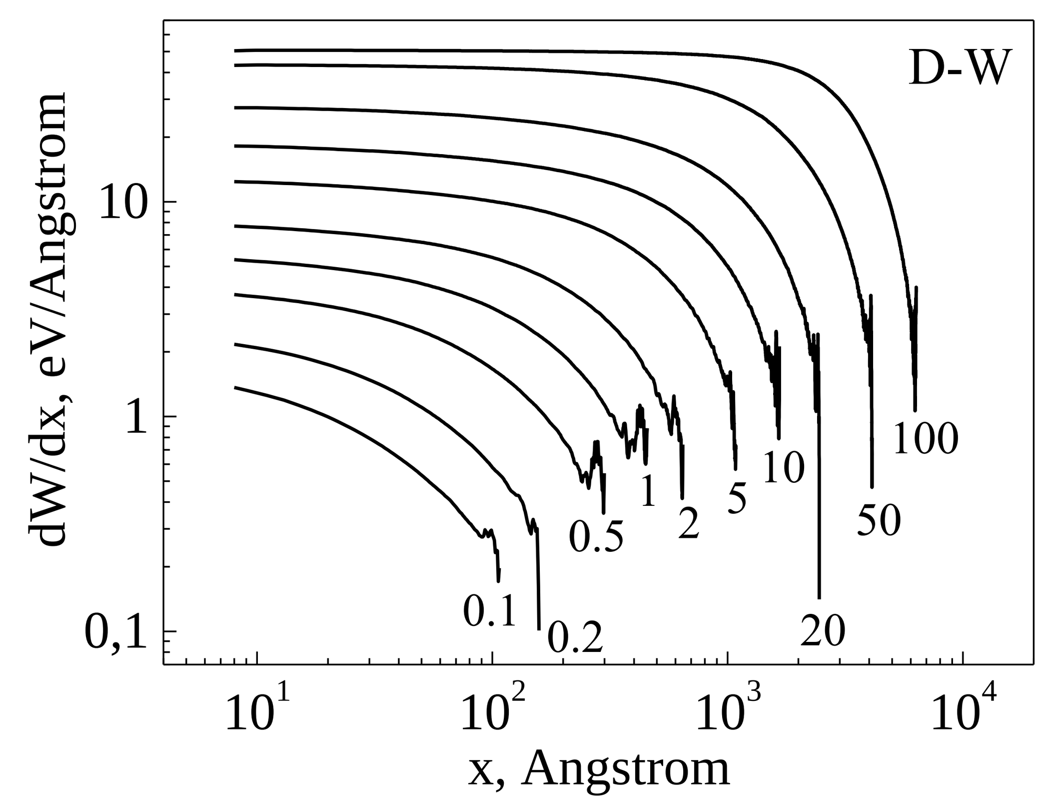


Fig. 2. Energy release in collisions of 10 keV D and T ions with beryllium.





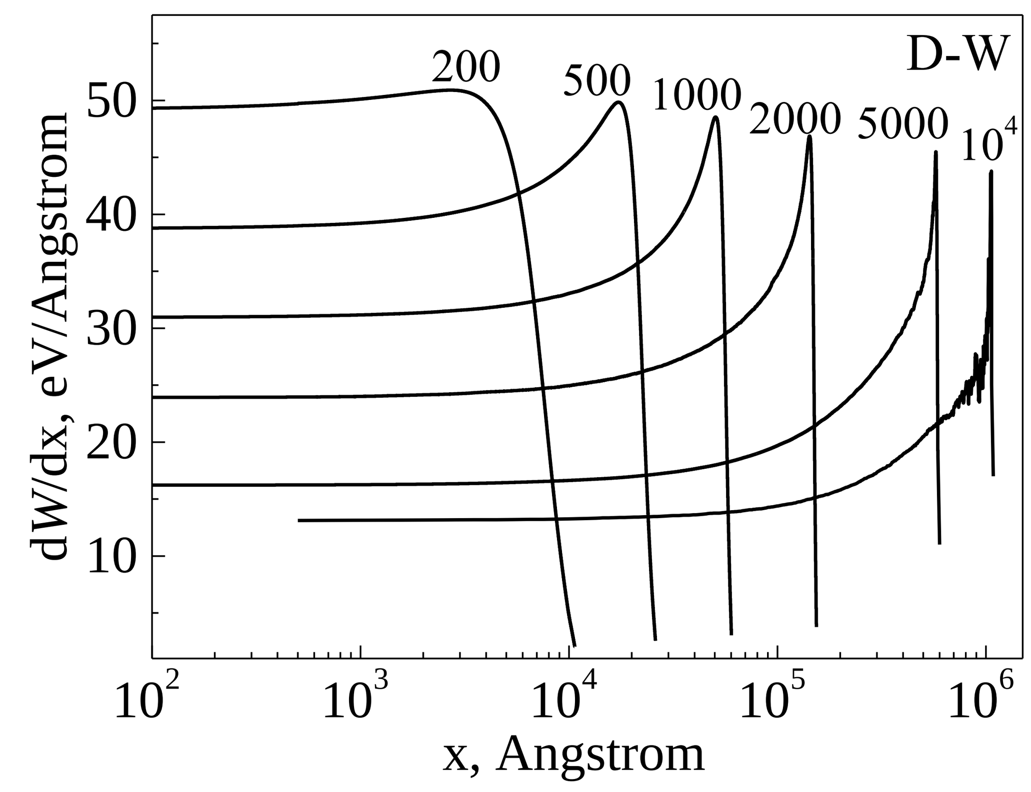


Fig. 3. Distribution of energy release over depth in deuterium bombardment of
a beryllium surface – **top left**;
a tungsten surface – **right top and bottom**.
The numbers on the curves are the initial energies of the particles in keV.

At energies below 50-100 keV, the distributions do not follow the expected pattern, i.e. there is no dominant Bragg peak at the end of a particle's path. The energy release maximum occurs near the surface and a decrease in energy release is observed with the increase in depth.
For tungsten, the Bragg peak is significant only at energies greater than 500 keV. Its emergence is connected with the change in the dependence of the electronic stopping on the energy.

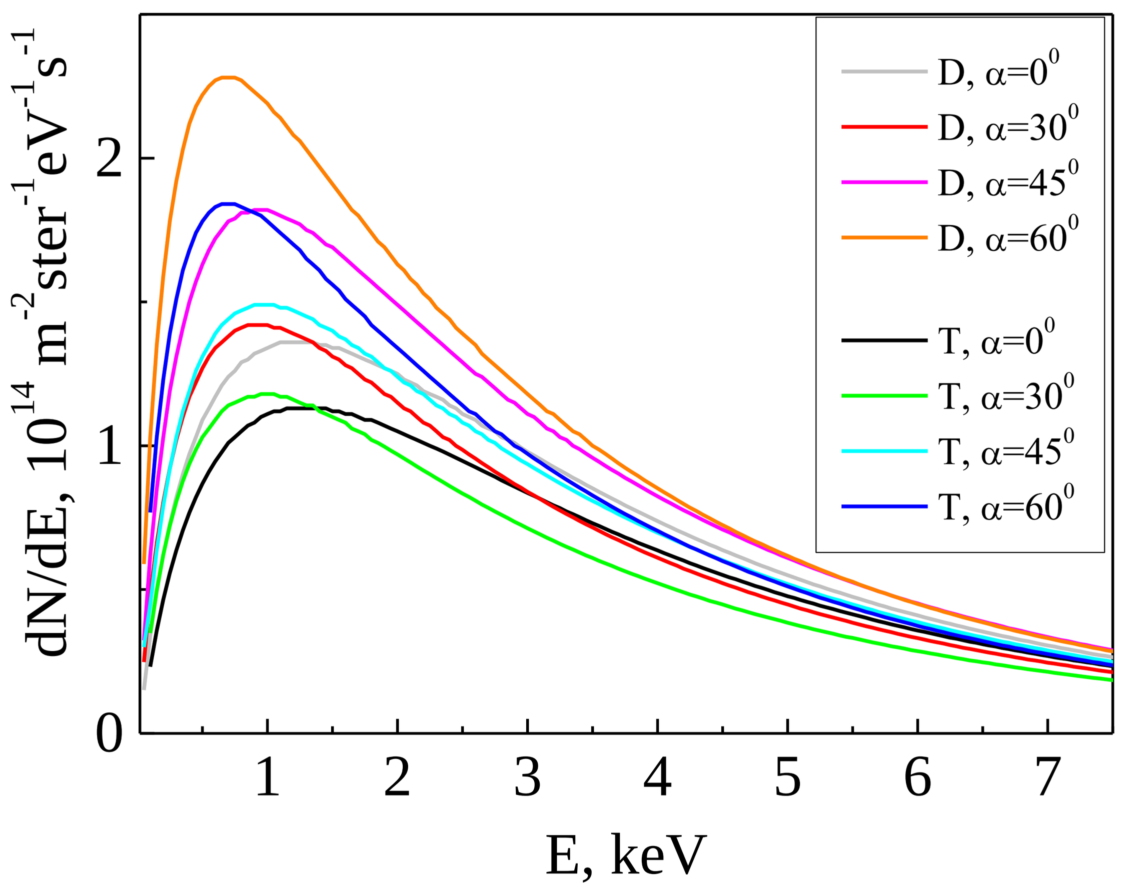
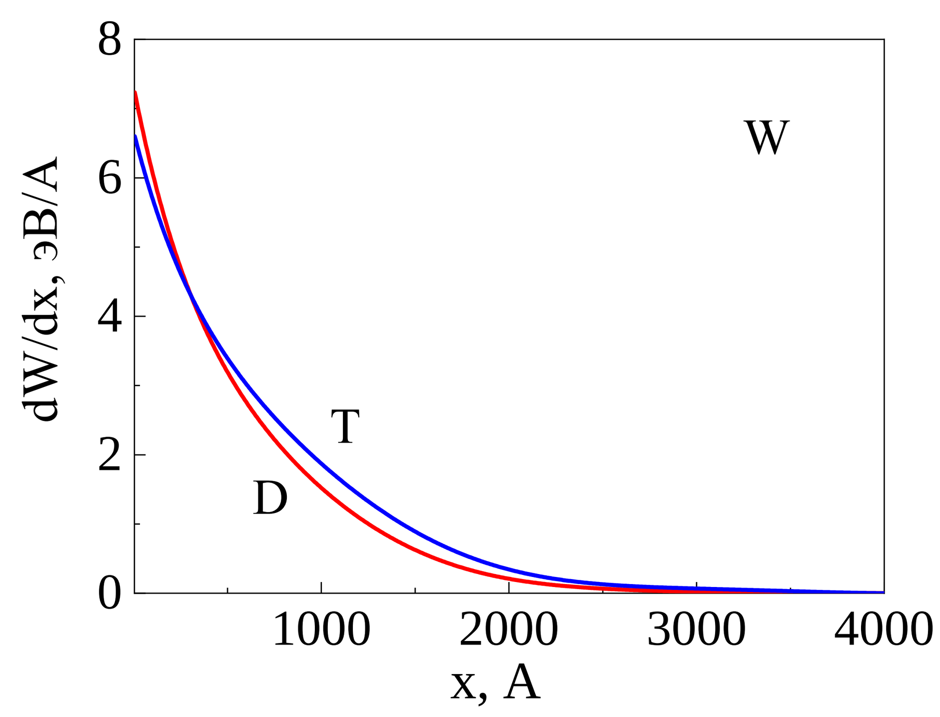
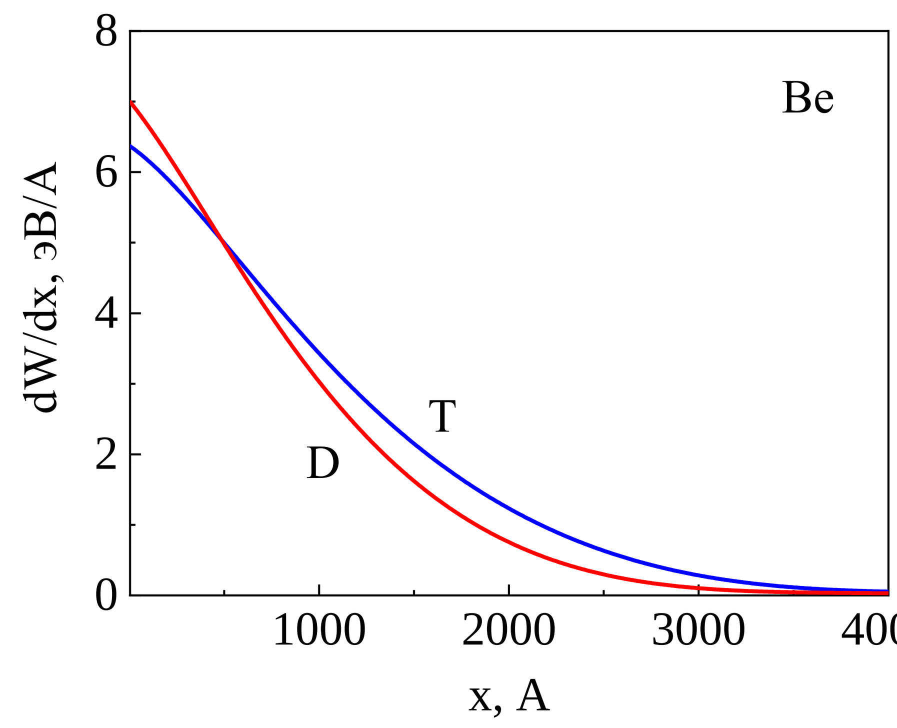


Fig. 4. Typical energy spectrum dN/dE of deuterium and tritium atoms bombarding the first wall of the ITER tokamak. α is the angle between the atomic beam and the surface normal. Similar calculation are described in [2].





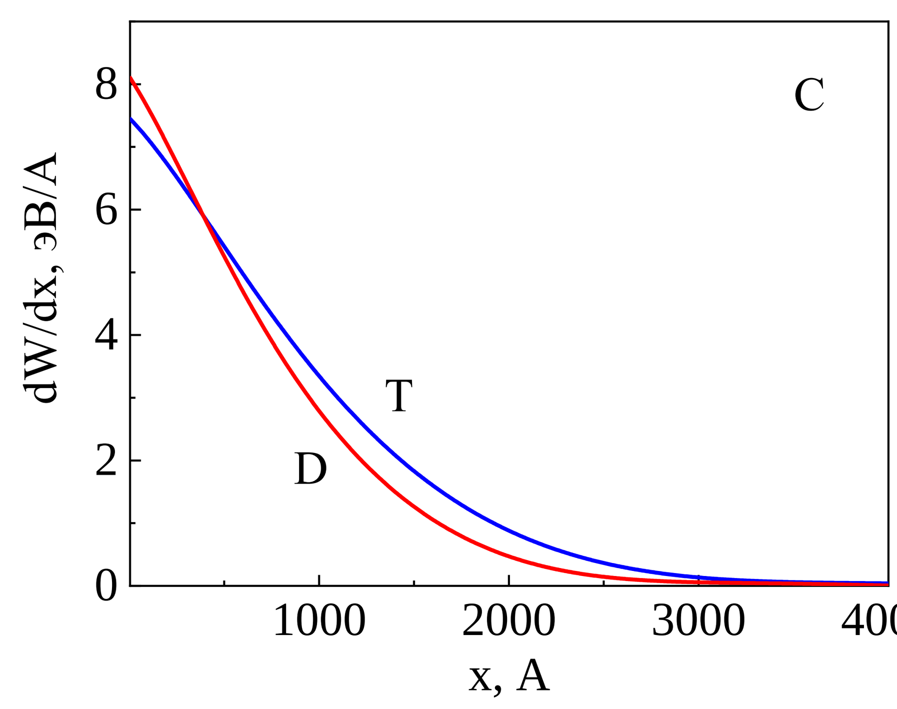


Fig. 5. The distribution of energy release per one incident particle over depth in beryllium, carbon and tungsten, irradiated with deuterium and tritium atoms leaving the plasma with energies typical to the ITER tokamak (Fig. 4).

The contribution of reflected particles was also taken into account.
The energy release maximum is located near the surface. Tritium atoms penetrate deeper into the material of the wall than deuterium atoms of the same energy due to the fact that electronic stopping power is lower for tritium than for deuterium.

CONCLUSIONS

The distribution of the projected energy losses over the depth of material was calculated for bombarding Be, C, W, which are important materials in the field of thermonuclear research, with deuterium and tritium atoms. It was shown that most of the energy release occurs in the near-surface layers of the materials.

The energy release of one bombarding particle was calculated for the case of irradiating materials under consideration with atoms with a broad energy spectrum typical for ITER tokamak.

It was shown that, on average, tritium atoms penetrate deeper into the wall material than deuterium atoms, which can lead to their accumulation.

Refrences

1. Ziegler J.F., Biersack J.P. SRIM – http://www.srim.org.

2. Afanasyev V.I., Mironov M.I., Nesenevich V.G., Petrov M.P., Petrov S.Ya. // Plasma Phys. Control. Fusion. 2013. V. 55. N 4. P. 045008.