§12. A New Formula for the Energy Spectrum of Sputtered Atoms from a Target Material Bombarded with Light Ions at Normal Incidence

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It is known that the energy spectrum of sputtered atoms from a target material bombarded by heavy ions is well represented by the Thompson formula. This corresponds with the fact that heavy ions can make a developed collision cascade in the material. For sputtering due to low-energy light ions, however, some experiment [1] show that the energy spectra of sputtered atoms deviate from this formula. Light ions can make only few collisions cascade because of the mass difference between light ions and target atoms. Thus, a direct or few collisions process becomes dominant for light ions. We will derive a new formula to agree with the energy spectrum of sputtered atoms from a target material bombarded by light ions at normal incidence on the basis of Falcone-Sigmund model.

The detailed derivation of the new formula has been given elsewhere [2]. Therefore, only the expression of the new formula is explained here:

$$Y(E,E_2)\mathrm{d}E_2 \propto \mathrm{d}E_2 \frac{E_2}{(E_2+U_S)^{2-2m}} \times\left[\frac{1}{m}\left(\frac{\gamma(1-\gamma)E}{E_2+U_S}\right)^m - \ln\frac{\gamma(1-\gamma)E}{E_2+U_S} - \frac{1}{m}\right], \quad (1)$$

where E is the incident energy, E_2 is the energy of the sputtered atoms, m is a constant ($0<m<1$), U_s is the surface binding energy, $\gamma=4M_1M_2/(M_1+M_2)^2$ is the energy transfer factor in an elastic collision, M_1 and M_2 are the masses of projectile and target atom, respectively. m is taken as 0.05 in the present work. It is noticeable that above formula depends on the incident energy of projectile E.

Figures 1 shows the calculated energy spectra of sputtered atoms from a Ti target material bombarded by 200 eV H^+ ions at normal incidence, using our new formula and the Thompson one, together with simulation data calculated with the ACAT code. The formula agrees better with simulation results calculated with ACAT code than the Thompson formula for a Ti target material bombarded by 200 eV H^+ ions at normal incidence. The spectra was normalized to unity at the maximum point. From this result, a direct or few collisions process is most probably the dominant mechanism for light ion sputtering.

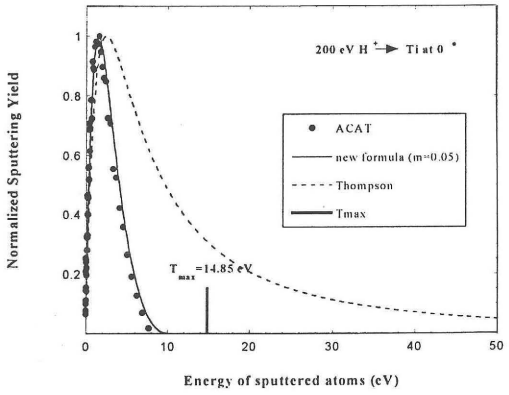

Fig.1 Sputtered energy spectra calculated with the new formula and with Thompson's one for 200 eV H^+ ions incident on a Ti target at normal incidence. Also shown is the simulation data calculated by the ACAT code.

Reference

1) H. L. Bay, B. Schweer, P. Bogen and E. Hint, J. Nucl. Mater. **111&112**, 732 (1982).
2) Kenmotsu, T., et al.,NIFS-DATA-65 (2001)