§16. Secondary Charged Particle Emissions under Low Energy Ion Impact on Non-Metallic Surfaces

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In the present study, the secondary electron emission yields, γ^-, and the secondary positive ion emission yields, γ^+, from some non-metallic surfaces induced by low energy ion impact have been measured using a cylindrical double-wall cup under an ultra high vacuum chamber ($\sim 10^{-10}$ Torr). The target surfaces were cleaned by Ar^+ sputtering and the surface cleanness was examined by Auger electron spectroscopy.

It has been found that the observed γ^- from the $YBa_2Cu_3O_7$ and $SrCeO_3$(5% Yb) is proportional to the electronic stopping power S_e over the whole impact energy range investigated. However, the proportional coefficients in γ^- observed in these non-metallic targets are found to be 3-4 times larger than those for metal targets. We have also observed an interesting phenomenon where the observed γ^- in clean $SrCeO_3$(5% Yb) target strongly depends on the incident ion beam flux and becomes zero above a critical ion flux which has been found to depend on the incident ion energy as well as the temperature of targets (see Fig. 1). This feature has also been observed for unclean $SrCeO_3$(5% Yb) [1] and oxidized Be surfaces [2].

Similarly, we have found that the observed γ^+, which has been found to be independent of the incident ion flux investigated, is larger than the results calculated with the TRIM code. It has been found from TRIM code calculations, however, that a significant part of the observed γ^+ in H^+ and H_2^+ impact are due to the secondary electrons emitted from the wall of the inner cup under impact of the neutral hydrogen atoms backscattered from the target surfaces. Nevertheless, the observed γ^+ from these non-metallic targets under Ar^+ impact is far large, compared with the calculated results. It has been found that γ^+ induced by Ar^+ impact on $SrCeO_3$(5% Yb) is likely to proportional not to the nuclear stopping power S_n but to the electronic stopping power S_e (see Fig. 2). This result shows that a great part of these secondary positive ions are not emitted through physical sputtering. It is expected that these secondary ions are emitted through either the Coulomb explosion or the deexcitation of exciton which is induced by the electronic energy loss of the incident ions. Furthermore, it can be qualitatively explained that the incident ion flux dependence of γ^- is due to charge accumulation on these non-metallic material surfaces which have high resistivities.

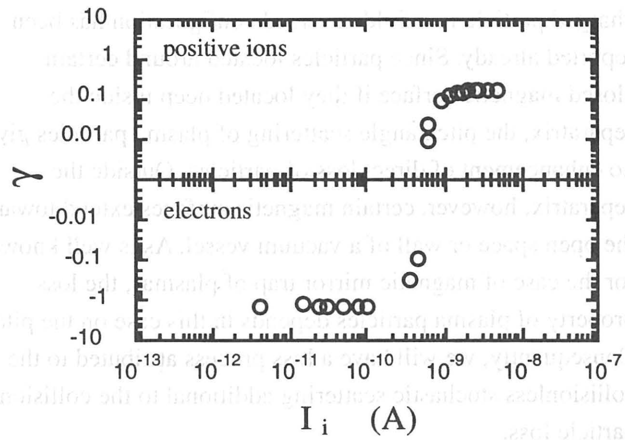

Fig. 1. Ion-flux dependence of γ induced by 2.5 keV H^+ impact on $SrCeO_3$ (5 % Yb) at room temperatures. I_i is the incident H^+ ion current.

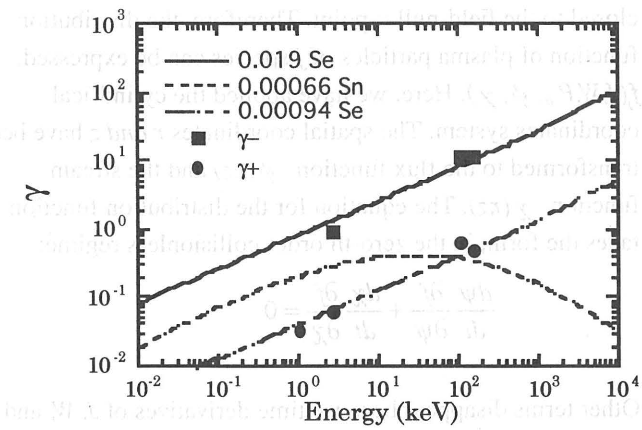

Fig. 2. The incident energy dependence of γ^- and γ^+ in Ar^+ impact on $SrCeO_3$(5 % Yb). The solid line corresponds to the calculated electronic stopping power S_e multiplied by a constant of 0.019, meanwhile the dotted line corresponds to the calculated nuclear stopping power S_n with constant 6.6×10^{-4}. The dash-dotted line corresponds to the electronic stopping power S_e with constant 9.4×10^{-4}.

References

[1] N. Matsunami et al., NIFS Annual Report (1995-96) 136

[2] K. Hosaka et al., Physica Scripta T73 (1997) 320