§19. Positive Ion and Secondary Electron Emission from Oxides by Ion Impact

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We have measured secondary electron emission (SEE) and secondary positive ion emission (SPIE) yields by ion impact on various oxides, for which there are few investigations. For uncleaned $SrCeO_3$(5%Yb), where measurements were made in 10^{-6}~ 10^{-7} Torr, we find incident ion beam current dependent SEE yields and anomalously high SPIE yields [1]. Measurements at 2.5 keV H^+ and Ar^+ were done in UHV. The SEE and SPIE yields appears to be insensitive to the surface conditions. The results are summarized in Table 1, where 2-3 means 2×10^{-3}.

SEE yields γ_e taken at the incident ion beam current (I_B) of 0.1 nA reach the constant values at the +90V bias of the electron collector. These values may not be the true SEE yields, because of the I_B dependence of γ_e, but are regarded as the representative SEE yields. They are found to follow roughly the electronic stopping power Se (eV/nm). The ratios γ_e/Se of 0.012 -0.035 (nm/eV) are comparable with those for metals and other oxides such as HTC superconductors [2].

SPIE yields γ^+ do not much depend on the collector bias and I_B. Firstly, γ^+ is much larger than the reflection coefficient R_N of TRIM calculation, confirming that SPIE is not due to the reflected ions. Secondary, γ^+ for H^+ impact is much larger than the sputtering yields Y_S of TRIM calculation with the surface binding energy of 6.1 eV (average of thermodynamically determined values for SrO and Ce_2O_3). Comparison of γ^+ for He^+ and Ar^+ impact with Ys implies high efficiency of charged fraction, if the SPIE originates from the sputtering. Thirdly, γ^+ does not follow the nuclear stopping power Sn. Anomalously high γ^+ is also observed for HTC superconductor oxides [2].

Rutherford backscattering analysis of graphite and Be which were used to collect the SPIE (neutral atoms are inevitably included) under 100 keV Ar^+ and 60 keV H_2^+ show that Sr, Ce and Yb are deposited on the collector approximately in proportion to the composition. Larger amount of oxygen than expected from the composition is detected. A very small fraction of C is also detected, however, this amount of C can not explain SPIE.

I_B dependence of γ_e and anomalously high γ^+ are under investigation.

Table 1

E(keV)	Ion	γ_e	γ^+	R_N	Y_S	γ_e/Se (nm/eV)	γ^+/Sn
2.5	H^+	1.3	0.18	8.1-2	7.3-3	0.027	0.087
20	H^+	1.5	0.13	1.6-2	1.8-3	0.012	0.15
100	H^+	6	0.025	2.4-3	2.6-3	0.035	0.084
50	He^+	3.5	0.05	3.4-2	1.3-2	0.018	8.8-3
100	He^+	9	0.08	1.4-2	6.3-3	0.031	0.022
150	He^+	10	0.11	7.0-3	2.9-3	0.030	0.039
2.5	Ar^+	1	0.063	6.2-2	1.2	0.013	1.4-4
100	Ar^+	12	0.65	2.7-2	1.3	0.025	1.1-3
150	Ar^+	12	0.5	1.9-2	1.1	0.020	8.9-4

References
[1] N. Matsunami, K. Hosaka and H. Tawara, NIFS Report 1996.
[2] N. Matsunami, S. Majima and T. Kawamura(to be published).