§13. Secondary Positive Ion Emission from $SrCeO_3$ (5%Yb) Thin Film on Si

Matsunami, N. (Dept. Energy Eng. and Sci., Nagoya Univ.), Hosaka, K., Sakaue, H., Tsumori, K., Tawara, H.

We have measured the secondary positive ion emission (SPIE) yield Y^+ from an epitaxial thin film(~100 nm) of 5% Yb doped $SrCeO_3$ (SCO) on Si by ion impact. The current due to the positive ions was measured by using a cylindrical Faraday cup with a shield surrounding the cup. The Faraday cup was negatively biased, and the sample and the shield were grounded. Thin film on an electrical conductive substrate was employed to minimize the charge accumulation effect. As reported previously, a strong beam current dependence of the secondary electron emission (SEE), i.e., a strong suppression of SEE with increasing the beam current, was observed for thick polycrystalline SCO (p-SCO). We consider that this dependence is partly due to the surface potential modification by the charge accumulation effect.

As shown in Fig. 1, it appears that Y^+ is nearly constant over a wide range of the ion beam current (I_B) and saturates at bias of -90 V. It is also found that Y^+ is insensitive to surface condition (clean or unclean surface). A quite similar behavior was observed for H^+ impact. The above results of thin SCO film on Si and of p-SCO are given in Table 1. Values of Y^+ of thin SCO film is somewhat smaller than those of p-SCO. Also included in the Table are the calculated backscattered yield Y_B, sputtering yield Y_S and corrections Y_C associated with the Faraday cup method. The correction means that backscattered ions and sputtered atoms hit the Faraday cup and generates the SEE, resulting in positive currents. Difference between the present Y_C and those in ref.[1] is due to different choice of Y_B, Y_S and etc.

True SPIE yield, γ^+, is given by $\gamma^+=Y^+-Y_C$ and the results are given in Table 1. For 2.5 keV H^+ impact, γ^+ divided by the sputtering yield is larger than unity. This indicates that the correction is not adequate, because the sputtering of SCO is well described by the elastic collision process for low energy ion impacts, on which the calculation of Y_S is based, and hence γ^+/Y_S should not exceed unity. For Ar^+ impact, γ^+/Y_S varies from 0.003 to 0.1, and this implies that γ^+ does not scale with the elastic collision and there may be a contribution of electronic excitation effects. To clarify this contribution, improvement of the correction accuracy is inevitable. Development of other methods to evaluate γ^+ is also under investigation.

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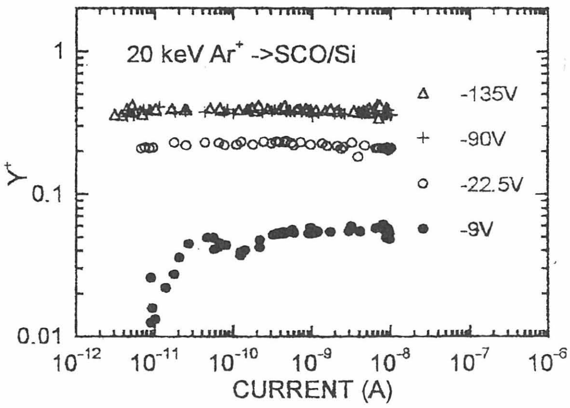

Fig.1 Dependence of secondary positive ion emission yield Y^+ per ion on the beam current for 20 keV Ar^+ impact on SCO/Si at various bias indicated in the Figure.

Reference

[1] K. Hosaka, N. Matsunami and H. Tawara, Nucl. Instrum. Meth. B149 (1999)414.

Table 1 Y^+, correction Y_c with the calculated backscattered yield Y_B and sputtering yield Y_S for thin SCO film on Si. Y^+ in the parentheses is the result for thick polycrystalline SCO. $\gamma^+ = Y^+-Y_c$. Se and Sn are the electronic and nuclear stopping powers in eV/nm, respectively.

E(keV)	Ion	Y^+ (unclean) film	(poly)	Y_B	Y_S	Y_c	γ^+/Y_S	Se	Sn	Y^+ (clean) film
2.5	H^+	0.11		0.18	0.0086	0.065	5.2	47.5	2.08	0.11
2.5	Ar^+	0.04	(0.063)	0.066	1.3	0.036	0.003	76.1	464	0.035
100	Ar^+	0.45	(0.65)	0.025	1.6	0.38	0.04	481	619	
150	Ar^+	0.44	(0.5)	0.021	1.35	0.26	0.1	590	561	