§6. Secondary Electron Emission Yields under Low-Energy Singly and Doubly Charged Ion Impact on Metallic and Non-Metallic Surfaces

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The secondary electron emissions (SEE) from solid surfaces under ion impact are known to be separated in two parts: one is the potential emission (PE) and the other the kinetic emission (KE). The purpose of the present study is to investigate the SEE from clean metallic and non-metallic surfaces at low incident energy (< 0.5 keV) where the PE becomes dominant.

In the present study, a compact duo-plasmatron ion source provided low energy ($\leqq$ 2.5 keV) ions. After charge and mass selection by a Wien filter, the ions were directed into a collision chamber. Before arriving at the target surfaces, the incident ion beam was decelerated through a series of the retarding electrodes down to the energy required. The present vacuum system consists of two chambers: the preparation chamber (its base pressure is 1×10^{-10} Torr) and the main chamber (5×10^{-11} Torr). The target surfaces were cleaned by sputtering with an Ar ion gun. After cleaning, the surface cleanness was examined by an Auger-electron-spectrometer (AES). Finally the targets were brought onto the beam line normal to the incident projectile beam. The current of the secondary electrons was measured with stainless steel double cylindrical cups.

Hagstrum [1] was the first to theoretically treat PE phenomena under ion impact. Then, Kishinevsky [2] developed a theoretical model to estimate the secondary electron emission coefficients (γ_{PE}) due to the potential energy of the incident ions as a function of parameters relevant to the solid. On the other hand, Baragiola et al. [3] proposed an empirical formula for metallic targets based upon the observed data mostly for the singly charged ions. These formulas can reproduce the observed data reasonably well in relatively low ion potential energy region. But as already pointed out by Kishinevsky [2], these formulas are found to be of large variation from the observation near the threshold potential energy.

We have tried to find a convenient empirical formula for the secondary electron emission coefficients (γ) over a wide range of the potential energy of the incident ions from the threshold to a few 100 keV by taking into account the reduction of γ due to the image acceleration and also due to the incomplete collection of high energy Auger electrons. Thus, this yield γ_0 may be different from γ_{PE}. In order to fit to the experimental data the present new formula keeps basically the form of ($0.8\ E_{PE} + 2\ \Phi$) which is used in the previous formulas [2, 3], where E_{PE} and Φ are the potential energy of the incident ion and the work function of the target. In Fig.1 are shown the observed γ_0 for slow secondary electron emissions over a wide range of the potential energy of the incident ions [4,5] and also the present empirical formula whose best fit to the observed data is given as follows :

$$\gamma_0 = 0.023\ (0.8\ E_{PE} - 2\ \Phi + \alpha)^{0.81} \qquad (1)$$

with $\alpha = 0.50$ for clean Au targets. In Fig.1, we also show our experimental results under low charge ions such as H^+, Ar^+, Ar^{2+}, Kr^+ and Kr^{2+} impact on clean Cu targets. It is found that our data are in good agreement with this empirical formula (1).

We have also measured SEE induced by Ar^+, Ar^{2+}, Kr^+ and Kr^{2+} impact on clean TiO_2 surfaces. As might be expected by the empirical formula, we could not observe the PE for Ar^+ and Kr^+ as Φ of TiO_2 is large. And γ_0 for Ar^{2+} and Kr^{2+} is also in good agreement with the empirical formula (see Fig.1).

In order to understand the SEE mechanisms for low energy ions, more systematic studies using other targets, for example non-metallic targets, which have the electronic structure very different from metallic targets, should be performed.

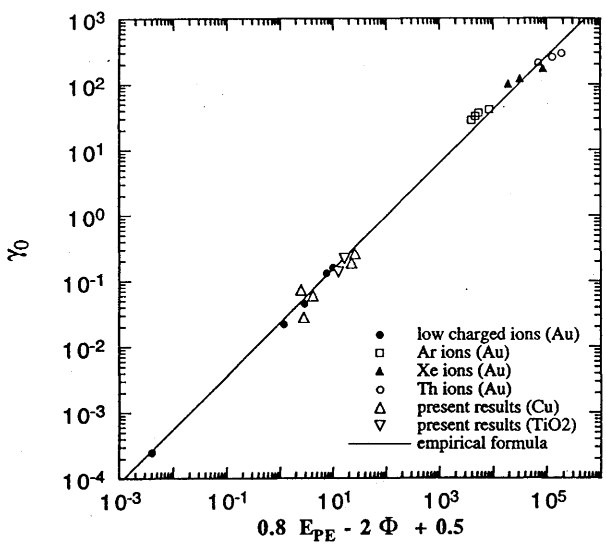

Fig. 1. γ_0 of clean Au, Cu and TiO_2 targets as a function of the potential energy parameter ($0.8\ E_{PE} - 2\ \Phi + \alpha$) of the incident ions.

References

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