Surface and Depth Profile Analyses by the Ion Induced Light Emission

V. 36 Surface and Depth Profile Analyses by the Ion Induced Light Emission

Shinozuka T., Hino Y.* and Sato S.**
Cyclotron and Radioisotope Center, Tohoku University
Department of Nuclear Engineering, Tohoku University*
Daini Seikōsha Co., Ltd.**

Ion beam induced light emission has been measured and applied for surface analyses. Samples of Al, Si, SiO_2, V, Cu, Brass and Ta were bombarded by 60 keV Ar^+ ion beams, and visible photon spectra from excited sputtered atoms were measured. The H_α line (~6563 Å) from the sputtered hydrogen atoms was also observed, and the hydrogen concentration at the target surface was estimated.

The optical radiation observed during ion bombardments of solids is due to radiation from excited states of sputtered surface constituents, radiation from excited states of backsattered beam particles and radiation resulting from the excitation of electrons in the solid. The spectra from the first and second of those have the characteristic lines and the third has the broad continuum which was observed in many solid material studies.[1] It is the first of these mechanisms which enables the analysis of surface composition. Especially, this method has a good feasibility to become one of a few tools for measuring hydrogen and other impurities of light elements at the solid surface. In addition to this composition analysis, line intensity measurements taken as a function of bombardment time can be used to provide the depth profile, since surface atoms are continuously removed by sputterings.[2]

In metallic targets, besides the de-excitation process by emitting radiation, an excited atom leaving the surface can also de-excite by non-radiative process such as resonance and Auger transition between the atom and the solid surface. In insulators, these radiationless processes are thought to be absent because of the large forbidden energy band gaps at the solid surface. As a results, the photon emission process is more dominant for insulating targets than metallic targets.[3] Up to present, however, there are no satisfactory unifying teory on the excitation and de-excitation mechanisms. Systematic experimental studies are necessary to provide a better understanding of the light emission process. This paper reports our experimental system of light emission measurements and preliminary results of composition and depth profile analysis.

The CT-50 grating monochrometer (Japan Spectro scopic Co. Ltd.) is equipped with a grating mirror of 1200 lines/mm and a low noise photomultiplier. The phototube (Hamamatsu R376) has multi-alkali cathode which covers 3000 ~ 7000 Å, so that it is very sensitive to the thermal noise. To reduce the thermal noise, the phototube was kept at -20°C during the measurement by Hamamatsu C659 phototube cooling system. The ISŌL (Isotope Separator On-Line) in Cyclotron and Radio Isotope Center of Tohoku Univ. was used to provide a mass separated Ar^+

ion beam in the range of 30 to 100 keV.[4] The sample was placed on the beam axis and its surface was at an angle of 45°. The monochrometer was looking the sample surface through the quarts lens system and a quarts window to hold a vacuum. The axis of the lens system is perpendicular to the beam axis. Emitted photon spectra were collected and stored in 4096 channel M. C. S. (ORTEC). As for the depth profile, wave length of the spectrometer was set at some intense line (such as 6563 Å of H_α), and the intensity was recorded as a function of bombarding time or beam current.

Spectral lines for Al, Si, SiO_2 and copper coated Si samples were measured. The photon spectrum for copper coated Si sample is shown in fig. 2, which clearly shows characteristic lines from the major constituent elements of the sample. The intense hydrogen lines are probably due to hydrogens contained in the sample, that were also observed on the other samples. Argon line are from the back-scattered bombarding ions. As can be seen, the background levels were low enough to identify the major constituents (about 1:100 for H_α lines). The wave length was calibrated using the Cu lines and each line was identified by ref.[5]. The variation of the H line intensity vs. bombarding time is shown in fig. 3. The sample was SiO_2. During the measurement the beam current of 50 keV Ar^+ was kept constant to 20 μA. The intensity decreased to about one third of the initial value in 20 min. It is suspected that this variation reflects the consentration profile of hydrogen in the sample surface.

Although any attempts to search the dependency on other parameters were not made, the feasibility and efficiency of this method as a surface analysis technique was comfirmed by these preliminary experiments.

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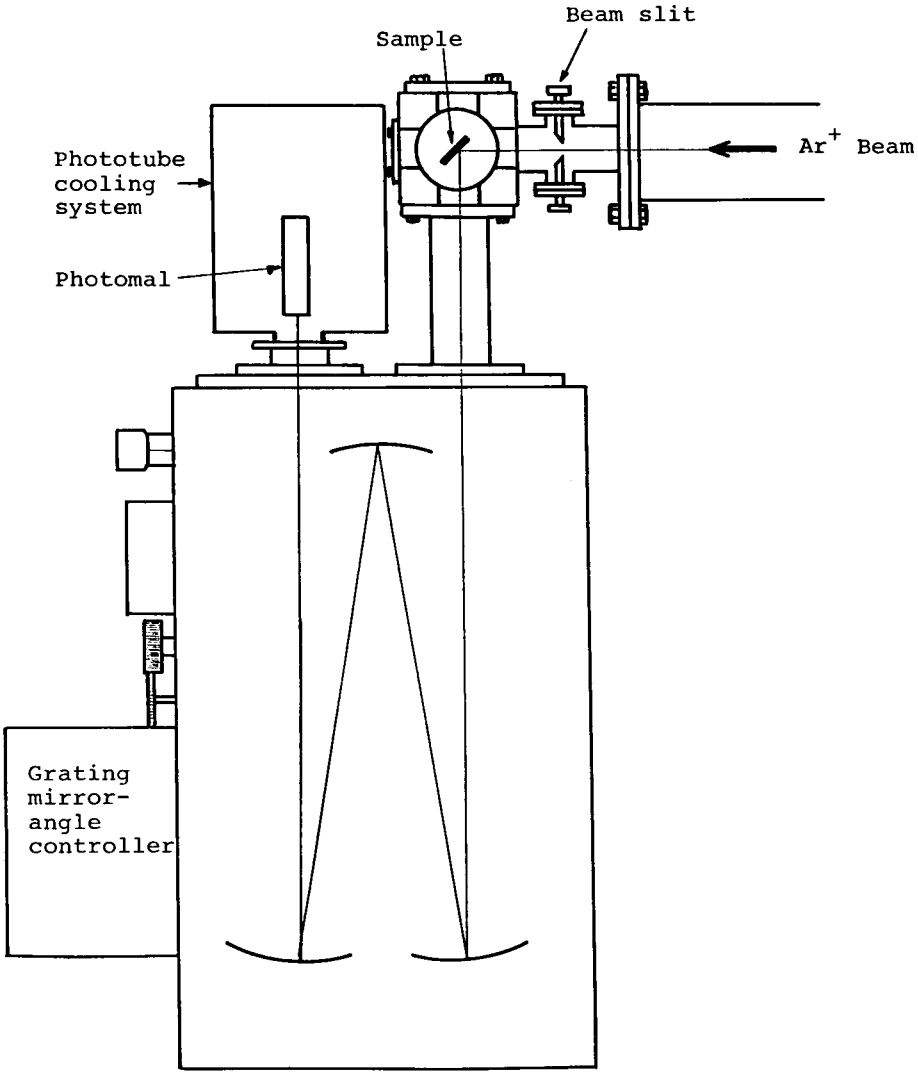

Fig. 1. The Experimental Set-up.

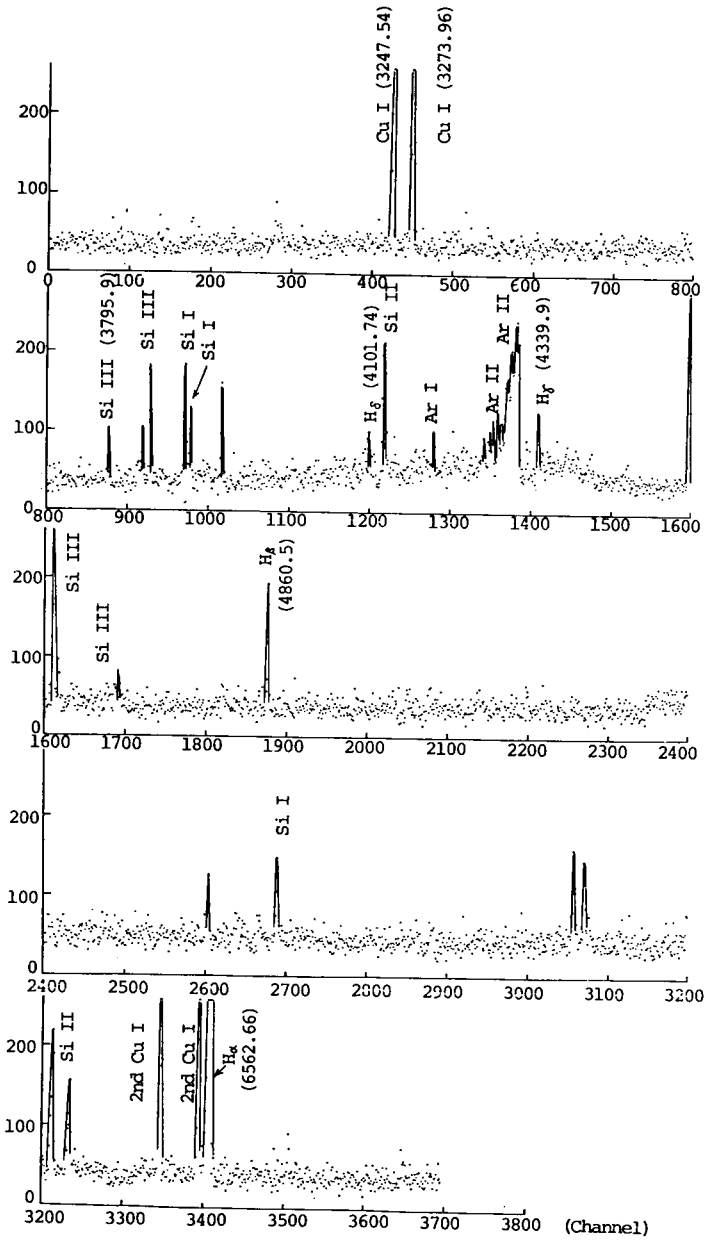

Fig. 2. Emitted photon spectrum due to Ar^+ ion bombardment on the copper coated silicon surface.

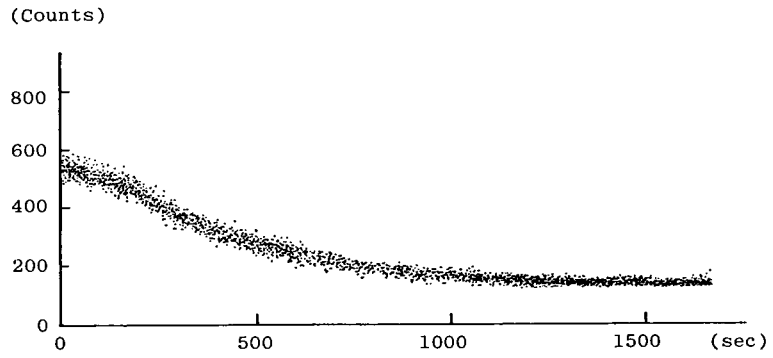

Fig. 3. The variation of the H_α line inteneity vs. bombarding time at SiO_2 surface.