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SHORT NOTE

A Combination Ion Source and Surface Ionization

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A simple ion source which is a combination of a conventional electron bombardment gas analysis source with that of single filament surface ionization was fabricated. As shown in Fig. 1, a filament for surface ionization was stretched in an ionization chamber for gas analysis a few millimeters apart from the electron beam path and parallel to it. The ionization chamber used was an open type being both sidewalls removed, and close to the chamber exit two half-plates were fixed for ion focusing and deflection. No exit deflector plates were needed and thus entire scheme was very simple and easy to mount. The source material was stainless steel, SUS 27. For surface ionization, a tungsten ribbon filament of 0.75 mm in width, 0.03 mm thick, and 10 mm in length was used and heated by a. c. current, and simultaneously it served as an ion repeller for both gas and solid analyses. The mass spectrometer was a machine of the copper analyzer tube of 15 cm in radius and 60° deflection with a wide slit in the collector to observe the peak shape of spectrum recorded.

Fig. 1. Scheme of ion source.

S: Hot filament for surface ionization used as a repeller, A: Ionization chamber, B: Ion focusing half-plates, I₁: Repeller current, E₁: Ion repeller voltage, E₂: Ion focusing voltage.

A mercury diffusion pump with a liquid nitrogen trap was equipped and the end vacuum in the analyzer tube measured by an ionization gauge calibrated for N₂ was nearly 5×10^{-7} Torr. The residual gas peaks when the pump was almost closed are shown in Fig. 2. Probably, the peak 28 might mainly be due to CO, since the

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Fig. 2. Spectrum of residual gas when pump was closed.

peak 32 increased only a little when the pump was closed showing that leak of air could be ignored. The ion accelerating voltage was kept at 2,000 volts throughout the experiment.

Neon gas was introduced for test analysis because of less background peaks. The peak shape of the spectrum recorded was fairly good as in the case of K^+ shown later in Fig. 4, and Figs. 3 (a) and (b) show the relation of the peak height of $^{20}Ne^+$ vs. the focusing voltage (E_2) and the optimum repeller voltage (E_1).

Figure 4 shows the spectrum of $^{39}K^+$ and $^{41}K^+$ obtained from a KCl sample coated on the surface of the ionization filament. It may seem quite well, but the abundance ratio $^{41}K/^{39}K$ varied in every run. The similar characteristics to those for $^{20}Ne^+$ were observed for the peak height of $^{39}K^+$ vs. the ion focusing and repeller voltages, but the peaks shifted remarkably in every experiment especially when the repeller

voltage was changed.

To check the cause of variation in the K^+ beam, the following observations were carried out:

(1) Building-up. During this observation the ion repeller voltage was kept to be zero. It had been supposed that a few tens minutes would be required before the surface ionization source got stable. Figure 5 shows the building-up characteristics of the $^{39}K^+$ beam recorded after switch-in. As is seen, the characteristics were almost anomalous and irreproducible. Several records seemed to show the tendency, however, that when the filament heating current was set to a higher value than that in a previous run and a new start was made, the building-up curve showed an overshoot before getting into a normal decreasing characteristic, and on the other hand, when the starting current was the same value as in a previous run, or when the current was increased during a run,

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Fig. 3 (a). $^{20}\text{Ne}^+$ peak height vs. focusing and repeller voltages.

Fig. 3 (b). $^{20}\text{Ne}^+$ peak height vs. repeller voltage.

Fig. 4. Spectrum of $^{39}\text{K}^+$ and $^{41}\text{K}^+$.

the building-up curve showed a monotonous exponential-like increase or a sudden increase followed by a slow decrease.

(2) Effect of Repeller Voltage. As in the case of gas analysis, the application of proper repeller voltage which depended on the location of the filament and the ion focusing voltage tended to increase the intensity of the ion beam from the hot filament, too. But it was observed that the sudden impression of a repeller voltage

Fig. 5. Building-up characteristics of $^{39}\text{K}^+$ beam.

caused a sudden abnormal increase of the ion current and then this decreased rather rapidly to a intensity higher or sometimes lower than before, and when once a repeller voltage was applied, the peak height vs. the repeller voltage characteristic had been changed to some extent. Thus, it

was almost impossible to set a repeller voltage precisely in its optimum value by adjusting it back and forth. An example observed is shown schematically in Fig. 6.

(3) Effect of Vacuum. When N_2 gas was introduced into the ionization chamber to the amount of about 5×10^{-5} Torr, the

Fig. 6. Effect of repeller voltage on $^{39}\text{K}^+$ beam.

Fig. 7. Effect of residual gas on $^{39}\text{K}^+$ beam.

$^{39}\text{K}^+$ beam from the hot filament decreased to some extent, but in this case, as the $^{39}\text{K}^+$ spectrum was somewhat flattened by scattering, no obvious effect of N_2 on surface ionization was observed. A similar effect was observed for H_2 gas, too. On the other hand, however, as is shown in Fig. 7, when the diffusion pump was nearly closed and the pressure of the residual gas in the analyzer tube increased, the peak height of $^{39}\text{K}^+$ increased gradually to a higher stable value after a short-term drop, and a sudden evacuation reduced the peak to its normal height within a short time. This seemed to suggest that H_2O , CO , O_2 , etc. would have some effect on surface ionization.

(4) Effect of Ion Accelerating Voltage. After a long transient period had passed, the $^{39}\text{K}^+$ beam began to decrease slowly, which might be the case expected. However, during this decreasing period, when the ion accelerating voltage was turned off, the decrease had been stopped until the accelerating voltage was turned on again. The effect is shown in Fig. 8, and it seems that the ion current drawn out from a hot filament by electric field causes

the decrease of ion supply more than that due to evaporation.

(5) Effect of Electron Beam. The electron beam for gas analysis was turned on and off during the $^{39}\text{K}^+$ beam was being recorded. The electron beam was accelerated to 70 volts and was collimated carefully to be caught on a trap electrode by a source magnet so as no electron would hit the surface of the hot filament. During a run without the electron beam and repeller

Fig. 8. Effect of ion accelerating voltage on $^{39}\text{K}^+$ beam.

Fig. 9. Effect of electron beam on $^{39}\text{K}^+$ beam.

voltage, the electron emission current from the hot filament heated by 4.1 amp. a. c. current, for example, was $6.4\ \mu\text{A}$, but when the electron beam of $80\ \mu\text{A}$ in the trap current was passed the emission from the hot filament decreased to $5.7\ \mu\text{A}$, and this would show that some electron flow hit the hot surface. Figure 9 shows a remarkable increase in the $^{39}\text{K}^+$ current

from a new surface up to more than several hundreds times at the instant when the electron beam of $80\ \mu\text{A}$ was turned on. The current decreased rapidly at once and then it tended gradually toward a steady value of several tens times stronger than before within nearly ten minutes. There observed no change in the peak shape of $^{39}\text{K}^+$ in this "double" ionization except in its intensity. After the electron beam was turned off, the $^{39}\text{K}^+$ beam dropped suddenly but to a somewhat stronger intensity than that obtained before the baptism of an electron beam, and once an electron beam had been passed, there appeared no serious transient phenomenon in the ion current as shown above but a simple increase when the electron beam was turned on again. Probably these facts would suggest some after-effects on the surface of the hot filament due to electron bombardment. The temperature variation brought with turn-on and -off of the electron beam would also affect the ion current, of course.

It is not intended to get any conclusion from above observations, of course, but it seems likely that the surface ionization phenomenon is too sensitive to residual gases, external field, electron bombardment as well as to temperature to expect to get fine results easily. Further studies on individual items will be carried out and reported elsewhere.