United States Patent [19]

Schillalies

[11] **3,859,226**

[45] **Jan. 7, 1975**

[54] **SECONDARY ION MASS SPECTROSCOPY**

[75] Inventor: **Helmut Schillalies**, Rondorf, Germany

[73] Assignee: **Leybold-Heraeus-Verwaltung G.m.b.H.**, Koln(Bayental), Germany

[22] Filed: **Nov. 12, 1973**

[21] Appl. No.: **414,768**

[30] **Foreign Application Priority Data**

Nov. 11, 1972 Germany 2255302

[52] **U.S. Cl.** **250/282,** 250/292, 250/309

[51] **Int. Cl.** **H01j 37/26**

[58] **Field of Search** 250/309, 307, 282, 292

[56] **References Cited**

UNITED STATES PATENTS

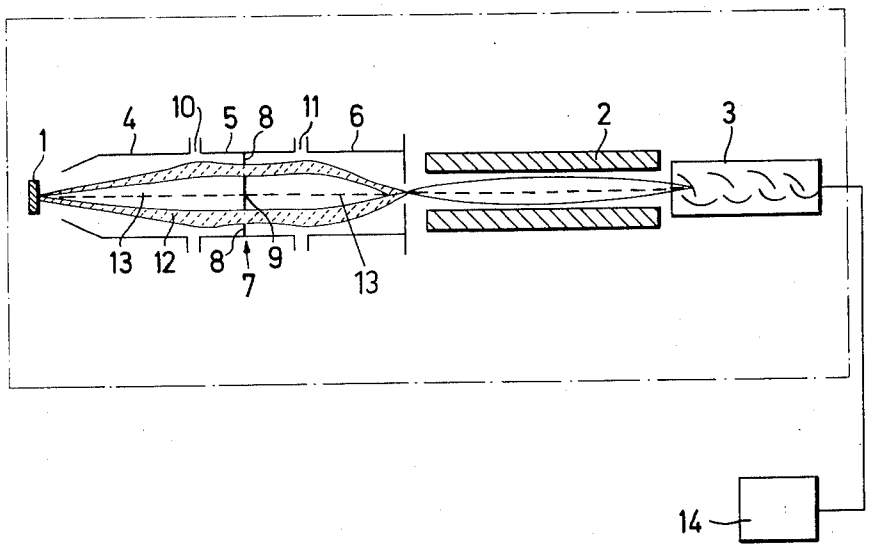
3,501,630 3/1970 Brubaker 250/292

Primary Examiner—Archie R. Borchelt
Assistant Examiner—C. E. Church
Attorney, Agent, or Firm—Spencer & Kaye

[57] **ABSTRACT**

In a secondary ion mass spectroscopic instrument including a source of ions to be measured and a quadrupole mass analyzer, a baffle is disposed in the instrument between the source and the analyzer so as to block direct line-of-sight communication therebetween and thereby prevent fast neutral particles, photons and fast electrons and reflected fast ions from reaching the analyzer.

8 Claims, 2 Drawing Figures



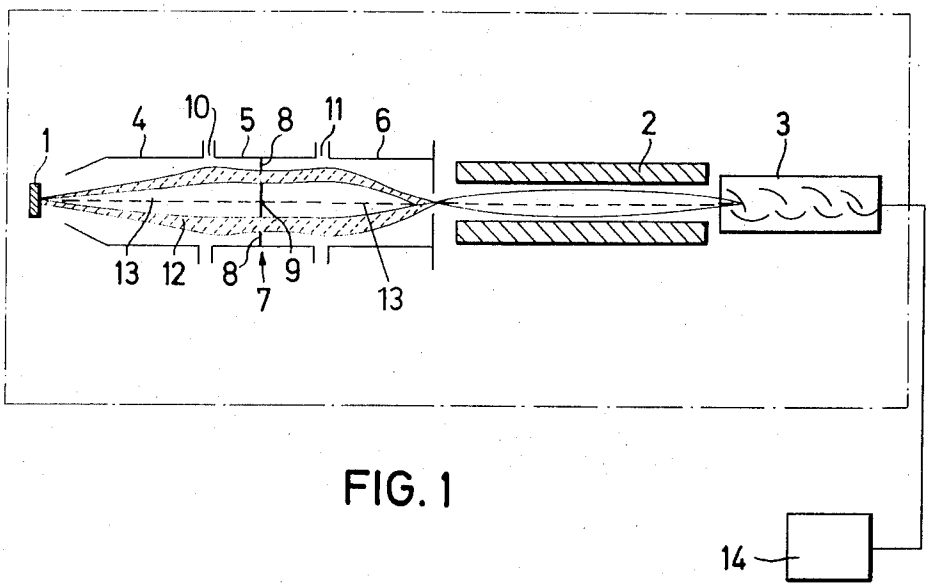


FIG. 1

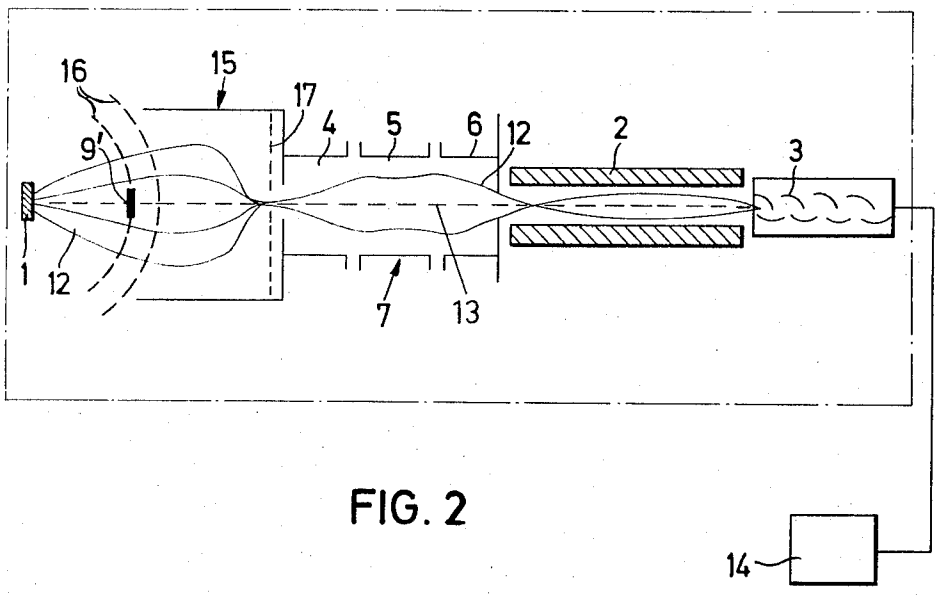


FIG. 2

SECONDARY ION MASS SPECTROSCOPY

BACKGROUND OF THE INVENTION

The present invention relates to secondary ion mass spectroscopy, and particularly to apparatus for this purpose which includes a probe from which the ions emanate, a quadrupole mass analyzer for the ions, and a secondary electron multiplier for detecting the ions.

Devices of this type are known and are described, for example, in the periodical "The Review of Scientific Instruments," Volume 42, No. 1, at pages 44 et seq (New York).

When such known devices are used for secondary ion mass spectroscopy, there often exists an interfering background, or noise, produced by fast neutral particles, photons and fast electrons and reflected fast ions. This can be eliminated by arranging the secondary electron multiplier which is disposed at the output of the quadrupole analyzer, to be axially offset or rotated by 90° and by deflecting the ions leaving the quadrupole analyzer with the aid of a suitable deflecting field.

Such devices, however, are not completely satisfactory, since, on the one hand, further tertiary particles can be produced at the input of the secondary electron multiplier and, on the other hand, a relatively large portion of the ions to be detected can be lost if, as often occurs, the deflecting field is not accurately aligned. Finally the devices for producing the deflecting field are mechanically complicated and thus expensive.

SUMMARY OF THE INVENTION

It is therefore the object of the present invention to provide a device for secondary ion mass spectroscopy, including a probe from which the ions emanate, a qaudrupole mass analyzer for the ions and a secondary electron multiplier for registering the ions, which does not exhibit the above-described drawbacks.

These and other objects according to the present invention are achieved by disposing a baffle, which prevents direct line-of-sight communication, in such device between the probe and the entrance plane of the quadrupole mass analyzer. Such a baffle could be formed as a plane circular metal foil and prevents interfering particles of the type mentioned above from entering directly into the quadrupole mass analyzer and passing therethrough. The danger of the production of annoying tertiary particles in the region of the exit plane of the quadrupole is also eliminated so that the secondary electron multiplier need no longer be axially offset or rotated. The comlicated devices for producing the draw field can also be eliminated.

It is particularly advantageous to arrange the baffle within an electrostatic lens which is disposed between the probe and the quadrupole mass analyzer. Such an electrostatic lens can be so designed that the ions travel around the baffle, so that the intensity loss of the ion stream due to the baffle will be low.

In an advantageous embodiment of apparatus according to the invention, the lens is composed of three tubes which form two tubular lenses. The baffle is here arranged in the center tube and is connected thereto to be at the same electrical potential as the center tube. The electrostatic properties of such a lens can be selected so that particle paths in the center portion of the lens extend parallel to the axis. The baffle in the center tube does not create any interference with the potential distribution with the lens since the baffle is at the same potential as the center tube. The significant advantage of such a lens is that a characteristic analagous to that producing a strong chromatic color error in an optical lens will automatically result, particularly with a focal length which is selected to be relatively short. This property can be utilized to effect a rough energy analysis of the particles.

The chromatic aberration effects of a lens can be represented by the following equation:

$$\delta_F = \alpha\ (\Delta E/E)\ C_F,$$

where

δ_F is the diameter of a beam at the focal point of the lens,

α is the convergence angle of the beam toward the focal point,

E is the mean energy of the beam,

ΔE is the beam energy deviation range, and

C_F is the chromatic aberration constant of the lens.

Those particles which present large convergence angles α produce a large spot with a diameter δ_F. Thus, short focal lengths are preferred for producing large chromatic aberrations. Since the axial portion of the beam is blocked, those particles with a large ΔE will not reach the quadrupole entrance.

Since the ions to be analyzed in secondary ion mass spectroscopy generally have an intensity maximum between 2 and 10eV with an intensity distribution which tapers toward higher energies, the higher energy particles often impede the analysis of those masses which have a lower energy value directly adjacent to that of masses with high energy. The above-described rough energy analysis effected by the lens connected ahead of the quadrupole prevents the occurrence of these undesired effects.

Finally, the tubular lenses permit accurate adaptation of the lens to the acceptance characteristics of the quadrupole so that the device can be operated in its best possible manner. Within the scope of this requirement it is finally advantageous for the probe to be disposed in the focal plane of the tubular lens facing the probe and for the focal plane of the second lens to lie in the entrance plane of the quadrupole mass analyzer.

A further advantageous solution of the problem of the present invention involves disposing the baffle within an energy analyzer located between the probe and the quadrupole mass analyzer. The energy analyzer may be a known analyzer which is suited for focusing decelerated particles. Such a combination of a known energy analyzer and a quadrupole mass analyzer has been found to be particularly suitable. Between the energy analyzer and the mass analyzer there need merely be provided a decelerating device for the ions. This decelerating device may be constituted, for example, by a grid or an electrostatic lens. A lens connected therebetween also permits adaptation of the energy levels and acceptance characteristics of the energy analyzer to the quadrupole system. The cutting out of the center beam is then assured already by the baffle disposed in the analyzer.

A baffle according to the invention can be inserted in any known mass spectroscopic apparatus employing a quadrupole mass analyzer.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic cross-sectional view of one preferred embodiment of the invention.

FIG. 2 is a view similar to that of FIG. 1 of a second preferred embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows the basic elements of apparatus according to the invention which includes a probe, or sample, from which the ions to be analyzed emanate. A known quadrupole mass analyzer **2** is provided for the mass analysis of these ions. Such analyzers are known to be composed of four parallel cylindrical rods, pairs of which are provided with superposed alternating and constant voltages which filter out all ions except those of a predetermined mass. The measurement of the ions passing through the quadrupole **2** is effected with the aid of a known secondary electron multiplier **3.**

Between the probe **1** and the quadrupole **2** there is disposed an electrostatic lens **7** composed of three tubes **4, 5** and **6.** In the center **5** a baffle **9** is mounted through the intermediary bars **8** to prevent a direct line-of-sight communication between probe **1** and the entrance plane of the quadrupole **2.**

The electrostatic focussing properties of the tubular lenses **10** and **11** formed by tubes **4, 5** and **6** are selected so that the probe **1** lies in the focal plane of lens **10,** the entrance plane of quadrupole **2** lies in the focal plane of lens **11,** and the particle paths **12** in the region of the center tube **5** extend parallel to the lens axis **13.** Thus lens **7** is simultaneously suited for producing a rough energy analysis. The ions penetrating the quadrupole **2** are measured, or detected, by the secondary electron multiplier. The signals produced thereby are processed by the electronic system shown as block **14,** which can be of any well known type currently used for this purpose and which, therefore, will not be described in detail.

In FIG. **2,** an energy analyzer **15** is additionally disposed between lens **7** and probe **1.** Such an arrangement is known and is described, for example, in the periodical "Journal of Applied Physics," Volume 43, No. 5, at page 2291 (New York).

The baffle **9'** in this embodiment is mounted inside analyzer **15** in a manner not illustrated in detail. Thus a line-of-sight communication between probe **1** and the secondary electron multiplier **3** is avoided.

The energy analyzer **15** includes deceleration grids **16** and a draw grid **17** producing the requisite acceleration field, with the aid of which the energy of the ions passing around baffle **9** is analyzed.

In order to decelerate the ions leaving the energy analyzer **15** to the entrance speed suitable for the quadrupole **2,** a suitable deceleration unit is provided. In the illustrated embodiment this is lens **7** of FIG. **1,** with baffle **9** removed. This lens may be replaced, however, by a known deceleration grid or any like known element disposed in the exit region of the energy analyzer **15.**

The arrangement shown in FIG. **2** has been found to be very advantageous since it permits the realization of an improvement in the energy resolution without interfering with optimum adaptation to the input requirements of the quadrupole **2.**

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. In a secondary ion mass spectroscopy apparatus composed of a probe from which the ions to be measured emanate, a quadrupole mass analyzer presenting an entrance plane for the ions, and a secondary electron multiplier for receiving the ions to be measured, the improvement comprising baffle means disposed between said probe and said entrance plane of said quadrupole mass analyzer for blocking direct line-of-sight communication therebetween.

2. An arrangement as defined in claim **1** wherein the apparatus further includes an electrostatic lens disposed between said probe and said quadrupole mass analyzer, and said baffle means is located in said lens.

3. An arrangement as defined in claim **2** wherein said lens comprises three successive tubes which define two successive tubular lenses, and said baffle means is disposed in the center one of said tube and is placed at the same potential as said center tube.

4. An arrangement as defined in claim **3** wherein said probe has an ion emission surface disposed in the focal plane of that one of said tubular lenses which is nearer said probe and the focal plane of the other said lens lies in said entrance plane of said quadrupole mass analyzer.

5. An arrangement as defined in claim **3** wherein said lenses are given focal lengths which are sufficiently short to produce energy-dependent deflections.

6. An arrangement as defined in claim **1** wherein the apparatus further includes an energy analyzer disposed between said probe and said quadrupole mass analyzer, and said baffle means is disposed in said energy analyzer.

7. An arrangement as defined in claim **6** wherein said energy analyzer constitutes means for focusing slow particles.

8. An arrangement as defined in claim **7** further comprising ion deceleration means disposed between said energy analyzer and said mass analyzer.

* * * * *