

mined in part by the electrical applied to the diaphragm **39** (or the member **19** if the diaphragm **39** is omitted), which components therefore serve as electrode means for determining the potential comprised in the interface. In the case of a quadrupole mass analyzer, as shown in FIG. 1, they are typically grounded, but this is not always the case. As explained, the potential at which the ions enter the evacuated chamber, together with the plasma potential and other plasma conditions such as temperature and gas flow rates, determines the kinetic energy at which the atomic ions pass into the evacuated chamber. Although this energy is not predictable from the potentials and the plasma conditions it can be measured experimentally for ions of any given mass-to-charge ratio and providing the plasma conditions are not changed, will remain substantially constant. Thus, atomic ions of any given mass-to-charge ratio will enter the evacuated chamber **23** at a particular kinetic energy, which as the inventor has observed, is generally higher than the energy at which molecular ions enter the chamber.

Energy filtration means comprising a mesh grid electrode **40** connected by a lead **41** to a power supply **14** are disposed as shown in FIG. 1 to receive ions entering the evacuated chamber **23**. Efficient ion transmission from the hollow tapered member **19** to the energy filtration means is ensured by a series of electrostatic lenses schematically illustrated at **21**. The potential applied to the grid electrode **40** by the supply **14** is adjusted to prevent ions having lower energies than a given kinetic energy passing through the grid electrode. As explained, this kinetic energy is selected to be equal to the particular kinetic energy for ions of any given mass-to-charge ratio.

Ion mass filtering and detection means are provided by a quadrupole mass filter **22**, disposed in the evacuated chamber **23**, and an ion detector **24** comprising a converter electrode **26** and an electron multiplier **25**. signal from the multiplier **25** is amplified by an amplifier in a display unit **27** which in turn feeds a digital computer **28** and a terminal **29** to allow further processing of the data. The computer also controls the function of the quadrupole analyzer **22** and the potential applied to the mesh electrode **40** by the power supply **14**.

The quadrupole analyzer **22**, detector **24** and the data acquisition and control system comprising items **27**, **28** and **29** are conventional. Further, as explained, a magnetic sector analyzer may be substituted for the quadrupole analyzer **22**. PCT publication number W089/12313 describes a suitable interface for such an analyzer.

The method by which the apparatus illustrated in FIG. 1 is employed in the invention has been described above. In order to monitor atomic ions of a single mass-to-charge ratio the computer **28** is used to set the quadrupole analyzer **22** to transmit only ions of the desired mass-to-charge ratio to the detector **24** and to set the potential on the electrode **40** to the highest value at which those ions are transmitted. Any molecular ions of the same mass-to-charge ratio, typically of lower energy, will then be prevented from entering the mass analyzer.

In order to record part of (or the whole) mass spectrum of the atomic ions comprised in a sample, or to monitor several mass-to-charge ratios in a repetitive sequence, the computer **28** is arranged to set the mass analyzer **22** to the desired scan pattern and simultaneously adjust the potential on the electrode **40** according to the previous paragraph in sympathy with the changing mass-to-charge ratio set on the mass analyzer. The necessary potentials may be previously determined by calibration at particular mass-to-charge ratios, interpolating or extrapolating at mass-to-charge ratios where no data has been obtained.

However, it will be appreciated that if only a small range of mass is scanned (for example, a group of isotopes of a particular element) it may be sufficient to keep the potential on the electrode **40** at a constant value.

Referring next to FIG. 2, another preferred embodiment of apparatus according to the invention comprises the major components of the FIG. 1 embodiment (identified by the same reference numerals) with the exception of the chamber **20** and diaphragm **39**, the electrostatic lens system **21**, and the electrode **40**. In their place energy filtration means comprising a cylindrical mirror analyzer (CMA) **44** (discussed in detail below) is provided. The CMA **44** is arranged to focus the ions passing through the orifice in the hollow tapered member **19** on to the entrance aperture of the mass analyzer **22**, providing those ions have the particular kinetic energy. It further prevents the passage of ions having lower energy on account of its energy filtration properties. The CMA has a definable energy window and the width and the absolute mean position of the window can be synchronised with the scanning of the mass analyzer.

FIG. 3 illustrates in more detail a CMA suitable for use in the apparatus of FIG. 2. The CMA is a cylindrical on-axis device exhibiting no direct line of sight through the device (thereby preventing the passage of photons and neutral species). It comprises an inner cylindrical solid electrode **42** and an outer cylindrical electrode **43**. The method of operation of the CMA is well known and need not be discussed here. It should be pointed out, however, that the efficient combination of a CMA with a quadrupole analyzer is not straightforward because the CMA receives and focuses ions at an angle of about 42° to its axis whereas the quadrupole requires that the ions entering it have trajectories substantially aligned with the axis. In the CMA shown in FIG. 3 the interfacing is achieved by means of the shaped ends of the inner electrode **42** and the curved auxiliary electrodes **45**, **46**. The mode of operation of such a CMA and its combination with a quadrupole mass analyzer are fully disclosed in EP-A-0223520.

It will be appreciated, however, that other types of energy filters, such as electrostatic part-spherical or cylindrical analyzers, may also be used in the invention, and that such combinations may provide better resolution than the simple systems described above, resulting in improved discrimination between atomic and molecular ions, particularly at low mass-to-charge ratios.

I claim:

1. A method of determining the elemental composition of a sample by plasma mass spectroscopy comprising the steps of:

- a) introducing a said sample (**1**) into an inductively-coupled or microwave-induced plasma formed in an inert gas to generate atomic ions from the elements present in it;
- b) passing at least some of said atomic ions through a nozzle-skimmer interface (**15**, **19**) into an evacuated chamber (**23**), said interface comprising electrode means (**40**) for determining the electrical potential at which said atomic ions enter said evacuated chamber (**23**) so that atomic ions of a given mass-to-charge ratio enter said chamber with a particular kinetic energy; characterised by
- c) energy filtering the ions entering said chamber (**23**) to reduce isobaric interferences from molecular and multiple charged ions by setting the lower cut-off energy to said particular kinetic energy of said atomic ions of a given mass-to-charge ratio so as to prevent at least the molecular ions of approximately said given mass-to-