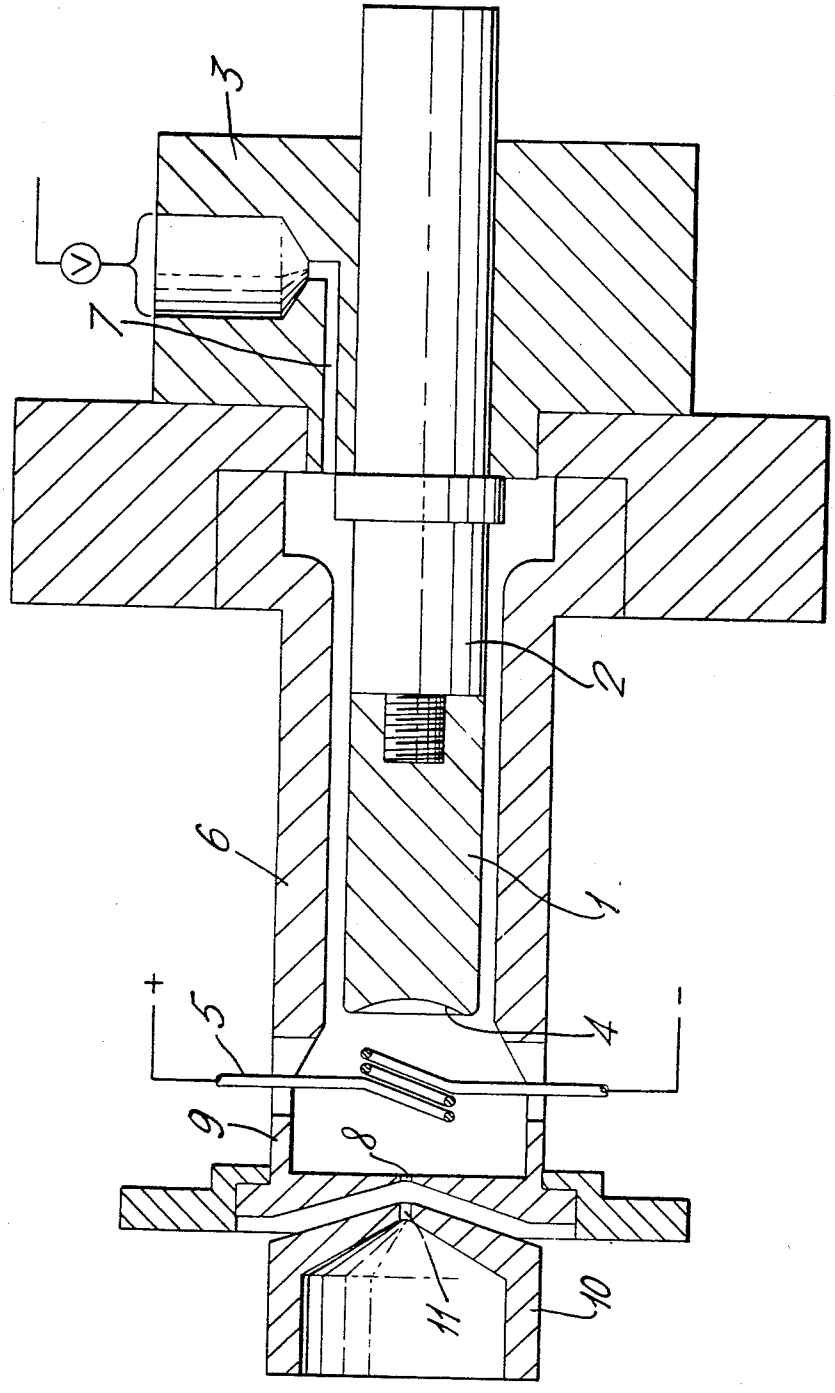
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SPUTTERING ION SOURCE FOR PRODUCING AN ION BEAM COMPRISING IONS OF A SOLID MATERIAL

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SPUTTERING ION SOURCE FOR PRODUCING AN ION BEAM COMPRISING IONS OF A SOLID MATERIAL

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ABSTRACT OF THE DISCLOSURE

A sputtering ion source for producing an ion beam comprising ions of a solid material has a helically coiled D.C. energized filament mounted in a low pressure gaseous atmosphere adjacent to and coaxial with an end surface of a first electrode formed of said material whereby electrons from the filament ionize the gas and the gas ions strike the electrode releasing atoms therefrom. These atoms are in turn ionized and the magnetic field of the filament tends to concentrate them on the axis. A further apertured electrode is provided to extract the ions thus concentrated on the axis and project them as a beam in a direction away from the first electrode.

This invention relates to ion sources.

Known ion sources commonly produce ions of inert gases. For some purposes, however, a beam comprising ions of a solid material is required, for example in investigating the damage resulting from the bombardment of a solid body with ions of the same or a different solid. Ion sources have been made for producing beams comprising ions of a metal, but these sources have had several disadvantages. Thus it is necessary for the metal to be vaporised initially, and this necessitates a very high temperature. To reduce the temperature which has to be attained a salt of the metal, frequently the metal chloride, has been used instead, but this has the further disadvantage of introducing chlorine ions into the beam produced. Also, in the case of some metals, for example gold, the chloride dissociates before it vaporises.

An object of the present invention is to provide a sputtering ion source in which these disadvantages are largely overcome.

According to the present invention, a sputtering ion source for producing an ion beam comprising ions of a solid material, includes a sputtering electrode having a surface formed of said material, means to energise the sputtering electrode, a coiled filament mounted adjacent said surface, means at least initially to supply a gas at low pressure to the region of the filament such that it emits electrons which ionise atoms of said gas and of said material produced by the collision of ions with said surface, the energised filament having an associated magnetic field which tends to concentrate the emitted electrons in the region of the axis of the filament, and an accelerating electrode positioned on the side of the filament away from said surface which electrode draws ions from the region of the filament to form said ion beam.

A sputtering ion source in accordance with the present invention will now be described by way of example with reference to the accompanying drawing, which shows a central cross section through the source.

The source will initially be described as producing a beam of copper ions. Referring now to the drawing, the source comprises a sputtering electrode **1** formed of copper and screwed on to a copper mounting **2** which passes out of the rear of the source through an insulator **3**. The forward end of the sputtering electrode **1** has a surface **4** which is closely adjacent a coiled tungsten filament **5**. The sputtering electrode **1** and the filament **5** are contained within a stainless steel housing **6** into the rear of which an inert gas such as xenon is passed by way of a bore **7** through the insulator **3**. Xenon is generally preferred to say argon as the heavier gas has a better sputtering ratio. At the forward end of the housing **6** is an ion exit aperture **8** formed in a graphite member **9**, and a graphite accelerating electrode **10** having an aperture **11** aligned with the aperture **8**.

Although not shown in the drawing, provision is made for cooling the source with air during use.

During operation the accelerating electrode **10** is maintained at earth potential, the housing **6** and hence also the member **9** at 1 to 20 kilovolts positive with respect to earth, the filament **5** at 0 to 200 volts negative with respect to the housing **6**, and the sputtering electrode **1** at 2,000 volts negative with respect to the housing **6**. The voltage across the filament **5** is about 3 volts and the current about 40 amps.

The operation is then as follows. Electrons driven off the filament **5** ionise atoms of xenon, some of the resulting xenon ions striking the surface **4** of the sputtering electrode **1** releasing atoms of copper. These copper atoms are also ionised by electrons from the filament **5**. This ionisation occurs in the region of the filament **5** because the magnetic field associated with the filament **5** tends to concentrate the emitted electrons near the axis of the filament **5**. The region of the filament **5** therefore contains a plasma which includes ions of copper and xenon. The accelerating electrode **10** draws these ions from the plasma so that a beam of these ions emerges from the aperture **11**.

To obtain satisfactory operation the pressure of xenon need only be about 10^{-3} mm. mercury initially, and in a particular embodiment of the source described the percentage of copper ions in the beam may for example be about 50% and the beam about 1 milliamp. This percentage tends to increase with the time since switching the source on. It can also be increased by decreasing the supply of xenon whilst adjusting the voltages to maintain the arc. In this way a self-supporting copper arc can be achieved and the resulting beam approaches 100% copper ions.

As the source can be made entirely of metal and glass, and as the apertures **8** and **11** are only about 1 mm. and 1.5 mm. respectively in diameter, the source is very suitable for use in association with low pressure equipment.

To produce a beam of ions other than copper, a sputtering electrode of the desired material is substituted. It will be appreciated that the operation is such that an ion beam can be obtained even from a material such as tungsten having a very high melting point. Where the material to be used is expensive, for example if gold is to be used, the mounting **2** can be extended so that the sputtering electrode **1** can be much shorter.

In addition to uses in the study of radiation damage, the source may, for example, be used in mass spectroscopy or mass separators. Furthermore, because a beam comprising a very high percentage of metal, say copper, ions can be achieved, the source can be used to produce electric conductors for printed electric circuits or microcircuits. The beam may either be sufficiently focussed to enable the desired pattern of conductors to be written, or a more diffuse beam may be used and the desired pattern obtained by masking.

We claim:

1. A sputtering ion source for producing an ion beam comprising ions of a solid material including a sputtering electrode having an end surface formed of said material, a filament formed by a helical coil mounted adjacent to said end surface with the axis of the coil intersecting said

end surface, duct means for at least initially supplying a gas at low pressure to the region of the filament, said filament being constructed such that when energized by a direct current it emits electrons which ionize atoms of said gas, and ions of said material are produced by the collision of said gas ions with said surface, the shape of said helical coil filament being such that the magnetic field created upon energization of the filament tends to concentrate the emitted electrons in the region of said axis, and including an accelerating electrode means positioned along the said axis on the side of filament away from the said surface for drawing ions from the said region to form said ion beam.

2. A sputtering ion source as claimed in claim 1 wherein said sputtering electrode is cylindrical and has an end of circular cross-section forming said end surface, the axis of said end surface being coincident with said coil axis.

3. A sputtering ion source as claimed in claim 2 including means for varying the pressure of the gas entering the ion source for varying the percentage of ions of said material in the said ion beam.

4. A sputtering ion source as claimed in claim 3 wherein the said material is copper and the said gas is xenon.

5. A sputtering ion source for producing an ion beam comprising ions of a solid material, including a sputtering electrode of cylindrical cross-section having an end surface formed of said material, a filament formed by a helical coil mounted adjacent to and coaxial with said end surface, a duct through which, at least initially, gas is supplied at a low pressure to the region of the filament, means for energizing the filament with direct current such that it emits electrons which ionize atoms of said gas and of said material produced by the collision of ions with said surface, the magnetic field associated with the energized filament being such as to tend to concentrate the emitted electrons in the region of the axis of the filament, and an accelerating electrode positioned on the side of the filament away from said end surface, which electrode draws ions from the region of the filament to form said ion beam.

6. A sputtering ion source as claimed in claim 5 wherein the pressure of the gas is regulated to vary the percentage of ions of said material in the ion beam.

7. A sputtering ion source as claimed in claim 6 wherein the said material is copper and the said gas is xenon.

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