United States Patent

[11] 3,566,185

[72] Inventor **Basil F. Gavin**
Berkeley, Calif.

[21] Appl. No. **806,649**
[22] Filed **Mar. 12, 1969**
[45] Patented **Feb. 23, 1971**
[73] Assignee **the United States of America as represented by the United States Atomic Energy Commission**

[54] **SPUTTER-TYPE PENNING DISCHARGE FOR METALLIC IONS**
8 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** **315/111,** 204/164, 204/192, 204/298, 204/312, 250/41.9, 313/63, 313/230
[51] **Int. Cl.** **H05b 31/26**
[50] **Field of Search** ..... 204/298; 250/41.9 (ISB) (ISE); 313/63, 230; 315/111

[56] **References Cited**

UNITED STATES PATENTS

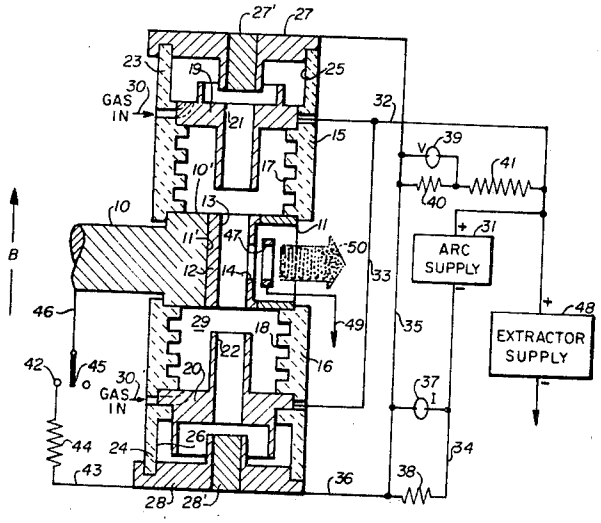
2,883,580 4/1959 Kilpatrick 315/111

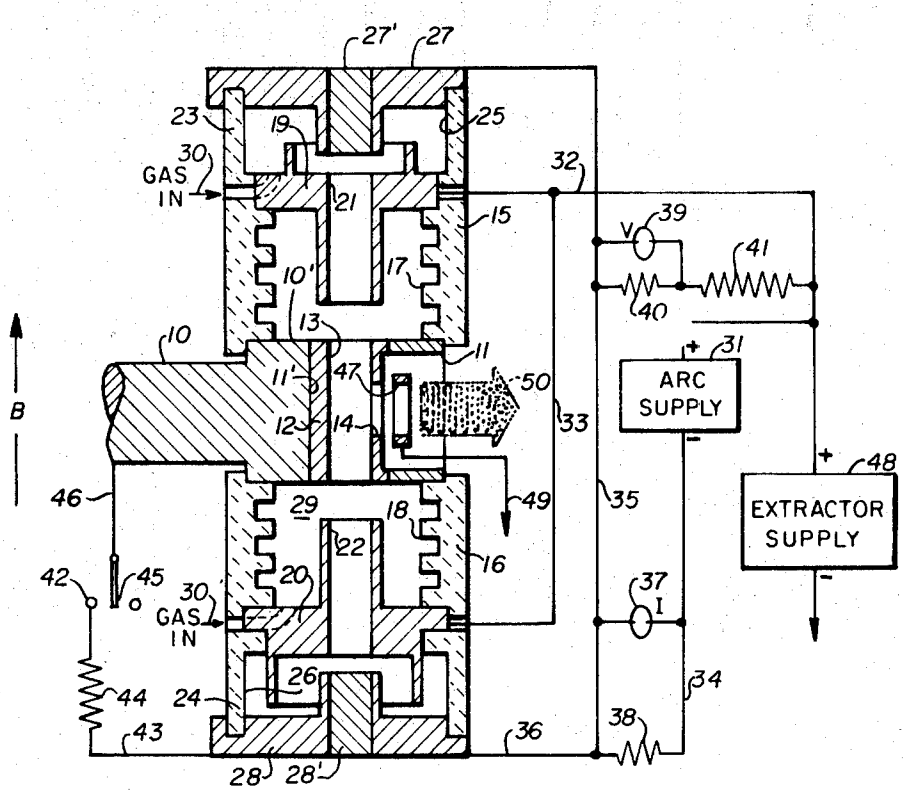
FOREIGN PATENTS

829,783 3/1960 Great Britain 204/298

Primary Examiner—Raymond F. Hossfeld
Attorney—Roland A. Anderson

ABSTRACT: An ion source in which ions of normally solid materials are easily produced. A plasma is generated in a gas adjacent the solid material from which ions are to be produced. The solid is negatively charged and the gas plasma ions bombard the solid, sputtering off ions of the solid. This is accomplished through the use of a Penning discharge with a cold cathode-type source and a centrally positioned and negatively charged dynode upon which the solid material is mounted, the dynode being electrically connected to the cathode and provided with an exit slit through which the metallic ions are extracted from plasma potential.





INVENTOR.
BASIL F. GAVIN

BY

ATTORNEY

SPUTTER-TYPE PENNING DISCHARGE FOR METALLIC IONS

BACKGROUND OF THE INVENTION

The invention described herein was made in the course of, or under, Contract No. W-7405-ENG-48, with the United States Atomic Energy Commission.

Electron discharge devices for electronically bombarding materials are well known in the prior art. However, much effort has been directed to eliminating the problems of the prior known devices associated with vaporizing materials at high temperature, based on the possibility of introducing sputtered atoms into an energetic, dense electron stream at a point where extraction in ionic form were physically feasible.

SUMMARY OF THE INVENTION

The above-mentioned problems have been solved by this invention by the utilization of the Penning or oscillating electron discharge, and in particular, with a cold cathode-type source, whereby sputtered atoms are introduced into an energetic, dense electron stream at a point where extraction in ionic form is physically feasible. Since the periphery of the plasma column, or electron stream in a gas, takes on a potential close to the most positive potential of the system, a negatively charged cylinder (dynode) made of desired material and containing the solid material to be ionized is inserted in the system and is bombarded by those ions exiting the plasma boundary. These ions are accelerated to full arc potential by electrically tying the dynode to the cathode, or to some fraction of the arc potential. These ions sputter close to their own number of metallic ions of the material into the arc and in turn serve to counter balance the greater ion loss evident when the dynode is at cathode potential (negative). The metallic ions produced are extracted from plasma potential by fitting the dynode with an exit slit through which the ions are driven by the negative potential on the dynode.

Therefore, it is an object of this invention to provide a discharge device for readily obtaining ions directly from solid material.

A further object of the invention is to provide a means for readily obtaining ions directly from solid materials by utilizing an oscillating electron discharge coupled by a cold cathode-type source and a negatively charged dynode containing the solid material.

Another object of the invention is to provide an ion source which introduces sputtered atoms into an energetic, dense electron stream at a point where extraction in ionic form is physically feasible, thus avoiding the prior problems associated with vaporizing materials at high temperature.

Other objects of the invention will become readily apparent from the following description and accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIG. is a cross-sectional view of an embodiment of the invention with the electrical circuitry therefor shown schematically.

DESCRIPTION OF THE EMBODIMENT

The embodiment of the invention illustrated in the drawing comprises a cylindrically shaped dynode 10 having an enlarged end section 10' including a flanged end portion 11 and an aperture 11' extending therethrough within which is mounted a piece of solid material 12 to be ionized, said material 12 being provided with aperture 13 extending therethrough and having a slit 14 in the side thereof, for example, ⅝ inch by 0.050 inch, which provides fluid communication between aperture 13 and the exterior thereof. For example, dynode 10 may be constructed of aluminum, while the material 12 to be ionized may be beryllium or calcium. Insulation members 15 and 16 having corrugated chambers 17 and 18, respectively, therein are secured to dynode 10 such that chambers 17 and 18 are in fluid communication with aperture 13 of material 12. Anodes 19 and 20 are mounted respectively on insulation members 15 and 16, the anodes being provided with central passageways 21 and 22, respectively. Insulator members 23 and 24 having respective cavities 25 and 26 are mounted on anodes 19 and 20 in spaced relation with insulation members 15 and 16 and function to support, in spaced relationship with anodes 19 and 20, cathodes 27 and 28, which are, for example, constructed of copper with titanium inserts 27' and 28' therein. Insulation members 15 and 16 and insulator members 23 and 24 may, for example, be a ceramic, while anodes 19 and 20 may be constructed of stainless steel. Cavities 25 and 26, anode passageways 21 and 22, chambers 17 and 18 and aperture 13 of material 12 form a chamber or cavity for support gas 29 supplied via gas inlets 30 and discharged through narrow slit 14 as described hereinafter. The support gas 29 may, for example, be nitrogen or argon or other suitable gas.

As shown schematically, anodes 19 and 20 are electrically connected to the positive terminal of an arc power supply 31 by leads 32 and 33, while the cathodes 27 and 28 are connected to the negative terminal of power supply 31 via leads 34, 35 and 36. An ammeter 37 is positioned between leads 34 and 35 across a resistor 38 in lead 34, while a voltmeter 39 is positioned between leads 32 and 35 across a resistor 40 and in series with a resistor 41. Cathode 28 is electrically connected to a switch terminal 42 via a lead 43, resistor 44, a switch 45 functioning to selectively interconnect terminal 42 with dynode 10 via a lead 46. Switch 45, for example, may be a lower internal impedance screen grid tube.

Positioned within the flanged end portion 11 of dynode 10 and in spaced relation to slit 14 of material 12 is a hollow extractor electrode 47. An extractor power supply 48 is electrically connected to arch power supply 31 via positive terminals thereof, electrode 47 being electrically connected to power supply 48 as indicated by lead 49. Extractor electrode 47 may, for example, be constructed of stainless steel.

As indicated by the arrow legended B in the drawing, a magnetic field is supplied, by an apparatus not shown, to produce the Penning or oscillating electron discharge within the above described apparatus as known in the art.

In operation, with the anodes 19 and 20 and 20), 27 and 28 connected to arc power supply 31 and operating in the magnetic field B, and with switch 45 closed thus connecting dynode 10 to the negative terminal of arc power supply 31 whereby material 12 is negatively charged with support gas 29 supplied via inlet 30, and with extractor electrode 47 connected to extractor power supply 48, the periphery of a plasma column, formed within support gas chamber by the Penning or oscillating electron discharge, as known in the art, takes on a potential close to the most positive potential of the system (anodes 19 and 20), negatively charged cylinder or dynode 10 makes the material 12 attached thereto negatively charged which will be bombarded by those ions exiting the plasma boundary. These ions can be accelerated to full arc potential, or some fraction thereof, due to the electrical connection of the dynode 10 to the cathodes 27 and 28. These ions sputter close to their own number of metallic ions of the material 12 into the arc and in turn serve to counter balance the greater ion loss evident when the dynode 10 is at cathode potential (negative). The metallic ions produced are extracted from the plasma potential through the slit 14 in material 12 by the extractor electrode 47, thereby producing a beam of metallic ions, indicated at 50, which for example, can be utilized in a linear accelerator, such as the Hilac (high linear accelerator).

It has thus been shown that this invention provides an apparatus or ion source in which ions of normally solid material are easily produced, this being done by generating a plasma in a gas adjacent the solid material from which ions are to be produced, the material being negatively charged, the gas plasma ions bombarding the solid, sputtering off ions of the solid which are extracted from the plasma.

While a specific embodiment of the invention has been illustrated and described, changes and changes will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications and changes as come within the spirit and scope of the invention.

I claim:

1. An apparatus adapted for operation in a magnetic field to produce an oscillating electron discharge for producing a beam of ions from a normally solid material comprising: a dynode means having secured thereto a material from which the ions are to be produced, said material having an opening therein, a pair of anode means insulatively spaced from said dynode means and having openings therethrough, a pair of cathode means insulatively spaced from said anode means, a support gas chamber defined by said openings in said material and anode means and space between said anode means and said dynode and cathode means, means for maintaining support gas in said chamber, electrical circuitry means for providing said anode means with a positive potential and said cathode and dynode means and said material with a negative potential, said material additionally being provided with a slit therein for providing fluid communication between said opening therein and the exterior thereof through which ions sputtered from said material are discharged, and extractor circuit means having an electrode thereof positioned adjacent said material slit for providing an extracting potential on ions sputtered from said material.

2. The apparatus defined in claim 1, additionally including switch means intermediate said dynode means and said cathode means for selectively electrically isolating or connecting said dynode means with respect to cathode means.

3. The apparatus defined in claim 1, additionally including a hollow insulating member positioned between said dynode means and each of said anode means, and a hollow insulator member positioned between said anode means and said cathode means, the hollow interior of said insulating members and said insulator members forming a portion of said support gas chamber.

4. The apparatus defined in claim 1, wherein said support gas maintaining means is located adjacent said anode means.

5. The apparatus defined in claim 1, wherein said support gas is an inert gas.

6. The apparatus defined in claim 1, wherein said dynode means is constructed of aluminum.

7. The apparatus defined in claim 1, wherein said anode means are constructed of stainless steel.

8. The apparatus defined in claim 1, wherein said cathode means are constructed of copper with a titanium insert therein, said insert being exposed in spaced relationship with said anode means.