HYDROGEN ION BEAM GENERATING ELECTRODE

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Filed: Dec. 8, 1970

Appl. No.: 96,145

U.S. Cl. 313/231, 313/63, 313/211, 313/217, 313/305, 313/311, 313/DIG. 8

Int. Cl. H01J 17/26

Field of Search 313/211, 305, 231, 311, 217, 313/218, 63, DIG. 8

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ABSTRACT

A hollow metallic electrode having a metallic mesh in the central portion thereof and a variable temperature heater for generating a hydrogen ion beam. By controlling the temperature of the electrode, its output is selectable from molecular hydrogen at temperatures below 1,500° K. to essentially pure monoatomic hydrogen for temperatures near or above 2,800° K. The combination of the electrode output and the source arc then allows a range of selection in ion source output composition of H⁺, H₂⁺ and H₃⁺. Above 2,800° K., the source output is essentially pure H⁺, from arc ionization of monoatomic hydrogen.

7 Claims, 3 Drawing Figures
Fig. 1

Fig. 2

Fig. 3

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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.

Hydrogen beam sources of the prior art usually produce a beam containing various combinations of $H_2^+$, $H_3^+$, and $H_4^+$, as dictated by the arc conditions. While such a beam is useful for investigating ion sources utilizing $H_2^+$, it is often desirable to use a pure beam of $H^+$ ions.

SUMMARY OF THE INVENTION

The inventive electrode for a hydrogen ion source features a hollow tube of tungsten or other suitable metal for producing $H^+$ exclusively, or a wide range of combinations of a mixed beam of $H_2^+$, $H_3^+$, and $H_4^+$. The tube is provided in the central portion thereof with mesh or wool of tungsten or other suitable metal and has a conically wound heating element concentrically about the beam output end of the tube for variably heating the tube for effecting the dissociation of hydrogen gas into atomic hydrogen. The arc ionizes molecular hydrogen into various mixtures of $H^+$, $H_2^+$, and $H_4^+$ or atomic hydrogen into $H^+$.

Therefore, it is an object of this invention to provide an electrode for the arc discharge of hydrogen ion beam source. A further object of the invention is to provide a means for dissociating molecular hydrogen gas to atomic hydrogen.

Another object of the invention is to provide a cathode for a hydrogen ion beam source with selectable beam composition.

Another object of the invention is to provide a cathode for a hydrogen ion beam generating electrode which utilizes a hollow tungsten tube for producing $H^+$ exclusively, or a wide range of combinations of a mixed beam of $H_2^+$, $H_3^+$, and $H_4^+$.

Another object of the invention is to provide a hydrogen ion beam generating electrode which utilizes a hollow tungsten tube having a tungsten mesh or wool in the central portion thereof and surrounded at the beam output end thereof with a conically wound heating element.

Other objects of the invention, not specifically set forth above, will become readily apparent from the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view, having a portion thereof cut away, illustrating an embodiment of the invention;

FIG. 2 illustrates a portion of another embodiment of the inventive cathode;

FIG. 3 is a graph showing tungsten temperature versus the percent of pure monoatomic hydrogen output.

DESCRIPTION OF THE INVENTION

The embodiment of the invention illustrated in FIG. 1 comprises an evacuated container 10 (only a portion being illustrated) which houses a hollow tungsten tube or cylinder 11, the central portion of tube 11 containing tungsten mesh or wool 12. If desired the tube 11 and mesh 12 can be made of either tantalum, molybdenum or rhenium or combinations thereof. A conically wound heating element indicated at 13 is concentrically spaced about the beam output end 14 of the tube 11. The opposite end 15 of tube 11 is formed in an inverted funnel shape through which molecular hydrogen $(H_2)$, as indicated by the arrow 16, is directed into tube 11, the molecular hydrogen 16 being supplied from a source not shown. Heating element 13 is connected through a variable switch or rheostat 17 to a power supply 18. By increasing the current in the heating col 13, the temperature within tube 11 increases so that the hydrogen gas 16 entering the tube 11 through end portion 15 thereof tends to dissociate into atomic hydrogen. As the temperature of the tungsten tube 11 approaches 2,800° K., hydrogen in the output end 14 of the tube 11 tends to become almost entirely atomic hydrogen $(H^+)$ due to thermodynamic dissociation. A concentric electrode 19 positioned near the end 14 of the tube 11 and coaxially aligned therewith is charged with a potential by a power supply 20 for creating an electric field between the electrode 19 and the tube 11. The electrode 19 tends to draw a hydrogen arc indicated at 21 from the output end 14 of tube 11; when the arc 21 is drawn in, nearly pure atomic hydrogen, mainly $H^+$ ions, is produced. This feature of an arc plasma consisting of essentially $H^+$ can be applied in any arc type ion source to change the source ion output to nearly pure $H^+$ ions.

FIG. 2 illustrates a partial alternate embodiment of the inventive apparatus wherein a hollow tungsten tube 25, having a tungsten mesh or wool central portion 26 and an inverted funnel-like hydrogen gas inlet end portion 27, is located coaxially within a hollow outer tube or cylinder 28 and electrically connected therewith at the open beam output end thereof as indicated by leads 29, so that tubes 25 and 28 can conduct a relatively high current therethrough for directly heating the hydrogen gas passing through the tube 25. The tungsten tube 25 and outer tube 28 are located within an evacuated housing or casing 30, and aligned with a concentric electrode as in FIG. 1 embodiment. Outer hollow casing 28 is connected through a variable control means 31 to an electrical power supply as indicated at 32. By directly heating the hydrogen gas, indicated by the arrows 33, greater system efficiencies can be obtained.

FIG. 3 is a graph of tungsten temperature $(T_w)$ versus the percent of pure monoatomic hydrogen $(\%H^+)$ output expected from the hollow cathode 11 of FIG. 1, for example. As the hollow tungsten cathode or tube 11 raises in temperature by the heating coils 13 the beam composition from the output end 14 of the tube rises in its percentage of $H^+$ until a limit is reached at approximately 2,800° K., the percentage $H^+$ being indicated as 93 percent at this temperature.

While it is possible to use materials other than tungsten to form the cathode 11, in general materials other than tungsten will require a temperature higher than 2,800° K. to achieve substantially over 90 percent ionized monoatomic hydrogen output. As pointed out above, while tungsten has been specifically described regarding the tube and mesh, tantalum, molybdenum or rhenium may be utilized for either or for both of these elements.

It has thus been seen that present invention provides a cathode for generating a hydrogen ion beam of selected composition. By controlling the temperature of the cathode, its output is selectable from molecular hydrogen at temperatures below 1,500° K. to essentially pure monoatomic hydrogen for temperatures near 2,800° K. The ion composition in the source arc then follows from a mixture of $H^+$, $H_2^+$ and $H_3^+$ for lower heater temperatures to nearly pure $H^+$ for temperatures near or above 2,800° K. Since the beam composition produced by the inventive ion source can be accurately controlled, it is particularly useful in energetic beam production for controlled thermonuclear reactors, for example.

While particular embodiments of the invention have been illustrated and described, modifications will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modification as come within the spirit and scope of the invention.

What we claim is:

1. An electrode for generating a hydrogen ion beam of selected composition comprising: a hollow tube means selected from the group consisting of tungsten, tantalum, molybdenum and rhenium, means through which molecular hydrogen gas is directed into said hollow tube means for dissociation thereof in said tube means, and means for heating said hollow tube means positioned around and in spaced relation to at least a portion of said tube means, said tube means including means for containing metallic mesh in the central portion thereof, said mesh being selected from the group consisting of tungsten, tantalum, molybdenum and rhenium.

2. The electrode defined in claim 1, wherein said hollow tube means and said heating means are positioned in an evacu-
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3. The electrode defined in claim 1, wherein said heating means comprises a conically wound heating element concentrically spaced about at least a portion of said hollow tube means, and means for adjustably controlling the temperature of said heating element.

4. The electrode defined in claim 1, wherein said heating means comprises a tube-like means positioned coaxially about said hollow tube means and electrically connected therewith, and means for adjustably controlling the temperature of said tube-like means and said hollow tube means.

5. The electrode defined in claim 1, wherein said gas directing means includes an end portion of said hollow tube means having an inverted funnel-shaped configuration.

6. The electrode defined in claim 1, wherein said hollow tube means includes an open beam output end and said gas directing means comprises an inverted funnel-shaped inlet end through which molecular hydrogen gas is adapted to be introduced; wherein said heating means includes a conically heating element concentrically spaced about said central portion and said open beam output end of said hollow tube means, and means for adjustably controlling the temperature of said heating element; and wherein said hollow tube means and said heating element are positioned in an evacuated housing means and in coaxial alignment with a concentric electrode means positioned in spaced relationship with respect to said open beam output end of said hollow tube means, and means for charging said concentric electrode means with a potential for creating an electric arc between said electrode means and said hollow tungsten tube means.

7. The electrode defined in claim 1, wherein said hollow tube means includes an open beam output end and said gas directing means comprises an inverted funnel-shaped inlet end through which molecular hydrogen gas is adapted to be introduced; wherein said heating means includes a tube-like means positioned coaxially about said hollow tube means and electrically connected therewith at said open beam output end, and means for adjustably controlling the temperature of said tube-like means and said hollow tube means, said tube-like means being positioned within an evacuated housing means.

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