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DEVICE FOR FORMING NEGATIVE IONS FROM IODINE GAS AND A LANTHANUM BORIDE CONTACT IONIZER SURFACE

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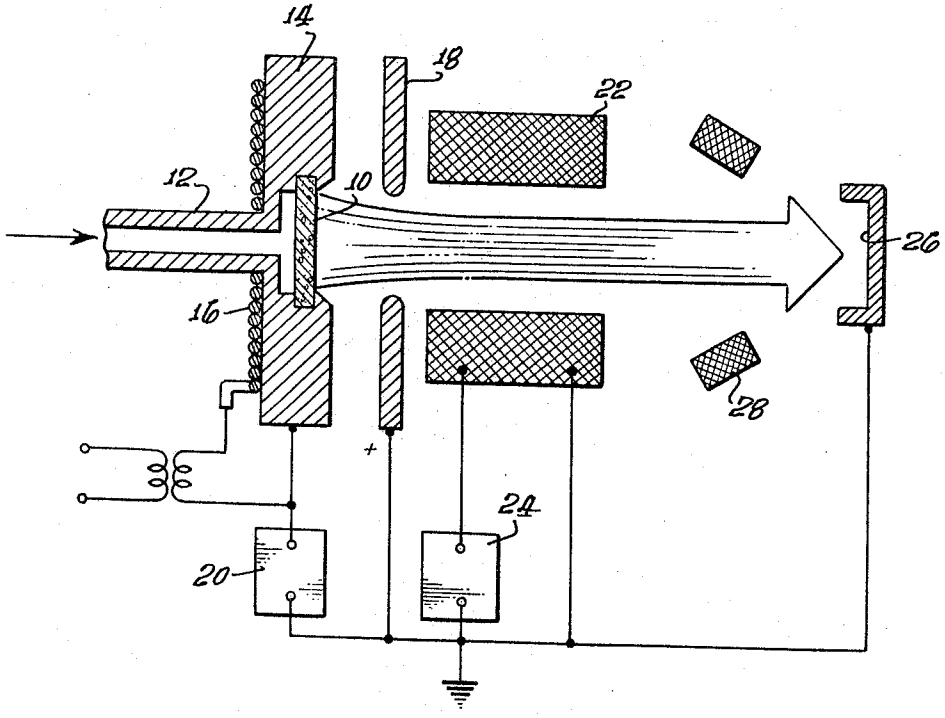

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DEVICE FOR FORMING NEGATIVE IONS FROM IODINE GAS AND A LANTHANUM BORIDE CONTACT IONIZER SURFACE

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This invention relates to improved negative ion sources and more particularly to a high intensity contact ionization negative ion source.

In the past, in the generation of negative ions using the surface contact method, the contact surfaces used were essentially of a high work function so that ion yields were correspondingly low.

In accordance with the present invention, negative ions are formed by a surface contact method in which the attachment of electrons to elementary neutral gas particles occurs while the gas particle is essentially in contact with an appropriate low work function surface.

The formation of negative atomic or molecular ions which appear as products evaporating from an adsorbed layer of gas particles can be explained in terms of the energy increments involved in the electron transfer from the surface to the gas particles. If the magnitude of the electron affinity of the elementary gas particles is greater than the work function of the contact surface, the electron transfer is preferred energetically and consequently the probability is very high that the evaporating gas particle will be a negative ion.

In general, to provide an efficient high intensity ionization source, the electron work function of the contact surface must be less in magnitude than that of the electron affinity of the neutral gas that is being ionized. The removal from the contact surface of ions which have been desorbed can be thereafter facilitated by application of high electric fields.

The work function of a surface defines the amount of energy that must be expended by an electron so that it may in general escape from a surface, such as the ionization contact surface. A low work function surface constitutes a lesser energy required for electron escape.

Various combinations of low work function surfaces and neutral gas species which have a higher electron affinity than the work function of the contact surface may be used for obtaining high yields of negative ions.

An object of the present invention is to provide a more efficient ion source having higher yields.

Another object is the provision of a more efficient contact surface for the negative ion formation of a neutral gas.

Another object is the provision of a negative ion source having various combinations of low work function surfaces and neutral gas species of sufficiently high electron affinity for obtaining high yields of negative ions.

Still another object is the provision of a high yield negative ion source wherein thermal electrons are removed from the ion beam.

Other objects and advantages will become more apparent as a description of a preferred embodiment proceeds, having reference to the drawing wherein is shown a schematic illustration of a preferred embodiment.

It is believed that a brief discussion of the properties and behavior of the essential part called the contact surface will be of help in understanding the present invention. When groups of atoms are massed together into solids or liquids, loosely bound electrons can readily pass from atom to atom. Because of the random velocity of these free electrons due to their temperature, these electrons are constantly moving about within the mass. It is these electrons that make metallic electrical conduction possible and play indispensable roles in the thermoionic initiative. An electron that happens to pass through the surface of the metal in the course of its random motion would, while it is still close to the surface, induce a positive charge on the surface of the metal. This induced charge results in a force that tends to return the electron into the metal. In order to escape from the metal, the electron must give up a certain amount of kinetic energy. The kinetic energy that an electron loses passing through the surface of the metal and far enough away to be beyond the range of the image forces is called the electron work function. The electron work function is different for different materials and varies greatly with the condition of the surface. The electron work function is reduced by strong electric fields at the surface and it varies from point to point on a given surface because of microscopic irregularities. It is smaller at the projections and larger in the hollows. The approximate electron work function of tungsten is 4.52 electron volts, barium, 2.0 and copper, 4.0. The presence of impurities in the metal may produce a marked change in the value of its electron work function, particularly when these impurities are at the surface. Such a layer may produce a very high field at the surface by virtue of the fact that it may be electropositive or electro-negative relative to the main metal. Thus, the presence of an absorbed layer of oxygen, which is electro-negative with respect to tungsten, results in a field that opposes the escape of electrons and therefore increases the electron work function of tungsten. The presence, on the other hand, of a monoatomic layer of thorium atoms or ions on the surface of tungsten reduces its electron work function remarkably. Pure metals having low electron work functions such as the alkali metals or calcium, can not be used as emitters in certain types of electron tubes because they vaporize excessively, but not necessarily, at temperatures which are of interest in the contact method of negative ion formation.

With the foregoing background information in mind, attention is now directed to the present invention wherein the effective work function for purposes of surface ionization is effectively less than the electron affinity of a neutral gas introduced thereto. In operation there are various ways in which the neutral gas can be introduced to the ionizer surface. For example, the gas may be directed onto the surface as a neutral beam or it may be diffusely introduced through a porous ionizer surface or introduced onto the ionizer surface from the edge of the ionizer surface. Various combinations of the low work function surfaces and neutral gases are possible for realizing highly efficient, high yield negative ion emission from the surface contact process, for example, lanthanum boride surfaces and iodine ions. Surfaces other than pure metals may be used in which a lower work function may occur from coatings such as cesium coated tungsten or from chemical compounds such as barium oxide. In all cases the low work function characteristic is to be preferably maintained during the operational time of the negative ion source.

The surface where the negative ion formation occurs may be heated to the point of thermal electron emission and means for removal of electrons from the negative ions are preferable. This is because the acceleration of electrons constitutes an unnecessary expenditure of energy and because monoisotopic beams are generally better adapted to specific applications.

Reference is now had to the drawing wherein is shown a porous surface ionizer **10**, positioned over the opening of the gas injector **12** by plate **14**. The ionizer may be formed of sintered powder, small holes in a composite

material or a matrix of small wire elements. This is heated through the plate by means of heater coils **16**. An accelerator electrode **18**, is positioned with an opening adjacent to the ionizer **10**, and biased by the accelerator power supply **20**. An electro- magnet **22**, powered by a magnet power supply **24**, is positioned around the negative ion beam resulting from the attraction of negative ions from ionizer **10** by accelerator electrode **18**. A purpose of the magnet is to separate electrons from the negative ion beam, which is directed toward a collector electrode **26**.

In operation gas molecules are adsorbed on the hot filament or porous surface ionizer **10**, where some molecules disassociate to become atoms which in turn are ionized and leave the filament as atomic negative ions or neutral atoms. If the negative ions exceed the neutral atoms by a large amount, then the process is considered efficient.

The transverse magnetic field created by magnet **22** bends the lighter particles more than the heavier ones. Since electrons are much lighter than negative ions, they deflect a greater amount. An electron catcher **28** is so positioned as to receive the deflected electrons and receive energy from them. Unless the electron catcher utilizes the energy it is wasted. If the magnet **22** is sufficiently close or is sufficiently powerful to turn the electrons back to again strike the porous surface of ionizer **10**, from which they were emitted, then substantially no energy is lost.

Having thus described a preferred form of the present invention, it is to be understood that such description was for illustrative purposes only and that the scope of this invention is not to be limited thereby. Other embodiments, alterations and modifications will become readily apparent to those skilled in the art and are intended to become part of the present invention, as set forth and defined by the following claims.

What is claimed is:

1. A high yield surface contact ionization negative ion source comprising:

(a) a contact ionizer surface of lanthanum boride;

(b) means for introducing iodine gas onto said contact ionizer surface;

(c) means for heating said surface to evaporate negative ions therefore at a rate sufficient to avoid collection of negative ions thereon; and,

(d) means for collecting negative ions evaporated from said contact ionizer surface and forming a negative ion beam, said means comprising an accelerating structure disposed near said contact ionizer surface and maintained at an electrical potential with respect thereto.

2. A high yield surface contact ionization negative ion source as defined in claim **1**, wherein said contact ionizer surface is porous.

3. A high yield surface contact ionization negative ion source as defined in claim **2**, wherein said gas is introduced onto said surface by diffusion through the porous material.

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