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To be presented at the American Vacuum Society
31st National Vacuum Symposium, Reno, NV,
December 4-7, 1984

H^- ION PRODUCTION FROM DIFFERENT CONVERTER MATERIALS

K.N. Leung and K.W. Ehlers

October 1984

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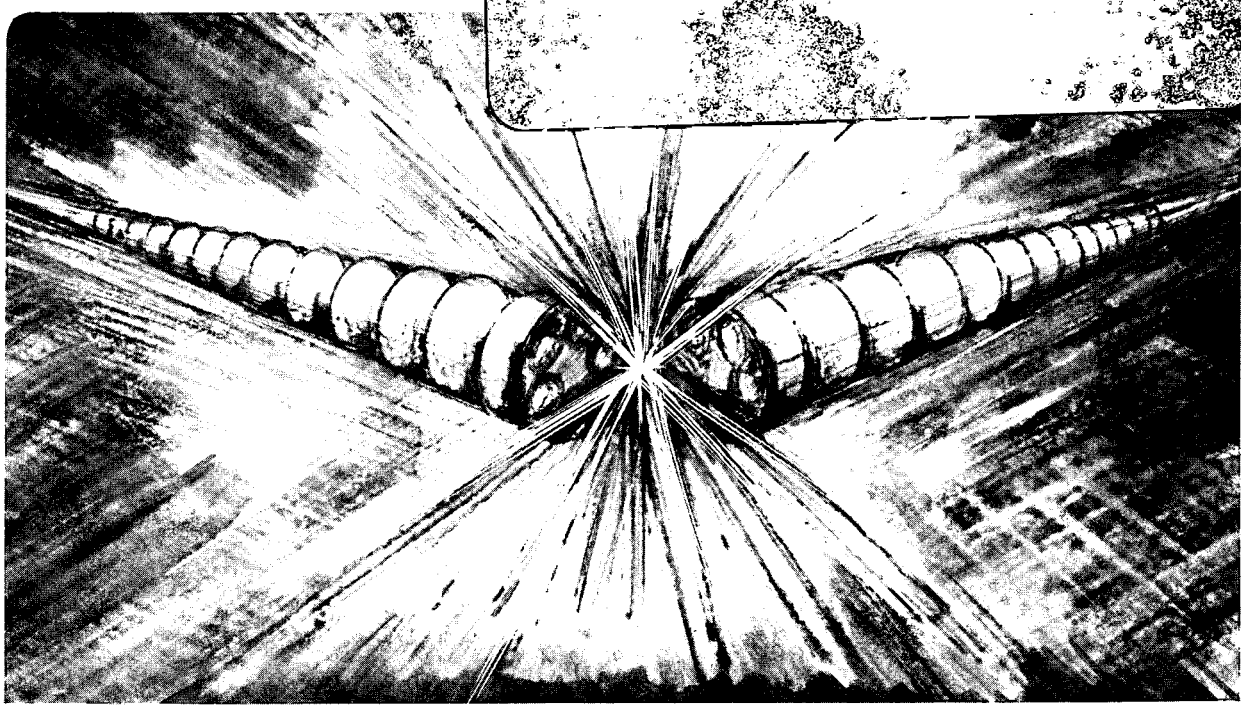

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Prepared for the U.S. Department of Energy under Contract DE-AC03-76SF00098

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For heating plasmas and for current drive in some fusion reactors, high energy neutral beams may be required.[1] The high neutralization efficiency of H^- or D^- ions makes them favorable to form neutral atoms with energies in excess of 160 keV.[2] It has been shown that a steady-state H^- ion beam with current greater than 1 A can be generated by a surface conversion type source with Mo being used as the converter material.[3] In order to achieve the proper cesium coverage and thereby increasing the H^- ion yield, the application of porous cesium-dispensing converters is being investigated.[4] It is also possible to optimize the H^- production by choosing the proper converter material. In this paper, we compare the negative ion yield generated by different materials (such as Mo, Ti, V, Nb, Pt, Pd, Rh, Cu, Ta, Al, Au, LaB_6 and stainless-steel) in the pure hydrogen and cesium-hydrogen modes of operation.

The experiment was performed in a cylindrical multicusp ion source (20 cm diam by 18 cm long) with the open end enclosed by a stainless-steel plate. A steady state hydrogen was produced by primary electrons emitted from two tungsten filaments which were biased at -70 V with respect to the anode (chamber wall). In normal operation, the source pressure was adjusted to 1.5×10^{-3} Torr.

In order to investigate the negative ions produced by different materials, a rotatable water-cooled copper disk with four different materials brazed onto the four quadrants was employed. By biasing the disk converter -200 to -300 V with respect to the plasma, positive ions are

accelerated across the sheath to strike the converter surface. Negative ions that are formed at the target surface will then be accelerated back through the sheath by the same potential. They pass through the plasma, the exit aperture on the stainless-steel plate, and then enter a magnetic-deflection mass spectrometer. With this arrangement, only one type of target material at a time is seen by the viewing system formed by the exit aperture and the entrance slit of the mass spectrometer. The yield of negative ions for each material tested can be compared under identical conditions of gas pressure, discharge power, and target potential. For negative ions with the same mass-to-charge ratio, the mass spectrometer also acts as an energy analyzer.

When the source was operated in the pure hydrogen discharge mode, the results can be summarized as follows:

(1) H^- ions are present in the mass spectra of all target materials.

(2) Other negative ions such as O^-, OH^-, O_2^- and CO_2^- are also produced but their distribution varies from one converter material to the other.

(3) Two distinct groups of H^- ions can be identified from the energy spectrum. The energy of one group is approximately equal to the converter bias potential. These H^- ions are <u>desorbed</u> (or sputtered) from the converter surface by bombardment with energetic hydrogen ions.[5] The second group of H^- ions has a higher energy and they are produced by <u>reflection</u> (or backscattering) of hydrogen ions (H^+, H_2^+, H_3^+) from the target surface.[6] Peaks resulting from H_2^+ and H_3^+ ion reflection are visible in the H^- ion energy spectrum shown in Fig. 1.

(4) For some materials (such as Mo and Al), the desorbed H^- ion group is much larger and correspondingly the O^- and OH^- ions produced by these

target materials are also higher. This result seems to suggest that H atoms are absorbed on the target surfaces preferentially in the form of OH. With ion impact, both H^-, O^- and OH^- ions are desorbed from the surface.

When cesium was added to the hydrogen discharge, the data shows that

(1) The total H^- ion yield is enhanced by two orders of magnitude but the amount of H^- ions produced again differs from one material to the other.

(2) The impurity negative ions form only a percent or two of the total self-extracted beam current.

(3) The H^- ion energy spectrum shows a very narrow peak near the converter potential (Fig. 1). This group of H^- ions presumably is formed by desorbing H atoms from the CsH absorbed on the converter surfaces. Under optimum conditions, the majority of the H^- ions are produced by the desorption process.

In the operation of the "self-extraction" negative ion source, the desorbed H^- ions are desired as they will have a much smaller transverse energy component than the H^- ions produced by reflection. These H^- ions can be better focused geometrically at the exit aperture of the source and then be accelerated to form a high energy beam. For this reason, materials such as Mo, Ti and V are better candidates to be used as converters.

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*Work supported by U.S. DOE under Contract Number DE-AC03-76SF00098.

Figure Captions

Fig. 1 The energy spectrum of the H^- ions produced by a Mo converter.

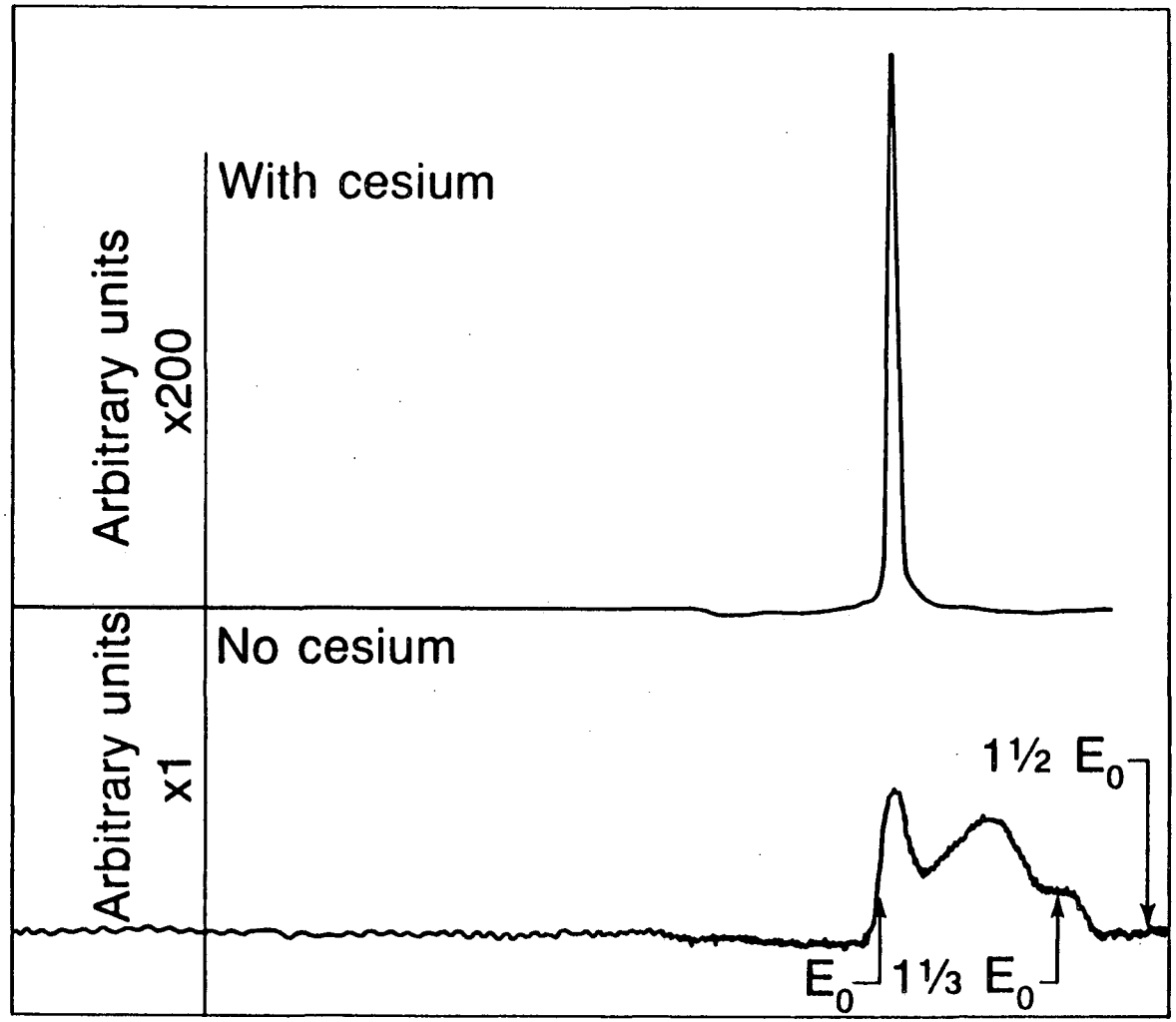

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Fig. 1

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

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