ION SOURCE DEVELOPMENT FOR LANSCE UPGRADE

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Abstract

Design and testing of the prototype ion source for the Los Alamos Neutron Science Center (LANSCE) Facility is described.

1 INTRODUCTION

The next generation spallation neutron sources, such as the upgrade of the Los Alamos Neutron Science Center (LANSCE) Facility will require high intensity negative hydrogen (H^-) beams. Lawrence Berkeley National Laboratory has been contracted by Los Alamos National Laboratory to develop an H^- ion generator that can meet the upgrade LANSCE neutron source requirement. Specifically, the output current of the new H^- ion source has to increase from 16 to 40 mA. In addition, source emittance, reliability, and availability will need to be improved. All of which must be achieved while operating under the facility's prescribed 12% duty factor (1 ms pulse at 120 Hz).

In order to meet the LANSCE source requirement, the Ion Beam Technology (IBT) Program at LBNL chose the surface-conversion multicusp ion source as the base candidate. The present LANSCE H^- source is also a surface-conversion source [1]. However, the H^- output current doesn't improve much beyond 20 mA with higher discharge power. Previous experimental study at LBNL demonstrated that if the surface converter source is operated with a magnetic filter, the H^- output current generated by a barium converter can increase without saturation with increased discharge power [2]. Based on this study, a prototype ion source has been developed to utilize the multicusp magnet arrangement as a filter. Cesium is used to enhance the H^- yield.

2 ION SOURCE CONFIGURATION

LBNL has been developing multicusp surface conversion ion sources for many years [3,4]. The typical multicusp H^- surface conversion source is primarily composed of a plasma chamber and a negatively-biased converter electrode as illustrated in Figure 1.

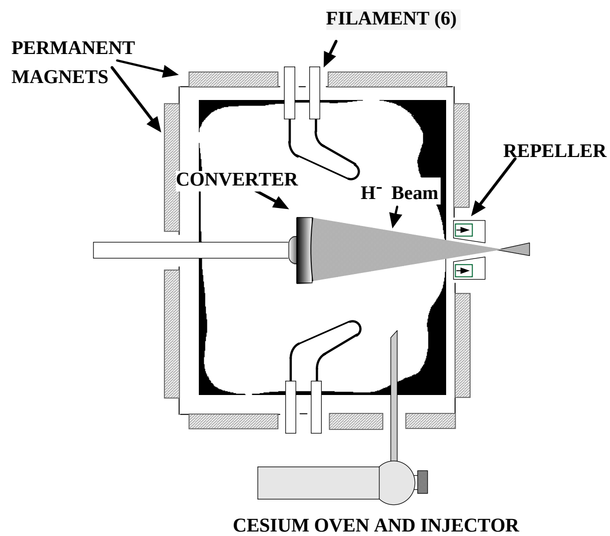

Figure 1: Schematic of the surface conversion ion source.

The positive ions present in the hydrogen plasma (H^+, H_2^+, H_3^+) are accelerated towards the converter surface. H^- ions can then be formed either by a backscattering process or by a sputtering process when the ions impinge on the converter surface. The converter is coated with a low work-function metal such as cesium to enhance negative ion conversion.

The current LANSCE ion source has a cylindrical body and the negative ions are extracted radially. The two filament cathodes are located on the cylinder end flanges. The LBNL prototype, Figure 2, is also of cylindrical design, however the negative ions are extracted along the source axis. This allows six filaments to be placed within the magnetic field generated by the cusp magnets on the wall (Figure 3).

The magnets provide a filter field which reduces the number of energetic electrons in the main plasma volume. This reduces the negative ion stripping due to energetic electrons. A converter of twice the area of the current converter is also used. The radius of curvature is increased to maintain the same projection angle. The axial position of the converter was optimized for maximum H^- output.

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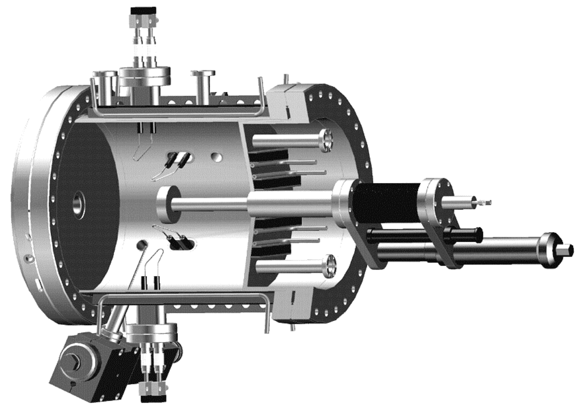

Figure 2: A 3-D rendering of the prototype ion source.

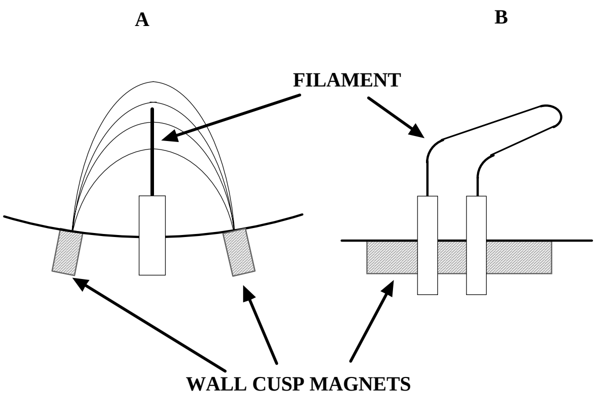

Figure 3: Location of the filament within the wall cusp magnet field. A. View along longitudinal axis. B. Viewed side on.

The prototype source utilizes a repeller electrode similar to the one in the current LANSCE ion source [1] This electrode is typically biased a few volts positive with respect to the anode to repel electrons. It also incorporates a dipole cusp arrangement in the extraction region which deflects the energetic electrons produced by secondary emission from the converter surface.

Figure 2 shows a 3-D rendering of the prototype ion source. The vacuum manipulator is used to optimize the converter position. In order to reduce cesium consumption, the ion source is designed for the walls to run at approximately 100° C, so as to avoid condensation of cesium in cool areas.

3 EXPERIMENTAL RESULTS

The prototype ion source has been operated at the design specifications. Figure 4 is a plot of H^- output as a function of arc power. The arc voltage was 80 volts, the source pressure was 1.2 mTorr and the converter voltage was 330 volts. It can be seen that the highest H^- current measured exceeded the required 40 mA. The duty factor was 12 %, 1 msec pulses at 120 Hz. Figures 5 and 6 show the H^- beam pulses at 12 % duty factor. These results were obtained without the normal LANSCE accelerator system.

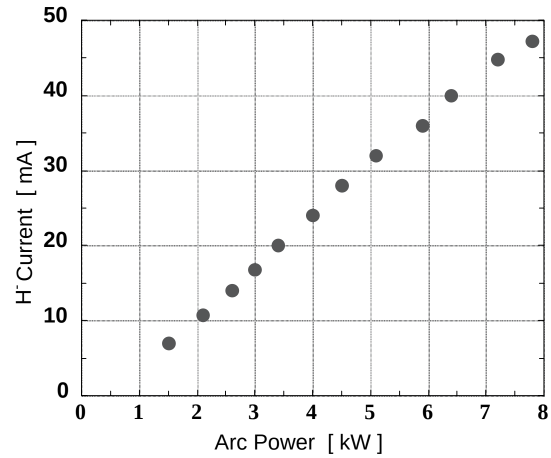

Figure 4: Plot of H^- current as a function of arc power

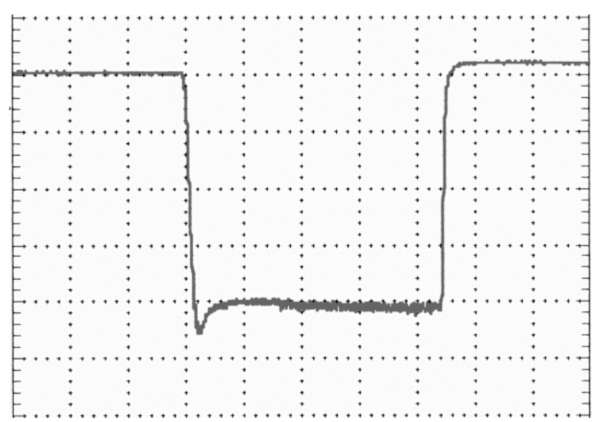

Figure 5: An oscilloscope display of the 40 mA H- pulse. The vertical scale is 10 mA/div. The time scale is 250 µsec/div.

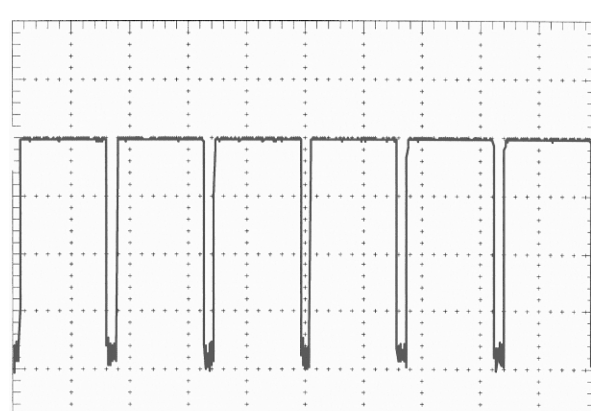

Figure 6: An oscilloscope display of the H- pulse at 12% duty factor. The vertical scale is 10 mA/div. The time scale is 5 msec/div.

4 CONCLUSIONS AND FUTURE PLANS

It has been demonstrated that the prototype ion source for the LANSCE upgrade can produce the required 40 mA of H^- at a 12 % duty factor. When operating with diligence the day to day operations show well reproducible results. The most significant problem with this source is getting a compromise between wall temperature and cesium injection. A low wall temperature requires constant cesium injection. If the wall is too hot, the cesium vapor pressure gets too high and the plasma is dominated by cesium ions and the H^- output tapers off requiring higher arc power to attain the 40 mA output. However, the present source is not constructed to allow for simple control of wall temperature; this issue will be addressed in the next design.

An earlier version of the proposed source design fabricated from existing components was tested at LBNL and is now being tested on the LANSCE Test Stand. The results obtained at both laboratories are similar. LANSCE is planning to make emittance measurements with the prototype source to compare with the present LANSCE operation source.

At this time a new production source is under design that will include features indicated by testing of the prototype ion source. One of the main concerns is the ability to adjust the wall temperature. The design is near completion and fabrication is expected to take about two months. Testing is expected to begin in early November.

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