Bernas Source for the Precision Implant 9200

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Abstract--A Bernas plasma source is in beta testing for the Applied Materials Precision Implant 9000/9200 series. The most distinctive feature of this source is a new two and a half turn pigtail filament. Compared with a Sigma Freeman, initial Bernas operation with P+, B+ and BF2+ has demonstrated spec beam with higher transfer ratios and double source life for a range of high current, low energy processes.

I. INTRODUCTION

A Bernas plasma source has been developed for the Applied Materials Precision Implant 9000/9200. Compared with a Sigma Freeman, initial Bernas operation with P+, B+ and BF2+ has demonstrated spec beam with higher transfer ratios and double source life for a range of high current, low energy processes. The other benefits of Bernas source operation are improved stability and more uniform beam profile. Source to source reproducibility is also better, because filament sag is eliminated as a performance variable.

The source is plug-in compatible with original power supplies and computer control, but new setup tables are required to optimize performance. Bernas sources often have a preferred magnet and filament polarity, so these must be checked. If evaporators are used for arsenic and phosphorous, lower oven temperatures are needed for the setup table. The source magnet must also be tuned to find the optimum setup, because both magnet current and inner/outer balance affect performance. For As+ and P+, optimum source magnet setup provides a factor of two enhancement of beam and source life. For B+ or BF2+, source magnet optimization can change the beam current by more than a factor of five.

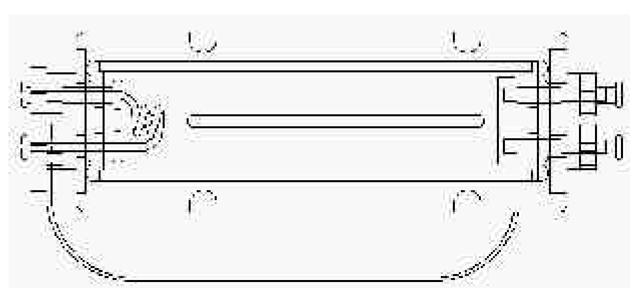
The Bernas chamber physically resembles the Sigma Freeman source, and the first beta versions were made for a Sigma base and extraction optics. Only minor modifications are needed to fit beamlines with other source and extraction hardware. The most distinctive feature is the addition of another turn to the pigtail filament. This two and one half turn filament gives significantly better lifetime than the standard pigtail, and easily achieves spec beam for high current, low energy processes.

II. SOURCE Design

Except for the filament, this source resembles a combination of the Sigma and the 9500 Bernas[1], as illustrated in Fig. 1. The body is graphite, and, like the Sigma, can be fitted with a variety of thick liner materials on the four sides and bottom: Carbon, molybdenum, tantalum, or tungsten. At present, the top plate is made of either molybdenum or graphite. A thin tungsten shim is used to line the top plate for processes that are sensitive to contamination by carbon or molybdenum.

The initial filament resembled the standard one and one half turn pigtail filament in the 9500 Bernas, with a wide base and similar overall dimensions. This filament gave acceptable beam currents, but disappointing life. The reason was that the hot wire length was 6.6 cm, only 66% of the 10.4 cm of the Sigma Freeman. Informal conversation with other source designers suggested that adding an extra turn might reduce desired beam current by making the filament magnetic field too strong. Nevertheless, a two and a half turn filament was designed to have 90% of the nominal Sigma hot wire length. Surprisingly, the extra turn had little affect on beam current, but significantly increased life. A plausible explanation is the filament magnetic field is too localized to affect the relatively long 9200 plasma, although it may be significant in a smaller chamber.

The repeller is relatively large, and rectangular. At this stage, it is not clear that this style has significant performance advantages compared with a circular repeller. The obvious disadvantage is that a non-circular repeller requires two legs, feedthroughs, and insulators. Applied's patented external insulator technology is incorporated to minimize insulator failure as a source life variable.



top view, 9200 Bernas ion source

Fig. 1. Top view of the 9200 Bernas. The incorporation of a two and one half turn pigtail filament has increased source life with little affect on beam current.

III. Performance

Operating data have been obtained for the most common implant ions. Spec beam has generally been achieved, so the real goal of further development is longer source life. The importance of beamline source and beamline tuning is illustrated in Fig. 2, where typical beam currents are plotted versus energy. The P+ current increases with beam energy, as expected, because beam space charge forces decrease with energy. However, BF2+ current drops between 20 keV and 30 keV, because extraction optics were not well matched to post acceleration optics. Extraction energy was 20 keV for both species.

Transfer ratios were generally higher for the Bernas source than the Sigma. For example, the P+ transfer ratio at 55 keV was 50%, compared with 32% for the Sigma. Higher transfer ratio accounts for some of the increased source life. Stretching the life of the solid evaporator charge suggests reduced material deposition in the beamline. Low energy transfer ratios were particularly good. For example, at 20 keV, the BF+ transfer ratio was 12% at 7.8 mA, and the B+ transfer ratio was 14% with 5 mA. In both cases, arc current was around 2 A. The boron transfer ratio fell to 10% if the current was increased to 7.8 mA at 5 A of arc. The Bernas source has also demonstrated superior performance and lifetime for high current processes down to below 10 keV.

Source life for high current phosphorous implants is about fifty hours with one to two amperes of arc current. The longest source life to date with BF3 source gas in beta production operation is eighty hours. At present, source life with fluorine gas compounds is limited by filament growth, but life is expected to increase with further development.

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References

[1] S. Poall, A. Devaney, C. Lowrie, and M. Wauk, Nucl. Instr. and Meth. **B** 96 (1995) 491-494.

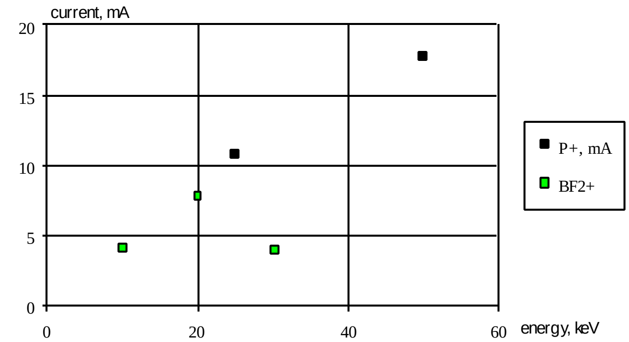

Fig. 2. Beam current versus energy. The drop in BF2+ current at 30 keV indicates that extraction and post acceleration optics could be better matched. Extraction energy was 20 keV