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Surface Modification by Beams and Plasma Flows of Boron Ions Generated by Vacuum Arc Source

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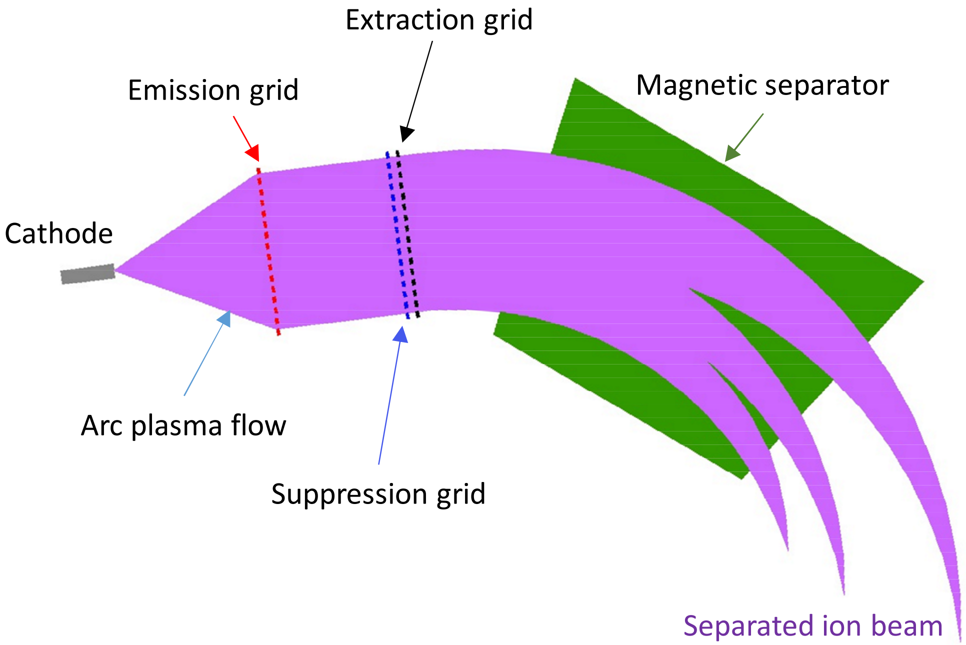
Introduction

The processes of boron ion plasma generation are interesting both as a problem of plasma physics and as a practical problem of application plasma and boron ion beams in the ion-plasma technologies. Presently, implanters most often generate boron ion beams using modern modifications of Freeman sources. As a plasma forming matter, such sources can use, for example, gaseous boron trifluoride (BF_3).

An alternative approach is to generate boron isotope ion beams in a vacuum arc using a lanthanum hexaboride (LaB_6) cathode instead of a boron one. This approach does not require to heat up the cathode and it uses a single high-voltage trigger discharge to initiate the vacuum arc, the way it is implemented in Mevva sources. The total fraction of boron ions in the beam in this case corresponds to their fraction in the cathode material and constitutes about 80 %.

New Approach



Using an ion source based on a vacuum arc discharge and a magnetic separator, we obtained compositionally uniform ion beams of boron isotopes with atomic masses 10 and 11 a.m.u.

We performed a separate implantation of $^{10}B^{+}$ and $^{11}B^{+}$ ions on silicon and zirconium-niobium alloy surfaces with exposition doses up to $5 \cdot 10^{15}$ cm^{-2}.

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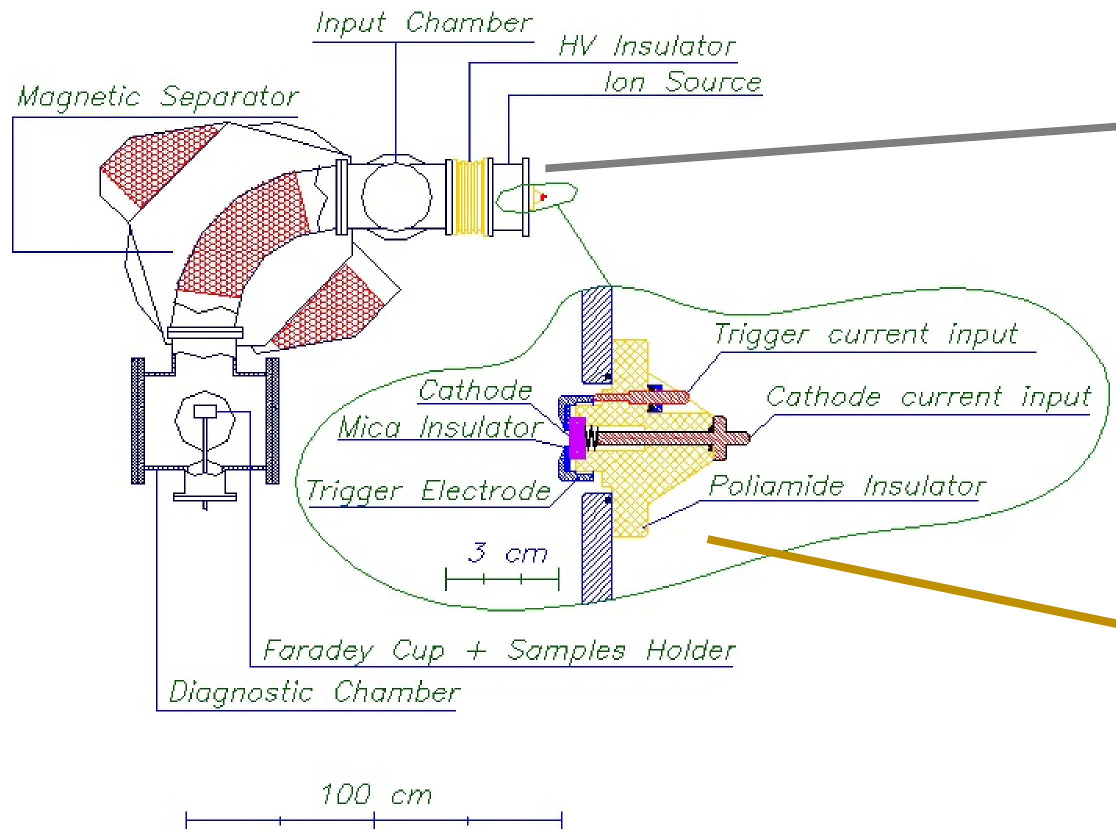
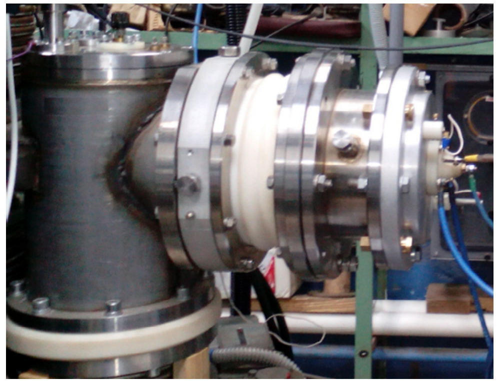
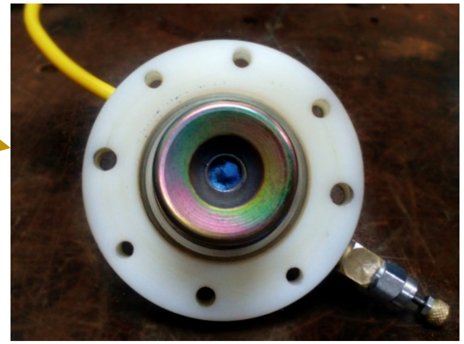
Experimental Setup



Ion source



Cathode unit



Parameters of separated ion beam

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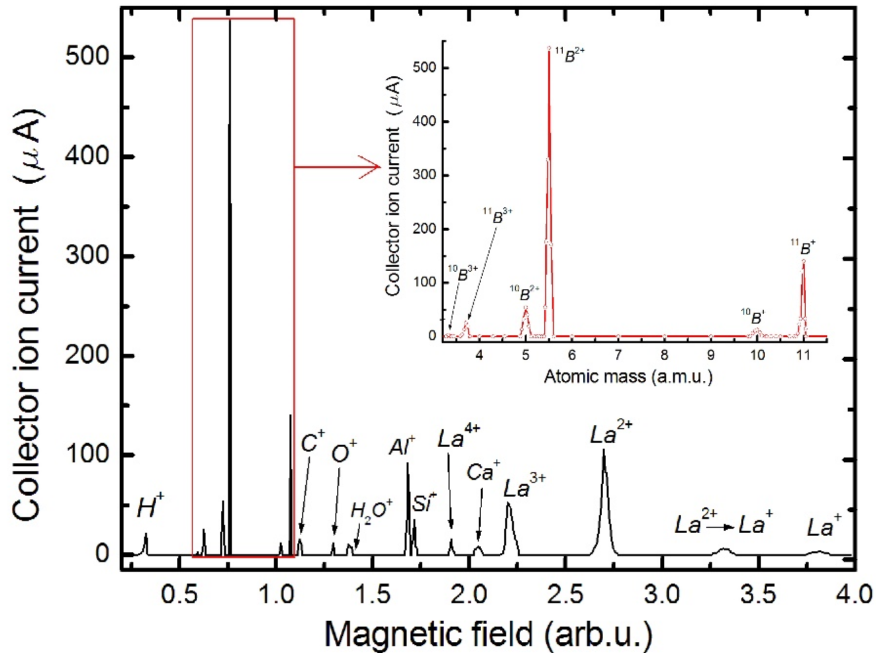
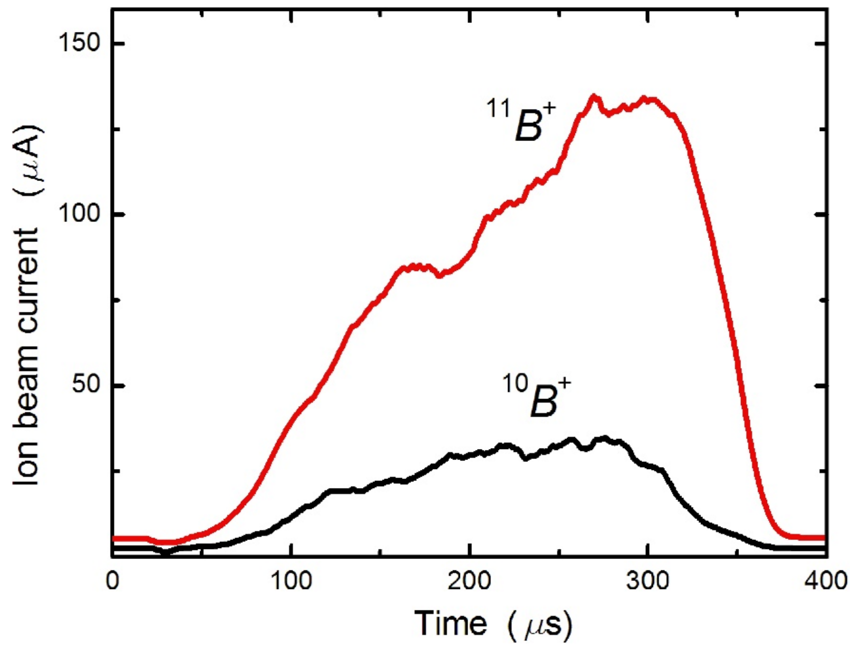
Background pressure - $2\cdot10^{-6}$ torr; accelerating voltage - 20 kV; arc current - 140 A, 300 µs, 2 pps.



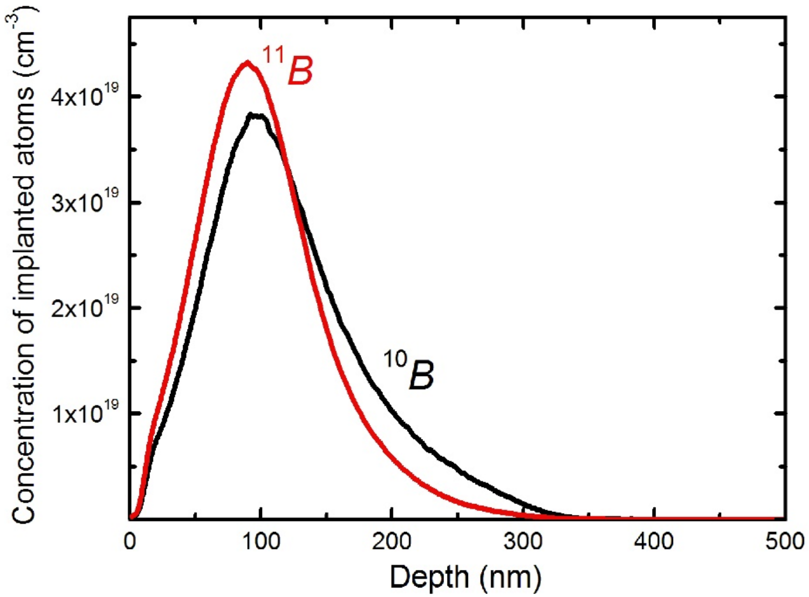
Mass-to-charge composition of the ion beam generated by vacuum arc ion source with LaB_6 cathode.



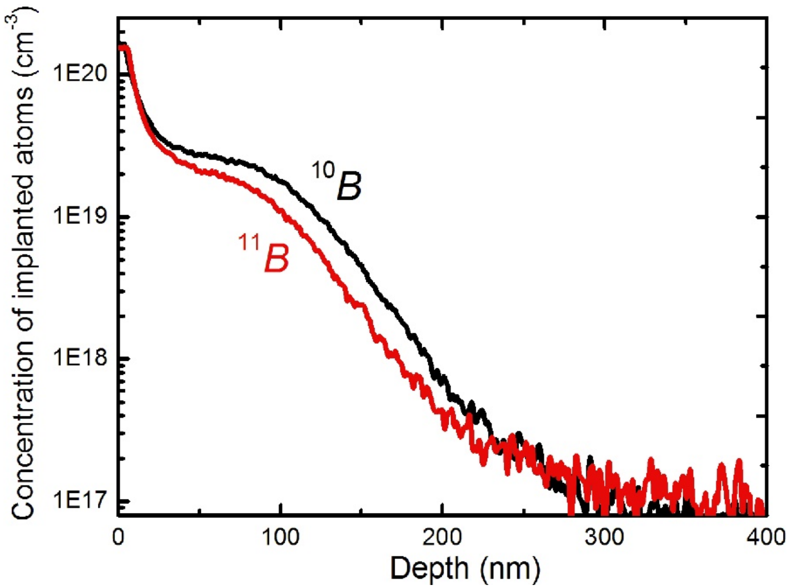
Waveforms of boron's isotopes ion currents measured after beam separation.

Ion implantation results

SIMS profiles of boron isotopes implanted in silicone up to $5 \cdot 10^{14}$ ion/cm^2 with energy 20 keV.



SIMS profiles of boron isotopes implanted in E110 (Zr-1%Nb) alloy up to $5 \cdot 10^{14}$ ion/cm^2 with energy 20 keV.



For both cases, at the same energy density, the distribution profile of ^{10}B atoms is wider than that of ^{11}B.

The rectifying properties of implanted samples

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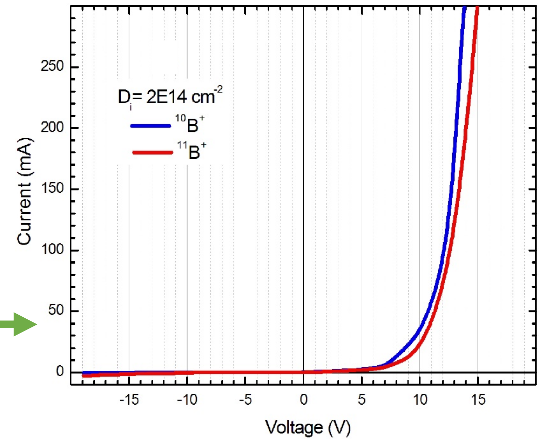
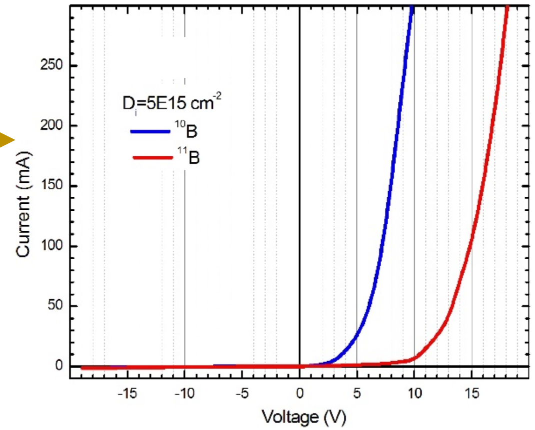
The CVCs of the silicon samples implanted with boron isotope ions up to **$5\cdot10^{14}$ ion/cm^2**



and **$5\cdot10^{15}$ ion/cm^2** at the accelerating voltage 20 kV.



The forward bias voltage of the p-n junction depended on the boron isotope atomic mass. For an implantation dose $5\cdot10^{14}$ cm^{-2}, the forward bias voltage for $^{10}B^+$ and $^{11}B^+$ was respectively 14 V and 15 V. With increasing dose up to $5\cdot10^{15}$ cm^{-2}, the voltage of the sample implanted with boron isotope $^{10}B^+$ was 10.5 and 18.5 V for the one implanted with $^{11}B^+$ isotopes.

Conclusion

As a result of a separate implantation of boron isotopes using an implanter with a bending magnet, it has been shown that under identical experimental conditions the distribution profile of implanted boron ^{10}B isotope ions is wider than that of ^{11}B isotope.

It indirectly confirms differences in electrical properties of the silicon samples used in the experiments, namely, lower values of the p-n junction forward bias voltage observed during the $^{10}B^{+}$ ion implantation in comparison with the $^{11}B^{+}$ implantation.

The demonstrated differences are qualitative in nature and require additional investigations, which we will continue in the future.

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Acknowledgement

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