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Evaluation of the ion beam generated by bipolar pulse accelerator
両極性パルス加速器におけるビーム特性評価

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The development of the bipolar pulse accelerator (BPA) is reported. A double coaxial type bipolar pulse generator was developed as the power supply of the BPA. The generator was tested with dummy load of 7.5 Ω, bipolar pulse with -138 kV, 72 ns (1st pulse) and +130 kV, 70 ns (2nd pulse) was successively generated. By applying the bipolar pulse to the drift tube of the BPA, nitrogen ion beam of 2 A/cm^2 was observed in the acceleratored, which suggests the bipolar pulse acceleration.

1. Introduction

Intense Pulsed Ion Beam (PIB) is expected to be applied for materials sciences including semiconductor implantation and surface modifications. However, in the conventional PHIB accelerators, the purity of the beam is usually very poor. [(1)] Hence, the application of the PHIB has been extremely limited. To improve the purity, bipolar pulse accelerator (BPA) has been proposed and developed in our laboratory. [(2-4)] In the paper the results are described of the acceleration experiment.

Figure 1 shows the conceptual drawing of the BPA. [(2-4)] It consists of a grounded ion source, a drift tube and a grounded cathode. The BPA is a 2-stage accelerator and operated with a bipolar pulse. When the bipolar pulse (V_1) is applied to the drift tube, ions produced in the grounded ion source are accelerator in the 1st gap toward the drift tube because at first the negative voltage pulse with the pulse duration τ_0 is applied. After τ_0 the polarity of the pulse is reversed and the positive voltage with the duration τ_0 is applied to the drift tube. As a result, the ions are again accelerated in the 2nd gap toward the grounded cathode. In the BPA improvement of the purity of the ion beam is expected [(2)]. In addition ion source can be installed on the grounded anode. This seems to be favorable for the active ion source is powered by an external power supply.

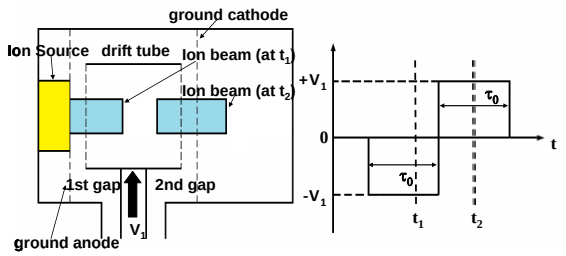


Fig.1. Conceptual drawing of bipolar pulse accelerator

2. Experiment

Figure 2 shows the bipolar pulse generator used in the experiment. The pulse line is double coaxial, water field line and on the down stream end of the line between outer and intermediate conductor low inductance rail gap switch is installed.

Figure 3 shows the waveforms of the intermediate conductor (V_{PFL}) and the output pulse (V_0), when dummy load (7.5 Ω) is connected to the output terminal of the generator. From the figure bipolar pulse of (-138 kV, 72 ns) (+130kV, 70 ns) is successfully generated.

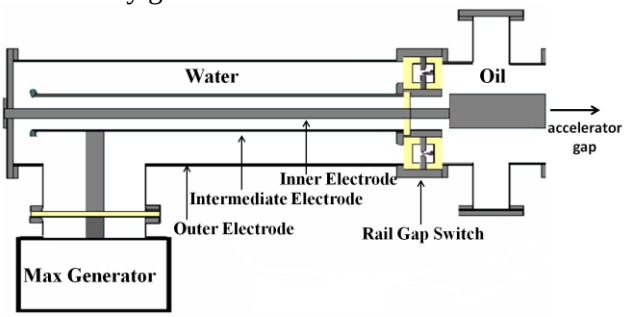


Fig.2. Cross sectional view of bipolar pulse generator

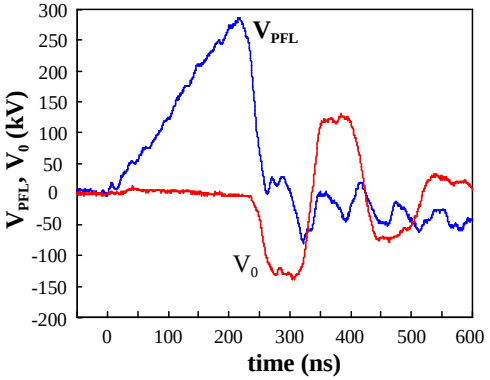


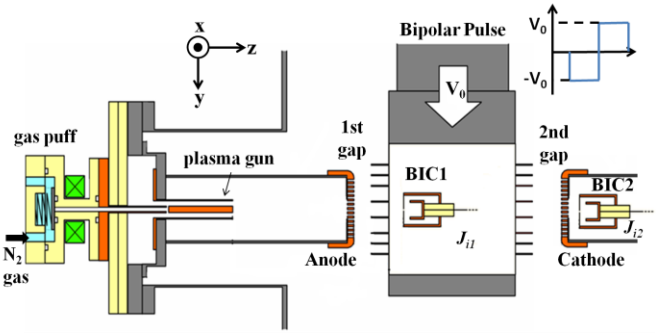
Fig.3. Typical waveforms of the charging voltage of the intermediate conductor (V_{PFL}) and the output voltage (V_0). Copper sulfite resister of Z_0 = 7.5 Ω was used as a dummy load.

Figure 4 shows the experimental setup for bipolar pulse acceleration of nitrogen ions. The system consists of a grounded anode where active ion source of gas puff plasma gun is installed, a drift tube where bipolar pulse is applied, and a grounded cathode. Biased ion collectors (BIC) are installed in the drift tube and in the cathode to evaluate the accelerated ions.

Figure 5 shows the typical waveforms. From the figure we see that ions are successfully accelerated in the 1st gap and ion current density (J_{i1}) of 40 A/cm^2 is obtained. From the time of flight delay of J_{i1} (45 ns), ion energy is estimated to be 130 keV if assuming N^+ ion.

Figure 6 shows the track pattern of magnetic ion energy spectrometer placed in the drift tube. The ion are observed in a drift tube by the spectrometer and the ion energy was evaluated to be 106 keV (N^+) and 101 keV (N^{2+}).

In the downstream of the 2nd gap, J_{i2} of 2 A/cm^2 is observed, which suggest the post acceleration in the 2nd gap.



Acceleration gap: d = 1 cm
Distance between anode and BIC1 : 6 cm
Distance between cathode and BIC2 : 1.5 cm

Fig.4. Cross-sectional view of the experimental system

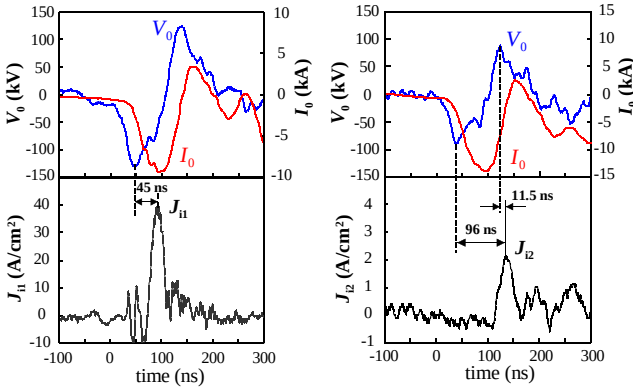


Fig.5. Typical waveforms of the applied voltage, current to the drift tube (V_0, I_0), ion current densities in the drift tube (J_{i1}) and in the cathode (J_{i2}).

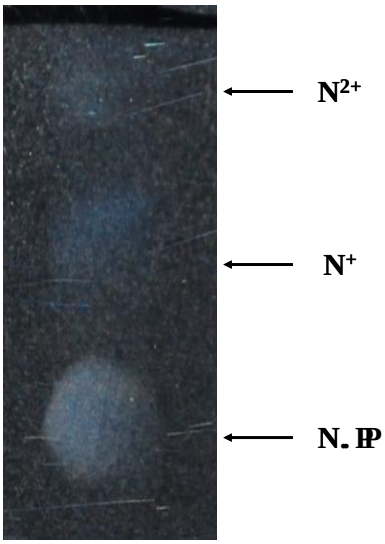


Fig.6. Track pattern obtained by energy spectrometer

3. Summary

A double coaxial type bipolar pulse generator was developed as the power supply of the BPA. The generator was tested with dummy load of 7.5 Ω, bipolar pulses of -138 kV, 72 ns (1st pulse) and +130 kV, 70 ns (2nd pulse) were successively generated.Energy of N^+ and N^{2+} in the drift tube were evaluated to 106 keV and 101 keV. Nitrogen ion beam of 2 A/cm^2 was observed in the cathode, which suggests the bipolar pulse acceleration.

References

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