§26. Basic Experiment on Traveling Wave Direct Energy Converter

Yasaka Y., Noda K. (Kyoto Univ.), Momota H., and Tomita Y.

We perform a proof-of-principle experiment of a traveling wave direct energy converter (TWDEC), which was proposed by H. Momota [1] as an efficient energy converter from high-energy protons produced by D-^{3}He fueled fusion reactor directly into electricity. In TWDEC, the incident proton beam is velocity-modulated so as to form a bunched beam, which is to be decelerated by a traveling RF wave. The induced current in the traveling wave circuit provides RF power to the load.

As a first step of the experiment, we use low-energy He-ion beam of a few keV and investigate the interaction of the beam with RF for modulation and deceleration. Figure 1 shows the schematic of the experimental setup consisting of a helicon-wave ion source, a modulator and a decelerator. The He-ion beam of V_{ex} =1.9 keV is velocity-modulated with the axial RF electric field at ($\omega/2\pi$ = 7 MHz) applied to the grid M_1 with M_2 grounded. The distance of two grids is 1 cm and the modulation voltage V_{mod} is around 100 V. The grids of the decelerator, D_1 to D_4, are aligned axially with each separation of 1.1 cm. They are connected to a transmission line which consists of series inductors and parallel capacitors terminated with a matched load resistor. We drive the transmission line at the voltage V_{dec} by the same RF source for the modulator with a variable phase difference. The energy distribution function of the beam is measured by a Faraday cup.

We have confirmed that the measured distance z from M_2 where the density modulation becomes a maximum is approximately given by the equation: $(\omega\ z / v_{ex})\ (V_{mod} / 2V_{ex}) = 1$, in accordance with the theory [2]. Here, v_{ex} is the initial velocity of the beam. Figure 2 shows the energy distribution of the beam for V_{dec} = 0 (dotted line) and V_{dec} = 100 V (solid line) with V_{mod} = 100 V. It is seen that the low energy component is increased by the application of V_{dec}. When the phase of V_{dec} with respect to V_{mod} is changed by π, the high energy component is increased. These results indicate that the ion beam can be decelerated by the traveling wave as planed in the TWDEC concept.

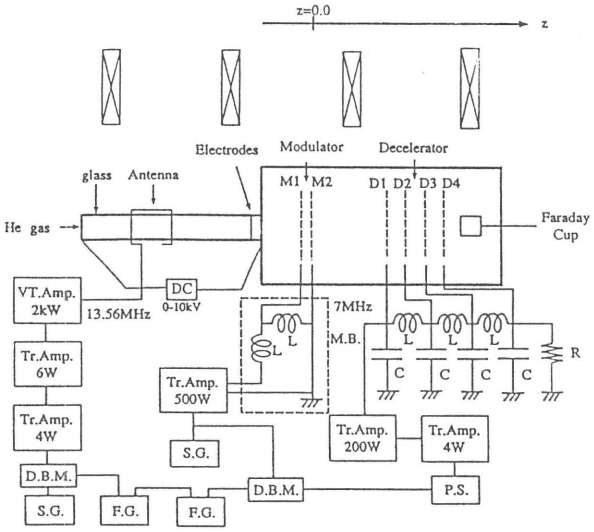

Fig.1. Schematic of the experimental setup consisting of a helicon-wave ion source, a modulator and a decelerator.

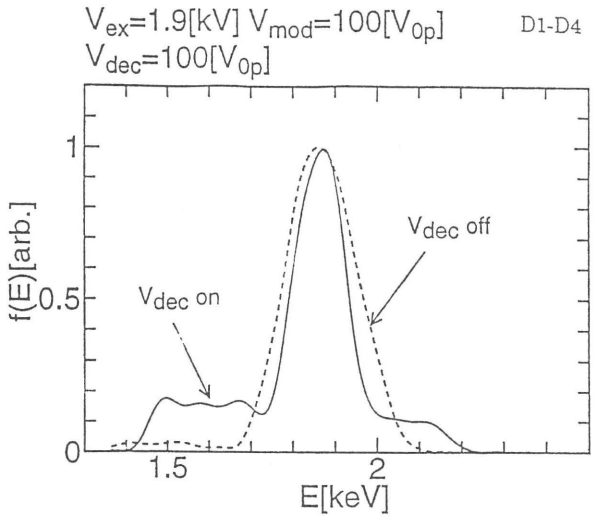

Fig.2. Energy distribution of the beam for V_{dec} = 0 (dotted line) and V_{dec} = 100 V (solid line) with V_{mod} = 100 V.

References

1) H. Momota; LA-11808, Los Alamos Natl. Lab. Rep., 8 (1989).
2) H. Atwater; Introduction to Microwave Theory (McGraw-Hill, New York, 1962).