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Characteristic of Relativistic Electron Beam Diode with Mesh Anode
メッシュ陽極を用いた相対論的電子ビームダイオードの特性

Daisuke Shimone, Tsubasa Ito, Hiroaki Ito and Katsumi Masugata
下根大侑, 伊藤　翼，伊藤弘昭，升方勝己

University of Toyama
3190, Gofuku, Toyama 930-8555, Japan
富山大学 〒930-8555　富山市五福3190番地

To realize the multi-shot operation of intense relativistic electron beam diode, mesh anode is utilized. The diode was successfully operated at diode voltage 110 kA, diode current 35 kA, and beam current of 7 kA and beam current density of 250 A/cm^2 are obtained. The diode was stably operated for 10 continuous shots without breaking the vacuum.

1. Introduction

Intense relativistic electron beam (IREB) has a wide area of applications including intense microwave generation, X-ray, γ-ray, and neutron sources, and surface modifications of materials. In those applications it is very important to know the characteristics of electron beam diode and the beam propagation. Foil anode has been utilized to generate very low impedance beam, however, in the diode the foil is broken in each shot due to the energy deposition of electrons passing through the foil. To realize the multi-shot operation, we have tested the metallic mesh as an anode.[1]

2. Experiment

Pulsed power generator used in the experiment is shown in Fig.1. The generator consists of Marx generator, pulse forming line (PFL), pulse transmission line (PTL) and vacuum electron diode. The Marx generator is 8 stage bipolar charging type and produces high voltage pulse of 800 kV, 5 kJ at maximum charging voltage of ±50 kV. The PFL uses deionized water as dielectric and produces high power pulse of 400 kV, 3 Ω, 50 ns when charged to 800 kV. The pulse is transported through the PTL and applied to the diode.

Figure 2 shows the cross-sectional view of the electron diode. The diode consists of a aluminum cathode of 60 mm diameter, mesh anode of 80 mm diameter, and a drift tube of inner diameter 110 mm, length 245 mm. Stainless steel mesh of wire diameter 0.25 mm, pitch 1.02 mm is used as the anode. Output voltage of the PTL (V_{PTL}) is observed at the end of the PTL by a resistive voltage divider. In the upstream and downstream of the anode, a pair of Rogowski coil is installed to evaluate the gap current (I_{up}) and beam current injected to the drift tube (I_{down}). Electron current density (J_e) is measured by a Faraday cup placed at 45 mm downstream from the anode on the axis of the diode. The diode voltage (V_d) is evaluated as $V_d = V_{PFL} - L(dI_{up}/dt)$, where L is the inductance of the diode (110nH). The A-K gap was adjusted to 4.3 mm.

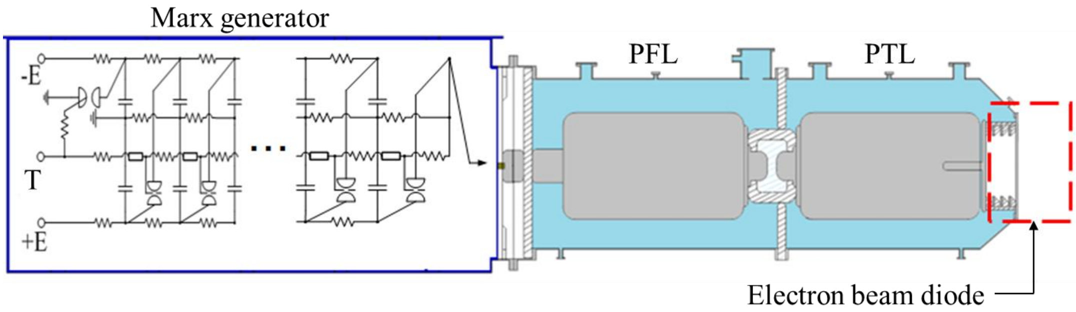

Fig.1. Overall view of laboratory equipment

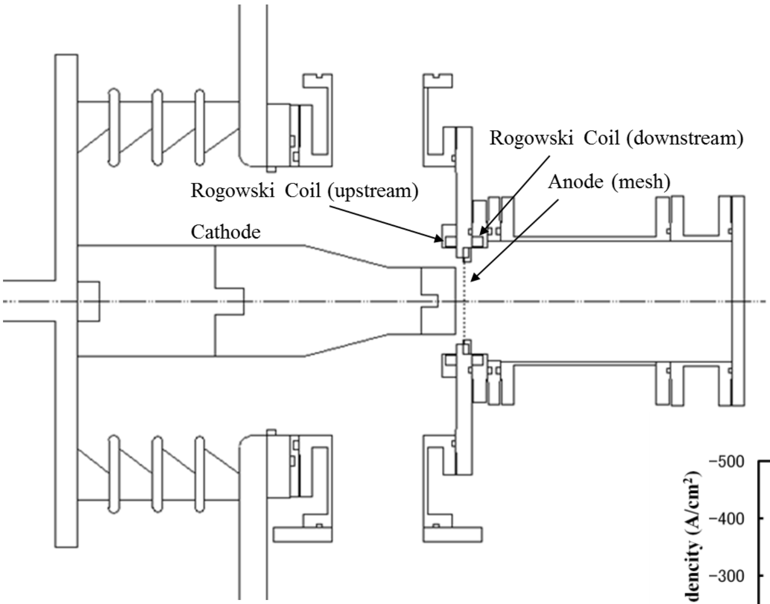

Fig.2. Cross section of electron beam diode

Figure 3 shows typical wave forms of V_{PTL}, V_d, I_{up}, I_{down} and J_e. As seen in the figure, V_d and I_{up} have a peak at t ≈ 80 ns after the rise of V_{PTL}. Peak values of V_d and I_{up} are 110 kV and 35 kA, respectively. The beam current (I_{down}) raises at t = 30 ns and reaches 7 kA at t = 80 ns. The peak value of J_e = 250 A/cm^2 is observed at t = 80 ns.

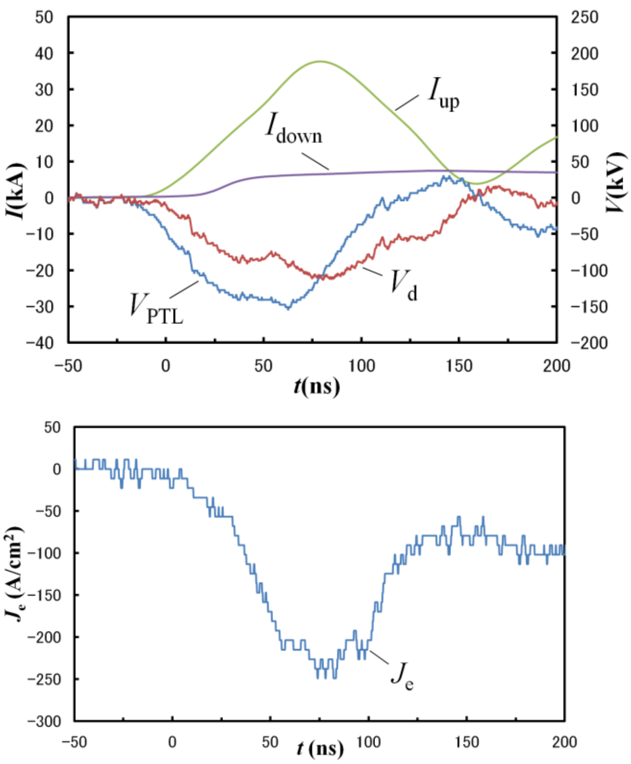

Fig.3. V_{pfl}, V_d, I_{up}, I_{down}, J_e at the time

Figure 4 shows the dependence of J_e on the shot number. From the figure we see that electron beam is produced for 10 continuous shot. After 10 shot, the anode mesh has heavily damaged and has a hole of 30 mm diameter, where as no strong damage was observed on the aluminum cathode.

Fig.4. Electron current density to the number of shots

5. Summery

Characteristics of IREB diode with mesh anode were evaluated. The diode was successfully operated at diode voltage 110 kA, diode current 35 kA, and beam current of 7 kA and beam current density of 250 A/cm² are obtained. The diode was stably operated for 10 continuous shots without breaking the vacuum.

References

[1] M. Onoi, M. Yamabuchi, and M. Yatsuzuka: *Improvement of Microwave Power from a Virtual Cathode Oscillator and Its Repetitive Operation Using a Metal Mesh Anode* Translated from Denki Gakkai Ronbunshi, Vol. 123-A, No. 1, January 2003, pp. 12-19