Electron-beam-current control at RTM injector

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SCRIT facility[1] is a unique facility to measure electron scattering off from short-lived nuclei. In the SCRIT facility, a racetrack microtron (RTM[2]) is used as the electron injector of the energy of 150 MeV for the electron storage ring (SR2) and ISOL-type nuclei source which is the electron-beam-driven RI separator for SCRIT (ERIS[3]). We have been working toward upgrading[4] the RTM to operate ERIS for efficient photo fission and run SR2 in a stable condition. Especially for ERIS, a higher electron beam current is desired for higher ion yield of short-lived nuclei.

RTM is equipped with a cathode-type electron source with the energy of 60 keV. Before adjusting and upgrading the RTM accelerator, it is important to know the specifications of the 60 keV cathode-type electron source of RTM.

It is evident that the electron beam current depends on the temperature of the cathode, which is controlled by the cathode heater power P_h and the electric field around the cathode to extract thermal electrons from the surface of the cathode. In this study, we examined these relationships.

The commercially available NJK2305, provided by New Japan Radio Co., Ltd., is used as the cathode-type electron source. The maximum electron beam current is 4.25 A at a heater voltage of 6.3 V. It has a grid mesh in front of the cathode surface to make electric field for the extraction of thermal electrons. The beam current ranges from 20 to 70 mA with a grid voltage of 20 V.

Figure 1 shows the cathode-heater-power P_h dependence of the electron beam current Ie. Unfortunately, we do not have information about the temperature of the cathode; however, it is considered that temperature is nearly proportional to P_h. The two lines in the figure represent the grid voltage (V_g) of 50 and 200 V. The

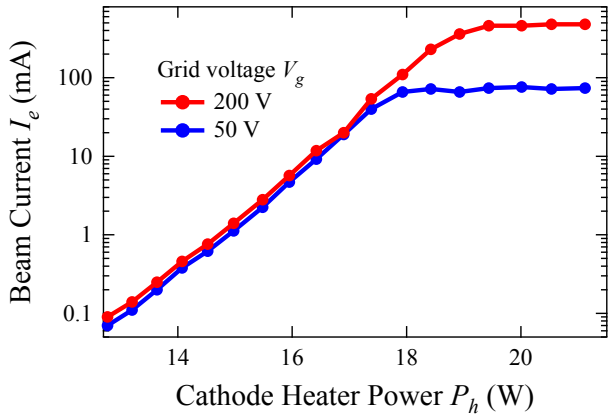

Fig. 1. Electron beam current depending on cathode heater power. It saturates around the heater power of 20 W.

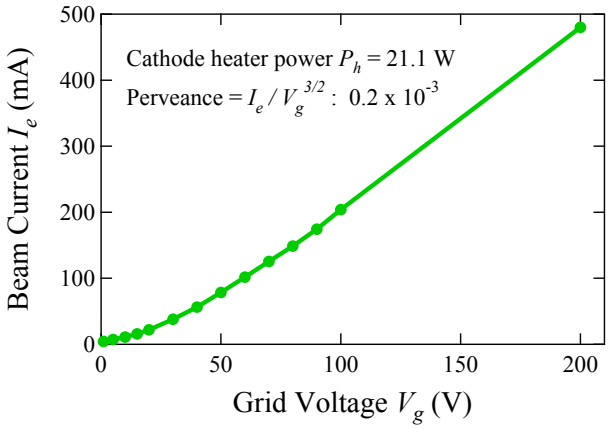

Fig. 2. Electron beam current depending on the grid voltage. The figure shows the case of cathode heater power of 21.1 W, which is saturated.

graph forms straight lines in the logarithmic y-axis up to P_h = 18 W. This is a common behavior of cathode-type electron source. In this range, it should be noted that the electric field by V_g does not significantly affect the beam current, indicating that the electric field used to extract the electrons does not have a dominant effect on extraction. However temperature plays a significant role in the extraction of thermal electrons. This is consistent with the exponential functions that produce straight lines in the logarithmic scale because the Fermi function is composed of an exponential function.

In contrast, I_e is saturated above P_h = 19 W. This is interpreted as the space charge between the cathode and grid manages the maximum beam current because the space charge suppresses the electron extraction by screening the electric field.

Figure 2 shows the dependence of electron beam current I_e on the grid voltage V_g. It seems that it is easy to extrapolate the line toward the higher V_g range to produce a higher beam current I_e. The original design of RTM has a maximum V_g of 200 V. However, we have already installed a grid voltage power supply of 500 V for this purpose.

According to these results, the heater power $P_h >$ 19 W for the cathode-type electron source NJK2305 is a better option to obtain a controllable beam current with $V_g <$ 200 V.

References

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