Electron energy stabilization at the electron gun in RTM

M. Watanabe,[*1] A. Enokizono,[*1] T. Hori,[*1,*2] and M. Wakasugi[*1]

We have been upgrading[1)] a racetrack microtron[2)] (RTM) as an electron injector for the electron storage ring SR2 and ISOL-type nuclei source, ERIS[3)] (electron-beam-driven RI separator for SCRIT), at the SCRIT facility.[4)] For both the apparatuses, a stable electron beam in two specifications of current and energy is important to accomplish reliable and continuous measurement of electron scattering in unstable nuclei. In addition to stability, a high power beam is necessary to maintain a good signal-to-noise ratio in the electron scattering measurement results.

The electron beam energy of 150 MeV from the RTM is determined by the mechanical design and magnetic field of the dipole magnets of the RTM. If the electron acceleration by the RF cavities is insufficient or unstable, the beam at the middle points in the RTM do not reach the designed energy and fail to exit the RTM. In order to accelerate the electron beam up to the designed energy, the RF power for the acceleration and electron beam current from the DC electron gun should be balanced at a certain ratio. Therefore, the stability of the DC electron gun with a maximum energy of 80 keV is important for the RTM and all of the facility.

We measured the stability of the DC electron gun of the RTM. The black line in Fig. 1 shows the time dependence of the voltage of the electron gun cathode, which corresponds to the electron beam energy at a test voltage of 1.45 kV, extractor-grid voltage of 200 V, cathode filament voltage of 6.1 V, and grid pulse width of 5 μs without any special treatment for stability. The voltage drop is 20 to 40 V during the grid pulse, except for the pulse switching noise. This voltage drop directly corresponds to the drop in energy of the electron beam, which results in different electron beam passes in the transport line and finally changes the beam current going into the RF cavities of the RTM. As a consequence, the outgoing 150 MeV electron beam becomes unstable

Simple solutions to reduce the instability include the installation of a high-current power supply as the DC voltage source of the gun, or the installation of a capacitor with high capacitance at the cathode to maintain the voltage. We tested the effects of the capacitances. The blue line and red line in Fig. 1 show the results of installing the 8.4 nF ceramic capacitor and 100 nF oil capacitor, respectively. The voltage drops were apparently reduced by these capacitors. The 8.4 nF ceramic capacitor reduces the voltage drop by half, while the 100 nF oil capacitor reduces it by more than 10 times. In general, the oil capacitor is not good at high-speed time ranges; however the result shows that it still works sufficiently in the microsecond time range.

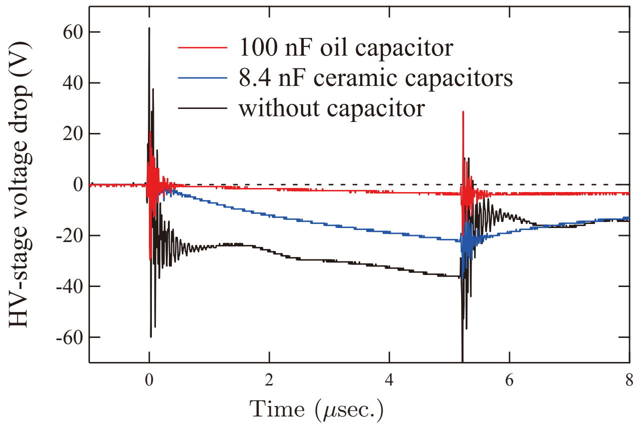

Fig. 1. Voltage drop of the H.V. stage of the electron gun in the time range of the grid pulse of 5 μs.

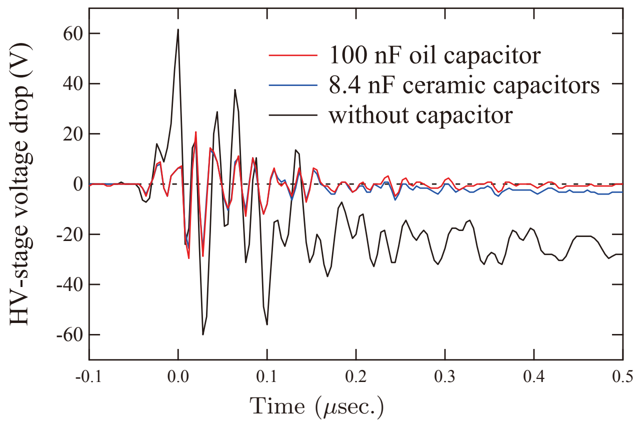

Fig. 2. Voltage drop of the H.V. stage in a short time range around the switching noise of the grid pulse.

In Fig. 2, the same data shown in Fig. 1 are shown for a different time range of 600 ns. The high speed oscillations of the data originate from the switching electronic circuit of the grid pulse. Compared to the black line, both the 8.4 nF ceramic and 100 nF oil capacitors reduce the high speed noise of more than 10 MHz by similar amounts. This means that the ceramic capacitors are good in the speed range of 10 MHz.

This result shows that the installation of a capacitor at the electron gun cathode electrode stabilizes the electron beam voltage of the RTM. Therefore, we are planning to install a larger oil capacitor of 500 nF at the electron gun cathode.

References

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*1 RIKEN Nishina Center
*2 Department of Physics, Hiroshima Univ.