Development of an Electron Gun for Nanosecond Electron Beam Generation

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1. Introduction

At the Advanced Radiation Technology Institute (ARTI) in Jeongeup, a pulsed radiolysis electron accelerator facility is being established for research on the physical properties of advanced polymeric materials, biological materials, and environmental materials. The purpose of this facility is to investigate radiation-induced changes in the physical properties of samples by analyzing transient species, such as radicals, generated through radiolysis when nanosecond electron beams produced by the electron accelerator are incident on the samples. Therefore, the generation of nanosecond electron beams is essential for the operation of the electron accelerator.

In this context, the development of an electron gun capable of generating nanosecond electron beams is discussed.

2. Specification of device

For pulsed radiolysis studies, an electron beam with a nanosecond-scale pulse duration is required. A photocathode electron gun driven by a laser can generate electron beams with picosecond pulse durations. However, considering the complexity of the overall system, a thermionic electron gun is being adopted for the present facility to generate nanosecond electron beams.

Thermionic electron guns are widely used in industrial applications, but they present challenges in generating pulses with durations shorter than a few nanoseconds. First, it is relatively difficult to generate high-voltage pulses with very short durations. In addition, the cathode of a thermionic electron gun must respond almost instantaneously to the high-voltage pulse and emit electrons with a correspondingly short pulse duration. However, commonly used cathode materials, such as tungsten, generally do not provide a sufficiently fast response to meet this requirement.

To overcome these challenges, a nanosecond pulse generator will be incorporated into the electron gun system in this study. A conventional approach is to generate a high-voltage pulse and apply it directly to the electron gun. In the proposed approach, a high voltage is continuously supplied to the electron gun, while an additional nanosecond pulse generator is employed so that the high voltage is applied to the electron gun only for a nanosecond-scale duration in response to a trigger signal. Figure 1 and Table 1 show the circuit configuration and the main specifications of the nanosecond pulse power supply, respectively.

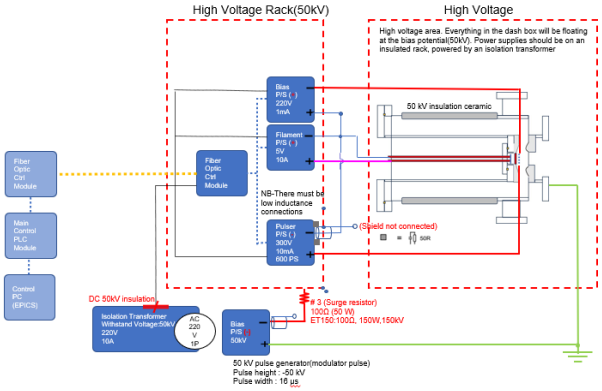


Figure 1. Circuit Diagram of the Nanosecond High-Voltage Pulse Power Supply

Table 1. Main Specifications of the Nanosecond Pulser Power Supply

Parameter	value
Outputs	4 x 50 Ω
amplitude	adjustable from 100V to >300V, negative into each of four outputs
Pulse width	≥ 600 ps (FWHM)
Trigger input	5 V

To achieve a fast response of the electron gun cathode, Y845 was selected as the cathode material. A dispenser cathode is employed, and a Wehnelt grid structure will be incorporated to focus the emitted electrons. A potential difference of 40 kV will be maintained between the cathode and anode. A cooling-water channel will also be incorporated into the electron gun structure to provide adequate cathode cooling. Figure 2 shows the schematic structure of the nanosecond electron gun.

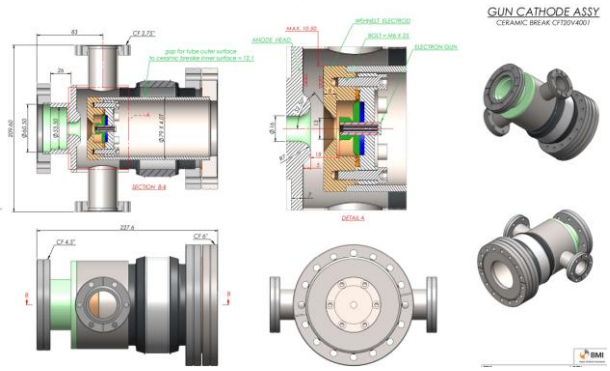


Figure 2. Schematic of the Nanosecond Electron Gun

3. Conclusion

An electron gun capable of generating nanosecond electron beams is being developed to irradiate sample materials for pulsed radiolysis studies. A dedicated power supply will be introduced to provide nanosecond high-voltage pulses, and fabrication is scheduled to be completed in the second half of this year, followed by basic performance testing.

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